

# **Union College Geology Department**

**Self review report for purposes of external review**

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## Union College

Union College, founded in 1795, is an independent, primarily undergraduate, co-educational, residential college for strongly motivated students of high academic potential. While the college's guiding philosophy emphasizes liberal education, strong programs in science and engineering have long been a significant focus at Union. The modern scientific curriculum in American education began at Union in the 1820's, and in 1845 Union became the first liberal arts college to offer degree programs in engineering. Over half of the more than 2000 currently enrolled regular undergraduates at Union major in science or engineering.

### Union College Geology Department

#### Background

Geology has been taught at Union since 1809, when mineralogy was first offered. During the following century mineralogy and other aspects of geology were variously taught as required and/or optional parts of the curriculum. The increase in specialized majors eventually led to establishment of a major in geology in 1926. The Geology Department consisted of a single faculty member for thirty years, until the nineteen fifties, when the faculty increased to two. E.S.C. Smith, who had been the Geology Department for many years, retired in the late fifties, and was replaced by a younger geologist, keeping the level of the Department at two. In the late sixties the Department was dissolved amid attempts by the faculty to increase the number of geologists and introduce a master's degree program. The Department was reestablished in 1985 following a generous gift from a geology alumnus. There are currently four geology faculty, and the Department occupies the second floor of Butterfield Hall. Student interest in the Department and in geology courses for general education is increasing substantially at the present time. Appendix I is the College Bulletin copy for the Geology Department. Appendix II is a more comprehensive account of geology at Union. Copies of the Geology Department brochure and the last five Department newsletters are attached.

#### Faculty and Staff

There are currently four faculty in the Geology Department: George Shaw, Kurt Hollocher, John Garver and Donald Rodbell. (Résumés of each faculty member are attached as Appendices VII a-d.) The teaching and research areas of each of the faculty are as follows:

George H. Shaw Teaching: Geophysics, Environmental Geology, Physical Geology, Mineralogy. Research: Experimental high pressure geophysics, modeling of planetary interiors, planetary evolution, geomorphic modeling, geochemistry and stratigraphy of bentonites.

Kurt T. Hollocher Teaching: Mineralogy, Petrology, Geochemistry, Physical Geology. Research: Metamorphic petrology, stratigraphy, structure and geochemistry of the Northern Appalachians, geochronology and geochemical modeling.

John Garver Teaching: Historical Geology, Sedimentology and stratigraphy of New York, Structural Geology, Tectonics, Carbonate Sedimentation. Research: Tectonostratigraphic analysis of orogenic sedimentary rocks, basin analysis, deformation of sedimentary rocks, provenance analysis through geochemical and fission-track studies.

Donald Rodbell Teaching: Geomorphology, Glacial Geology, Environmental Geology. Research: Glacial history, paleoclimate analysis.

The Department has a full time technician and shares a secretary (1/4 time) with the Civil Engineering Department.

### **Instruction**

Geology is beginning to attract majors in small numbers. It has never been a large Department at Union, and the lack of a major program from 1970-1985 certainly kept some students away, and led other students to leave for institutions where they could major in geology. An approximate idea of the likely number of geology majors can be obtained by comparing data from the fifties and sixties with total enrollments at that time (roughly 1000 students). For the ten year period from 1955-1964 there are forty-seven geology graduates listed in the alumni files, or about 5 per year. This would indicate about 20 geology majors in residence at any one time, or two percent of the student population. If that proportion is applied to the current student population, it suggests a potential for forty geology majors, about ten per class. Some factors may confound this simple analysis: the recent decline in interest in science and engineering among students generally, and the recent slow job market in the petroleum industry ( although this is somewhat offset by the surge in opportunities in hydrogeology). It is at least reasonable to expect 5 geology majors per class in the near future. At the present time we can identify about 23 declared or probable geology majors, 3 seniors, 8 juniors, 8 sophomores, and 4 freshmen. As is typical for Geology Departments we have a rather small number of entering majors, but the numbers increase in the sophomore and junior classes.

Instruction in the Geology Department meets three main requirements: courses for geology majors, for the General Education requirement, and for the Educational Studies Program for students interested in earth science.

### **General Education at Union College**

The core of Union's General Education Curriculum (GenEd) is the Freshman Preceptorial, taught to small groups of students by faculty drawn from a variety of departments. The preceptorial focuses on making students more effective at reading, analyzing, and writing by requiring them to read and discuss substantial works in a range of fields and to do extensive writing and rewriting.

Major goals of GenEd are to give students a surer grasp of the heritage represented by the western tradition and a better knowledge of foreign cultures.

All regular degree candidates must complete Sections I, II and III; and all must complete Section IV, except students majoring in engineering and students in Union's Educational Studies Program with a major in the sciences. (Students in the Seven—Year Medical Education Program, because of the breadth of their own special curriculum, take FP 10 but are otherwise not affected by the GenEd requirement.) After consultation with their advisor, engineering students who wish to

study a foreign language or participate in a foreign language Term Abroad may petition for a waiver of other courses in GenEd.

The five courses in Section I are to be completed early; courses in Sections II, III, and IV may be taken any time. Students wishing to study a foreign language are urged to get an early start. In many cases, courses fulfilling the GenEd Curriculum also count toward majors.

### I. History, Literature, Civilization

--FP10. Freshman Preceptorial: Perception and Persuasion (Fall, Winter, Spring). An introduction to general education through the study of representative or controversial works in the humanities, social sciences, and sciences; analysis of ideas and of the strategy of their presentation; emphasis on the student's own written communication.

--two courses in history, completed during the freshman year--either Classics 21 and 25 (Ancient) or History 35 and 36 (European) or History 13 and 14 (American);

--two courses that associate with the elected history sequence--either two courses in literature (GenEd:L), at least one of which is a survey course (GenEd: LS), or one course in literature and one course in civilization (GenEd: C), at least one of which is a survey course (GenEd: LS or CS). These courses are to be taken in timely association with the history courses to which they relate.

### II. Social or Behavioral Science

--one course from among Anthropology 10; Economics 12; Political Science 10, 11, or 12; Psychology 10; Sociology 10 or 22.

### III. Mathematics and Natural Science

--one credit—bearing course in mathematics;

--two courses in basic or applied science, one of which shall have laboratories, and the other of which shall either (a) also have laboratories, or (b) have a stated mathematics prerequisite, or (c) count for the major in the given science.

### IV. Other Languages; Other Cultures; Other Disciplines

Either Option 1 or Option 2:

**Option 1:** One of the following tracks in foreign language and culture, with appropriate double—counting for majors and for GenEd.

**Foreign Language Track:** Any sequence of three courses in a classical or modern foreign language. Students may begin a new language or be placed at the appropriate level in a language of which they have prior knowledge; students placed at the 12—level or higher earn the waiver of one of the three courses.

Non—Western Studies Track: Any related group of four courses in Asian Studies or Latin American Studies.

Foreign Study Track: Any Union Term Abroad with associated prerequisites or equivalent foreign study.

**Option 2:** Four additional courses beyond the academic division of the major, with the Divisions of the Natural Sciences and Engineering considered as one, and courses in psychology counting as if they were courses in the Division of Social Sciences.

The four courses may not all be taken in the same academic division and none may count elsewhere for GenEd. At least one of the four must be a course in literature (GenEd: L or LS) or a course in civilization (GenEd: C or CS).

Students completing interdepartmental majors may take an arbitrary choice of their "home" division. Students who change majors between divisions may apply the courses already taken in expectation of completing their first major toward satisfying the requirement.

The Key to GenEd abbreviations:

- Am--American
- An--Ancient
- Eu--European
- L--Literature
- C--Civilization
- S--Survey

Geology courses are attracting students seeking General Education courses. Although almost all geology courses satisfy the laboratory science requirement, most students seeking General Education credit choose from a few courses. The following chart shows recent enrollments:

1986-87	Physical Geology	67	Total	106
	Environmental Geology	39		
1987-88	Physical Geology	75	Total	129
	Historical Geology	3		
	Environmental Geology	51		
1988-89	Physical Geology	110	Total	150
	Environmental Geology	40		
1989-90	Physical Geology	85	Total	170
	Historical Geology	18		
	Environmental Geology	67		
1990-91	Physical Geology	49	Total	137
	Historical Geology	11		
	Environmental Geology	77		

1991-92	Physical Geology	31	Total	105
	Historical Geology	18		
	Geology of National Parks	56		
1992-93	Physical Geology	52	Total	104
	Historical Geology	27		
	Environmental Geology	25		
1993-94	Physical Geology	60 (est)	Total	112
	Historical Geology	20		
	Environmental Geology	32		

There are large enrollment changes for both Physical Geology and Environmental Geology during the past five years. Physical Geology has been taught as many as three times a year during the day session, and for a few years has been taught during the winter term as a night course; one year it was taught only once during the year. The variation in frequency and timing of course offerings results in significant differences in enrollments year to year. In the Spring term of 1988-89 an attempt was made to increase laboratory size by rearranging laboratory space. The result was a large enrollment, but it was clear that the laboratory space was inadequate for the larger number of students, and class sizes have been limited since then.

Environmental Geology was not taught for two years due to lack of staff. It had very significant enrollments for the prior two years, when it was taught by a Pew visiting lecturer. The addition of our fourth regular faculty member will allow us to teach this course on a regular basis. Geology of National Parks was instituted in Spring term 1992, in place of one of the Physical Geology sections. It has not been taught since, but it may be revived given the additional staff available next year.

No special courses have yet been introduced for the Educational Studies Program, although discussion concerning the matter has taken place. Some appropriate courses are currently taught using adjuncts (e.g. Meteorology). We currently have three students in the Earth Science part of the Educational Studies Program.

### **Writing Across the Curriculum**

Starting with the class that entered in the fall of 1990, every student will be required to complete (1) the Freshman Preceptorial; (2) two to four courses that have been specially certified as W1 or W3 courses, normally taken during the sophomore and junior years; and (3) a senior writing experience such as a senior thesis or a senior seminar paper. The program of Writing Across the Curriculum (abbreviated as WAC in the course listings that follow) brings together traditional elements of a Union education and new courses and methods in a systematic effort to promote improvement in student writing skills.

The Freshman Preceptorial, the first requirement, has for several years been required for all freshmen and is described in the section above titled "The General Education Curriculum."

The W1 and W3 courses that fulfill the second requirement are within the normal disciplinary offerings and have writing built in as an important and clearly evaluated part of the course work. A W1 course earns one unit of writing credit, while a W3 course earns three units. Each student must earn six units of credit by taking either two W3 courses or one W3 course and three W1 courses; it is not sufficient to take solely W1 courses.

This Academic Register lists courses currently certified by the College Writing Board as meeting W1 and W3 requirements. It is expected that additional courses will be certified in the future. Because of this, and because of possible future changes in courses currently certified, it is to be expected that the roster of WAC courses will change over time. A student may use certified courses in foreign languages to satisfy part but not all of the requirement. Students should check current registration materials each term for accurate information about which courses carry W1 and W3 credit.

The form of the senior writing experience that fulfills the third requirement will be determined by the Writing Board and the student's major department(s). Some departments--but not all--have required such an experience for some or all of their students for many years. In most departments, the WS requirement will be fulfilled by completing a thesis, an other research project, or a senior seminar. Courses that satisfy this requirement will be designated as WS courses in future catalogues.

The key to WAC abbreviations:

W1--Carries one unit of writing credit

W3--Carries three units of writing credit

\*--W1 or W3 credit is given for some, but not necessarily all, of the sections of this course offered in a given term.

There are three geology course that carry writing credit, all W3:

GEO 021 - Stratigraphy and Depositional Environments of Eastern New York

GEO 041 - Structural Geology

GEO 130 - Geochemistry

Because GEO 021 and GEO 041 are required of all geology majors, they automatically fulfill the writing requirement.

The senior writing requirement is currently met by our requirement of a senior thesis by all students. If we implement our proposed changes, with the addition of a BA Geology track, those students will be required to undertake some form of writing requirement as seniors, although not necessarily a thesis. We have not yet decided on a method of implementation of this requirement, but expect no difficulties in doing so, using course designations already available.

## **Geology Major**

The requirements for a major in geology include six core geology courses:

Physical Geology  
Historical Geology (Earth and Life Through Time)  
Mineralogy  
Petrology  
Stratigraphy and Sedimentation (Stratigraphy and Depositional Environments of Eastern New York)  
Structural Geology.

Three additional geology courses may be chosen from:

Geomorphology (Evolution of Landscapes)  
Carbonate Sedimentology  
Tectonics  
Environmental Geology  
Geochemistry  
Field Geology  
Geophysics  
Groundwater Geology and Hydrology  
Independent Study  
Research

Many students elect to take more than minimum required number of geology courses. At present all students are required to complete a senior thesis based upon at least two terms of research. In addition to geology courses, all geology majors are required to complete two terms of mathematics, two terms of chemistry, and two terms of biology or physics (or one of each). They are strongly encouraged to take at least two additional courses beyond the introductory level in one of the sciences, mathematics, or engineering. A summer field course is not required but strongly recommended, but few of our students take such a field course at present.

### **Enrollments**

Enrollments in introductory level courses have been listed above. The following chart shows enrollments in all course for the past five years.

year	GEO 010	GEO 011	GEO 015	GEO 021	GEO 022	GEO 031	GEO 032	GEO 035	GEO 041	GEO 042	GEO 050	GEO 130	GEO 150	GEO 160	GEO 170	GEO 190-3	GEO 195-8
	Physical	Historical	Nat Parks	Sed/Strat	Geomorphology	Mineralogy	Petrology	Carbonate sed	Structural	Tectonics	Environmental	Geochemistry	Field Geology	Geophysics	Groundwater	Ind Study	Thesis
1985F	21																
1986W						2					56						
S		7					2				96						
SU																	
F	31			3													
1987W					4						39	3					
S	36								2								1
SU																	1
F	35	3															
1988W						3				3	51						
S	40						2									1	
SU																	
F	35								6								
1989W	27					4					40						
S	48					9	4										
SU																	
F	31			3							67						
1990W	30	18				4								5			
S	24				6		3		3						14		
SU																	
F	31			6							77						1
1991W	18	11				3				3		3					5
S							2		5						8		5
SU																	
F	31			9										6			4
1992W		18				8				7							3
S			56				6		6						8		2
SU													6				
F	31			2				11			25						2
1993W		27				7						4					3
S	21						7								8		3
SU																	
F	32			11							32						4
1994W						9											

The college is presently engaged in rationalizing criteria for teaching loads, and one of the proposals may have an impact on geology. This criterion establishes an enrollment level of six students as the minimum for full teaching credit in a course. Some of our upper level courses have been below this number, mostly because of the small number of geology majors. The administration is sympathetic to the problems of a new Department, and we will probably not be held to this standard for some time. There is also the recognition that we provide a significant

service in general education laboratory science courses, and that we are faced with limitations on class size imposed by our facilities. In view of the increasing number of geology majors and enrollments in upper level courses, we hope we may be able to meet this criterion most of the time within five years. We are also instituting some curricular changes, in particular requiring two upper level geology electives exclusive of research, which should increase enrollments in these courses.

### **Instructional Laboratories**

Instructional laboratories must be considered separately from research laboratories, as they often have distinctly different requirements, especially the nature of the work in those facilities and the numbers of students involved. The Department currently has one instructional laboratory: Butterfield 201 which is used for large classes such as Physical Geology and Historical Geology. Butterfield 202 once housed our petrographic microscopes, which are used in mineralogy, petrology and for student research., but this space has been taken over by the ICP-MS. The instructional laboratory space is inadequate for a Geology Department offering a degree program, and even more inadequate with the additional demands associated with general education.

### **Research**

Before discussing research and laboratory facilities, it should be helpful to list recent and current research projects in the Department. Most of the projects involve student participation, either as thesis research or student-assisted faculty research (work-study or grant supported student assistants). The projects cover a wide geographic and disciplinary range, which be increased with the arrival of our fourth regular faculty member.

#### Research under the direction of John Garver:

My main research focus is on the interaction of sedimentation and tectonics, mainly associated with convergent margin tectonism and terrane accretion. One of my main focuses is using the provenance of sedimentary detritus to identify source terranes and unroofing trends. To this end, I have spend a considerable amount of my research effort at developing new techniques and new approaches for provenance evaluation. The principal avenue of provenance evaluation has been to use fission-track dating of detrital zircon and apatite to assess the thermal history of source terranes, correlating strata, and dating sediment deposited along active margins. Second, I have used the geochemistry of sediments, especially shale, to identify crustal provenance.

#### *Geochemistry of sediments*

In the foreland basin to the Taconic orogeny, sandstones have high concentrations of detrital chromite derived from ophiolites in the source region. For several years I have had students examining the geochemistry of shale in this basin to see if the geochemical signature of ultramafic rocks is well preserved in synorogenic shale. Well-developed Cr and Ni anomalies in shale tell of systematic variation in unroofing of ultramafic rocks during Taconian collision.

In the Bridge River area of southern British Columbia, I have had several concurrent studies. The first is aimed at deciphering the Mesozoic accretionary history of the miniterranes

that underlie this area. These terranes were probably accreted to the margin of North America in the mid-Cretaceous and there is a good geochemical record of this event. This geochemical record includes light rare earth enrichment, characteristic of evolved continental crust, and Cr and Ni anomalies (as seen in the Taconian foreland basin), characteristic of uplifted and eroded ultramafic rocks during accretion.

### *Fission-track dating*

After collision of the various miniterranes in the Canadian Cordillera, the Bridge River area was cut by numerous strike-slip faults that have a minor, but significant component of vertical movement. For several years I and Doug Archibald (Queens University) have been using fission-track dating and Ar/Ar studies to date the timing of uplift and presumably strike-slip faulting. The fault system that cuts this area includes several fault-bound blocks with different cooling histories - all of these faults are related to dextral movement and coastwise translation of these outboard terranes along the North American margin. The amount of movement is controversial.

In the Olympic Mountains in Washington state, my NSF-funded research is aimed at determining the tectonic evolution of this rapidly uplifted mountain range through cooling studies and provenance analysis of the flanking strata. This research is in collaboration with Mary Roden (R.P.I.) and Mark Brandon (Yale). The very rapid uplift of the Olympic massif (~1km/M.Y. for the last 12 Ma) is almost certainly related to plate dynamics, but may also be a result of the enormous quantity of sediment deposited in this area - sediment from both the Fraser and Columbia rivers. In evaluating the provenance evolution of strata in the Olympics, we have expanded our FT dating program of detrital minerals to include modern river sediment from the principal rivers in the Pacific northwest that may have served as paleodrainages for sediment deposited and now uplifted in the Olympics.

Future research, pending NSF support, would involve the collision of the Olyutorsky volcanic arc in the northern Kamchatka Peninsula in the Russian Far east. This project is aimed at understanding the timing of collision through changes in provenance and uplift and cooling studies in the collision zone. The present uncertainty concerning the timing of collision leaves a gap in our understanding of the evolution of the Bering sea, the Aleutian Islands and plate reorganization in the north Pacific.

### Research under the direction of Kurt Hollocher:

I have research projects in four broad areas. Students have worked in all three areas during work-study or for their senior thesis work.

### *Development of the Taconian island arc, western New England*

In 1987 I had one student who made and examined thin sections of metamorphosed Taconian island arc plutonic rocks and related volcanics, and concluded that the two were petrographically, and hence chemically, dissimilar (Hollocher and Lent, 1987). Since then I have continued to work actively in that field, but I have had only work study students involved in that project.

### *Geochemistry of natural surface and ground waters*

Although not my principal field of training, I have had a long-standing interest in environmental geology and water chemistry. All of my thesis students for the past four years have worked on problems of ground and surface water inorganic chemistry. These have included the Mohawk River and its tributaries in New York, hazardous waste sites, high-uranium waters in western New Hampshire, and currently a study of Lake Mascoma and its tributaries in western New Hampshire. These projects, because of their pertinence to modern problems in environmental geology, and their relevance for future employment, continue to attract students.

### *Development of laser ablation ICPMS*

Over the past year I have been working on developing the technique of laser ablation sampling for sample introduction to our ICPMS instrument. During my sabbatical leave last year I characterized a number of materials for use as standards, and last February I put together our own laser ablation sampler and obtained a few analyses. This winter I worked on having the mountings for the beam line made more stable, and I helped realigned the beam line optics. I also wrote the computer software to control the laser during testing and analysis. I currently have a work-study student who is working with me to test the laser control program, and to understand various aspects of laser operation, laser stability, and control of laser power levels. After we have finished this preliminary phase, we will start working on ablation tests and then run a series of analytical tests using the ICPMS. Once the tests are finished, we will start doing geologically related analytical work to try to understand problems of element partitioning during partial melting, and during solid state metamorphic reactions.

### *Analysis of platinum group elements in rocks*

I have recently started a project to separate platinum group elements from common rocks, and have them concentrated enough in solution for routine ICPMS analysis. Platinum group elements, because of their low concentrations in most rocks have been neglected in geochemistry. These elements should serve as useful tracers for various geochemical interactions, particularly silicate-sulfide and silicate-metal equilibria in magmatic systems. I just received a small grant to start this project, and I anticipate that students will be involved in this work should preliminary results prove successful.

### Research under the direction of Donald Rodbell

*Glacial Geology of the tropical Andes:* The principle objective of this research is to determine the timing and magnitude of glacier fluctuations in the Ecuadorian, Peruvian, and Bolivian Andes over the last Ca. 100,000 years. Because mountain glaciers are sensitive indicators of regional climate, the results of this study may be used to reconstruct the history of climatic change during the late Quaternary. Geologic records of climatic change are particularly needed from tropical regions because the tropics have been underrepresented in stratigraphic studies. This underrepresentation, in turn, has made it difficult to rigorously evaluate proposed interhemispheric climatic "teleconnections" that may have linked global climate in the past and may play an important role in regional climatic responses to anthropogenetically-induced warming. This research involves radiocarbon dating glacial deposits and the retrieval of sediment

cores from glacier-fed lakes. These latter are particularly valuable in that they can provide radiocarbon-datable archives of past glacier fluctuations, vegetation assemblages, and atmospheric dust.

*Stratigraphy of Loess Deposits in the central U.S. and northeastern Argentina:* During the ice ages, extensive regions of the Americas, Asia, and Europe were blanketed by thick deposits of loess (fine-grained dust) as a result of increased sediment supply from glacial outwash, drier climates, and increased atmospheric circulation. In contrast, during non-glacial periods, loess deposits were stabilized by vegetation and soils (paleosols) formed.

My research involves the stratigraphic study and dating of loesses and interbedded paleosols in the central Mississippi Valley and on the Pampean Plains of northeastern Argentina. Accurate absolute age determinations are critical to this study, and whereas radiocarbon dating of organic material preserved in loess can provide age estimates for the last ca. 40,000 years, deposits older than this have been poorly dated. Recent advances in thermoluminescence (TL) dating have enabled the dating of loess up to ca. 500,000 yr old, and I have been working extensively with this technique at the TL Dating Research Laboratory at The Ohio State University. Finally, I am studying the magnetic properties of the loesses and paleosols in order to identify short-term intervals of soil development, which are difficult to recognize in the field.

*Tephrochronology in the Tropical Andes:* Volcanic ash (tephra) are intercalated with deposits of the last glacial cycle in much of the tropical Andes. Sediment cores from glacier-fed lakes in southern Ecuador and glacial ice cores from the central Peruvian Andes have identified several tephra layers that were deposited during the last deglaciation, an interval of dramatic global change. These tephra provide important isochronous marker horizons which can be used to correlate among proxy records of climatic change preserved in sediment and ice cores. Organic material in sediment cores can provide close limiting radiocarbon age estimates for these tephra, and chemical fingerprinting can provide the basis for correlating tephtras between sites and for identifying possible source volcano(s). My work involves radiocarbon dating tephra layers preserved in sediment cores from lakes in the Ecuadorian and Peruvian Andes and determining the major-element geochemistry of these tephtras. I am collaborating with two Ecuadorian scientists who are providing samples of tephtras from known volcanoes for comparison with those found in the sediment and ice cores.

#### Research under the direction of George Shaw:

Shaw is currently involved in three main projects. His major effort concerns the geochemistry of apatite phenocrysts from bentonites. The goal of the research is to investigate the use of trace element chemistry of the apatites as chemical fingerprints in correlating bentonites. One aspect of this project concerns the effect of alteration on apatite chemistry, since a major assumption in using phenocrysts is the preservation of chemical information in spite of the extensive alteration of the original volcanic ash (now > 99% clay). He is working with his daughter, a geology student at Bryn Mawr College, who is doing her senior thesis comparing phenocryst chemistry from altered and unaltered parts of a thick Paleocene ash/bentonite (Sentinel Butte Formation) from North Dakota. Another element of this work concerns the uniformity of apatites from older (Cretaceous and Devonian), thick, completely altered ash layers. One student completed a senior project analyzing apatites from a 1-1/2 meter thick bentonite from the Gaspé Peninsula, and another student is currently working on a 2m bentonite from the Great Valley Sequence of central

California. It is hoped that these studies will help define the variability within a completely altered ash, and perhaps determine whether either of these two thick layers are comprised of more than one eruptive event. A third part of the project concerns the areal uniformity of apatite chemistry from a single well-defined bentonite. Apatites from a single layer at more than ten localities separated by hundreds of kilometers have been analyzed and found to be very uniform. Additional layers are being studied in an attempt to demonstrate between layer differences, as well as areal uniformity. Yet another aspect of the work on phenocrysts from bentonites centers on the Great Valley Sequence of California. There are dozens of bentonites present in these rocks, spanning much of the time of evolution of the Sierran Arc. Preliminary studies indicate a significant temporal change in apatite chemistry which appears to be related to the development of a more "continental" arc. These studies are continuing, with a student from Colgate University working on a senior thesis project. Finally, A student is working on apatites separated from Great Valley formation sandstones in order to assess the uniformity of detrital apatites for comparison with the volcanically derived apatites (presumably more uniform).

A second area of Shaw's research concerns chemistry of karst spring waters. A former student carried out a baseline study of trace elements in spring water in an effort to establish background levels of possible metals useful in water tracing. This led to the observation that spring water chemistry seemed to be related to the lithology of the rock from which the spring emerges. Another student then analyzed limestone samples for trace elements, indicating a relationship between chemistry of the limestone and the emergent water.

The final area of Shaw's active research is in shallow seismic studies in the peatlands of northern Minnesota. A former student completed a senior project testing an improved method for shallow seismic refraction and reflection, and gathering preliminary data on the depth to bedrock beneath selected areas in the peatland. Another student is continuing this work with the goal of relating peatland landforms to bedrock surface topography.

### **Recent Student Publications**

Hollocher, K. and **Lent, A.**, 1987, Comparative petrology of amphibolites in the Monson Gneiss and the Ammonoosuc and Partridge volcanics, Massachusetts. *Northeastern Geology*, v. 9, p. 145-152.

**Hood, E.** and Hollocher, K., 1991, Chemical composition of the Mohawk River and two tributaries, Schenectady NY, measured by ICP-MS. *Geological Society of America Abstracts with Programs*, v. 23, p. 46.

**Kahn, L.** and Hollocher, K., 1991, Tracking the horizontal spreading of heavy metals in groundwater, Naugatuck, Connecticut (abstract). *National Conference on Undergraduate Research*, 5th annual meeting, paper ENV.II.7K.

**Garbellano, L. L.** and G.H. Shaw, 1991, Baseline trace element chemistry of karst springs in Schoharie and Albany Counties, New York, *National Speleological Society Bulletin*, 53, 117-118.

- Shaw, G.H., Y-A Chen, and **T.J. Scott**, 1991. Multiple K-bentonite layers in the Lower Devonian Kalkberg Formation - Cobleskill, NY, GSA Abstracts with Programs, vol 23, p 126.
- Jahne, D.R.**, Shaw, G. and Hollocher, K. 1992, The migration of heavy metals in contaminated water from a landfill, Barkhamsted, Connecticut. Abstract #484, National Conference on Undergraduate Research, Abstracts with Programs, 6th annual meeting, University of Minnesota, Minneapolis.
- Yuskaitis, A.** and Hollocher, K., 1992, Chemical composition of surface and high-uranium well water, Sunapee area, New Hampshire. Abstract #483, National Conference on Undergraduate Research, 6th annual meeting, University of Minnesota, Minneapolis.
- Shaw, G.H., **T.J. Scott**, Y-A Chen, P. Lawson and M. Roden, 1992, Rare earth element chemistry of apatite phenocrysts from bentonites, GSA Abstracts with programs, 24, p. 75.
- Royce, P.R.** and Garver, J.I. 1992, Provenance analysis of foreland basin strata using Cr and Ni concentrations in shale deposited during the Middle Ordovician Taconic Orogeny, western Newfoundland (abs.): Geological Society of America Abstracts with Programs, v. 24, n.3, p. 72.
- Miller, P.**, Shaw, G.H., Glaser, P., and Siegel, D., 1992. Bedrock topography beneath the Red Lake peatlands (abs); Geological Society of America Abstracts with Programs, v. 23, n.7.
- Scott, T. J.**, 1992, Provenance Analysis of Taconic Orogeny synorogenic allochthonous strata using trace element geochemistry in shale, southwestern Vermont, and comparable studies of the Tyaughton basin, southern British Columbia [abs], Lafayette College NSF consortium, Easton PA.
- Royce, P.R.**, 1992, Provenance analysis of synorogenic strata using Cr and Ni concentrations in shale deposited during the Middle Ordovician Taconic Orogeny, western Newfoundland, The Green Mountain Geologist, v. 19, n. 1, p. 6,7.
- Jahne, D. R.**, 1992, The migration of heavy metals in water originating from source areas within a landfill, Barkhamsted, Connecticut, The Green Mountain Geologist, v. 19, n. 1, p. 6.
- Yuskaitis, A.**, 1992, Chemical composition of surface and high Uranium well water, southwestern New Hampshire, The Green Mountain Geologist, v. 19, n. 1, p. 6.
- Hollocher, K. and **Yuskaitis, A.**, 1993, Chemical composition of surface and high-uranium well water, Lake Sunapee area, New Hampshire. Northeastern Geology, v. 15, p. 159-169.
- Maranville, R.E.**, 1993. Fission-track dating of detrital zircons from modern rivers in the Pacific northwest: Implications for the provenance of the Olympic subduction complex; Green Mountain Geologist, v. 20, n. 1, p. 8.
- Scott, T.J.**, 1993, Shale geochemistry as a provenance indicator of mid-Cretaceous terrane accretion, southern British Columbia; Green Mountain Geologist, v. 20, n. 1, p. 10-11.

Shaw, G. H., and **Clark, L.**, 1993, Rare-earth elements in phenocrysts from Great Valley bentonites: A probe into arc evolution & terrane accretion, *EOS*, 74:23, 681.

Garver, J.I., Archibald, D.A., and **Van Order, W.F.**, 1994, Late Cretaceous to Paleogene cooling adjacent to strike-slip faults in the Bridge River area, Southern British Columbia, based on fission-track and  $^{40}\text{Ar}/^{39}\text{Ar}$  analyses; *In Geological Survey of Canada, Current Research*, 94-1A, p. 177-183.

Garver, J.I., **Royce, P.R.**, and **Scott, T.J.**, 1994, The presence of ophiolites in tectonic highlands as determined by Chromium and Nickel anomalies in synorogenic shale: two examples from North America, *Geologia i geofizika*, in press.

Garver, J.I., and **Scott, T.J.**, Rare earth elements as indicators of crustal provenance and terrane accretion in the southern Canadian Cordillera, *Geological Society of America Bulletin*, (in review since June 1993).

Shaw, G.H., **Miller, P.**, Glaser, P.H., and Siegel, D.I., An improved method for shallow seismic investigations in peatlands, (in review) *Canadian Journal of Earth Sciences*.

### **Research Equipment and Laboratory Facilities**

Laboratory facilities and research in the Geology Department are discussed together because of the close connection between available laboratory equipment and the research potential of the Department and its faculty. It should be understood that research in the Department serves the dual role of faculty development and instruction of students through research participation. All laboratory equipment is accessible to the students for use in independent, faculty supervised research projects.

A list of significant laboratory equipment is in Appendix II. The geological collections in the Department should be considered also, as they represent significant teaching resources, and potential research resources. These include the Wheatley, Pfordte, and Departmental mineral and rock collections, and a substantial collection of fossils. Appendix III discusses the Departmental mineral collections. The Department also maintains a sizable collection of topographic and geologic maps. Union College is a government document depository and currently maintains USGS topographic map collections east of the Mississippi River. It is possible to expand to full coverage, but lack of space in the library has led to the current arrangement.

The major items of laboratory equipment are focused around specific needs in geologic research and teaching. These include rock and mineral analysis (X-ray diffractometer, ICPQMS), high pressure equipment to simulate conditions within the earth and make measurements of properties of materials under those conditions, sedimentology (stream table, size analysis, cathodoluminescence), and general sample preparation equipment (crushers, sieves and shakers, rock saws, thin section equipment).

The X-ray diffractometer is used for conventional mineral identification purposes and semiquantitative mineral analysis. The ICPQMS is a state-of-the-art chemical analysis system capable of precision analyses for virtually all elements (ppm level and better), as well as isotopic

analyses for many interesting systems. It is the Department workhorse for geochemical and mineralogical analysis, and some isotope analysis.

The geochemical work requires adequate wet chemistry facilities for sample preparation under relatively clean conditions. For the time being we will continue to use the inadequate facilities in Butterfield 200 for these purposes, although a significant upgrading of the laboratory is clearly essential to get the maximum use from the instruments we will be using.

The high pressure equipment was brought to Union by Prof. Shaw from the University of Minnesota. It is capable of generating static pressures in excess of 30,000 atmospheres, and lower pressures (to 13,000 atmospheres) in large volume pressure vessels, with provisions to measure sound speeds under high pressure. The equipment is currently in storage in an enclosure in the Engineering laboratory. There is no space to set up this equipment now or for the foreseeable future.

The facilities for sedimentology are presently spread over a number of laboratories in Butterfield: a stream table in 201, size analysis in 200, and the cathodoluminescence equipment in 202. At present there is no alternative to this situation.

The fission-track lab at Union includes two elements: the mineral separation equipment, and the counting & analysis lab. The mineral separation facilities are located throughout the department and receive wide use for other research projects. The counting & analysis facilities, which include an automated stage for counting, video and computer equipment, are presently in Prof. Garver's office - a situation that is difficult when students spend a considerable amount of time doing analyses for their research.

Rock and mineral preparation is an important element in geologic research. Separate space must be maintained for preparation equipment, as much of the work is "dirty", involving sawing, crushing and grinding of rocks, polishing of thin sections, and sifting of crushed materials and sediments. These procedures not only produce considerable dirt and dust, but are also rather noisy. At the present time these facilities are housed "under the Alps". We cannot use the equipment for significant parts of the day, since doing so would significantly disturb lectures held in the Alps (Butterfield 204). No satisfactory alternate location is available.

The arrival of Donald Rodbell in July 1994, will further complicate our space problems. Although we have office space for him, his need for laboratory space for storage and analysis of core samples must be met by converting existing space. At present the only alternative is to convert Butterfield 309 (presently Shaw's office) to a laboratory. This will be done immediately prior to Rodbell's arrival.

We foresee additional equipment needs as the Department continues to develop, in order to meet the requirements of modern geological education and the research activities of faculty and students.

### **Special space requirements**

The Geology Department has substantial collections useful in teaching and research. These collections are currently stored in laboratory classrooms, under the Alps, in research laboratories, and in the basement of Steinmetz. This situation drastically limits the utility of these collections.

A summary of existing space, and allocation of that space, is included in Appendix IV.

### Geology Department Budgets

Budgets at Union College are divided into three categories: "A" budgets are for salaries, "B" budgets cover supplies, expendables, and operating expenses, and "C" budgets cover capital equipment. "A" budgets are not under the control of the Department, but are set by administrative review procedures and base salary at time of hiring. The following table gives the amounts in the "B" and "C" budgets for the last six years. The amounts given are as budgeted, except for 1993-94, when a freeze was applied to the "C" budget due to a college-wide budget shortfall. The "C" budget for 1993-94 is the amount spent at the time of the freeze. The significant drop in the "C" budget in 1989-90 was due to funding problems for science equipment in a previous year. The intention of the administration has been to bring "C" budget allocations for the science Departments back up to prior levels over time. Subsequent increases in the "C" budget reflect this effort. With the arrival of the new chair in 1988-89 the Department was allocated an additional \$100,000 for necessary equipment purchases. This was allocated to a variety of items including a new van, matching money for the ICPMS, some startup funds for Prof. Garver, and air conditioning for the ICPMS laboratory.

<u>Year</u>	<u>"B" Budget</u>	<u>"C" Budget</u>
1988-89	11646	25000
1989-90	12500	16000
1990-91	17500	20000
1991-92	19000	24400
1992-93	20574	24400
1993-94	21199	12849

In addition to the annual budgets, the Department has received funding for equipment, research, and teaching from a number of external and internal sources. Major grants from the Keck and Kresge foundations have added \$325,000 in equipment to the Department in the last five years.

The following list gives funding sources and amounts for the last six years:

1989	200,000	Equipment	W.M. Keck Foundation
	50,000	Equipment	NSF-ILI
	20,000	Visiting Lecturer	N.Y. Pew Cluster

	10,000	Undergraduate Research	N.Y. Pew Cluster
1990	9,000	Research	NSF-ROA
	5,000	Research	B.C. Geol. Surv.
	1,860	Research	Union College
	22,700	Equipment	IBM
1991	2,358	Research	UC
	2,000	Research	UC
	2,526	Research	UC
	1,575	Research	UC
	1,054	Research	UC
	2,333	Research	N.Y. Pew Cluster
	25,000	Visiting Lecturer	N.Y. Pew Cluster
1992	125,000	Equipment	Kresge Foundation
	24,824	Research	NSF
	46,626	Research	NSF
	28,162	Research	NSF-ROA
	5,000	Teaching	NSF
	1,595	Teaching	UC
	1,290	Teaching	UC
	2,119	Teaching	UC
	1,560	Research	UC
	828	Research	UC
	815	Research	UC
	1993	1,875	Research
500		Student Research	UC
6,000		Research	NSF
10,000		Equipment	NSF-ILI
10,000		Equipment	UC match
1,200		Research	UC

The Department has a small revolving fund from designated alumni contributions, which amount to about \$2000/year. This fund typically has \$3-4000 at any time and is used for a variety of expenses, such as student travel to meetings, field trips, and miscellaneous expenses. It serves as a small contingency fund when unusual circumstances or expenses arise. For example, two years ago it was used to fund the production of the Departmental brochure.

Finally, the Department is in the midst of a campaign to raise a \$250,000 endowed fund to support field geology: field camp scholarships, field expenses for student research, and Department field trips. The fund is currently at about \$70,000, mostly due to one particularly generous alumnus. When complete, the fund is expected to produce about \$12,500/year.

## **The Future of Geology at Union**

(The comments of the review committee on this section would be especially valuable to the Department.)

### **Geology Department Objectives**

These may be briefly stated:

- 1) Provide an excellent education for majors in geology. Geology graduates will receive a background which will allow them to excel at the best graduate Departments in the country, or successfully pursue professional careers. The emphasis is on preparing students for entrance to graduate school.
- 2) Provide stimulating courses for general education in science. These courses will not only cover the basic principles of geology, but will introduce the students to the methods of geologic investigation and problem-solving.
- 3) Provide for the development of faculty and students through active research programs and opportunities. Research is viewed as an integral part of the Department's function. The emphasis of research efforts should be on maintaining a continuing learning environment for faculty, and meaningful participation of undergraduates in the research process.
- 4) Provide support for faculty and students efforts which serve the campus and larger communities through the application of relevant individual and group expertise. Where appropriate to our professional background we should make concrete contributions to solving problems on and off campus.

### **Faculty and staff needs**

The present four faculty will be able to meet the needs of the geology major and an expansion of activity in the general education area without overloads. A fifth faculty member is very desirable to provide breadth of coverage and additional flexibility in general education. At present there are three fields which we have considered for the fifth faculty member in geology: Hydrogeology, Paleontology, and Economic Geology.

Although there is a trend for Geology Departments to hire hydrogeologists, we would probably not adopt that approach. The competition for quality faculty in the field is very high, with many positions open at major institutions. In addition, it is a rather specialized field, and unless we could find an individual who combines hydrogeology with another discipline, the benefits to our students would be limited. Since we are currently providing students with a course in hydrogeology through adjunct faculty, there seems to be no great benefit in hiring a full time person. In fact, a number of our students have done senior projects in the area of water chemistry, which gives them some practical background in at least one of the important parts of hydrogeology, in addition to the coursework available.

Some Geology Department's have eliminated paleontology during the past several years. While there may be justifications for this, we feel it is important to consider hiring a paleontologist, for three reasons. First, many students are attracted to geology through an interest in fossils. We view the addition of paleontology to our curriculum as a potentially significant draw for new students. Second, although some aspects of paleontology have (perhaps) lost the significance they once held, there is a considerable body of exciting research in the field, especially in furthering our understanding of evolutionary processes (which is, in fact, one of the oldest parts of paleontologic thought). Third, there are some individuals who could be described as paleontologists, but whose research goes beyond the usual bounds of the field, and who could make use of the special research facilities in the Department (we hope, in conjunction with the present faculty).

Economic geology has suffered in some Geology Departments during the past decade. But here again is a field which offers opportunities, especially if we can find an individual whose interests overlap with some of the present faculty. In addition, many students are attracted to geology by minerals, gems, and ores. There is a practical reason for considering this field. Many of the alumni of the Geology Department have had successful careers in industry. It may be possible to obtain an endowment to fund such a position, an opportunity perhaps unique to Economic Geology, and one worth pursuing.

A request for expansion of the Department to five faculty is supported by reference to the group of institutions normally used by Union College for comparison purposes. The average size Geology Department in that group is 4.7, ranging from 2 to 8. A histogram of Geology Department sizes (number of faculty) is shown in Appendix V. The proposed increase is also supported by considering the size of the Geology Department in the early sixties (two) when the college had an enrollment of about 1000, with the present enrollment of over 2000. Add to this the increased sophistication of geological research methods (and consequent specialization), and five faculty can be seen to be a minimum.

An increase in the size of the faculty implies consideration of additional staff, in particular secretarial support. Modern technology (microcomputers, word processors, and laser writers) limits this impact somewhat, and the Geology Department is already making use of these methods. On the other hand, an increase to five faculty will necessitate extra secretarial support. While we are hesitant to minimize what is required, it appears a 1/2 time secretary would be essential to the smooth operation of a Department of five.

### **Proposed changes in the curriculum**

We expect to change the curriculum for the major in geology during the next year. The curriculum as currently constituted leads to a B.S. degree in geology, but examination of other geology programs indicates that it has fewer requirements than it should have. Three years ago we added a requirement for a senior thesis for all majors, but with increasing numbers of majors, we may not be able to sustain this effort, and it may not be an appropriate avenue for all students. The addition of a fourth faculty member, and the additional course offerings, provides us with a chance to make important modifications to the geology program at Union.

We are considering adding a B.A. geology degree program which would closely follow our current requirements. The B.S. degree would be made more rigorous by the addition of a two course physics requirement which is presently an optional science requirement taken by a small proportion of the geology majors. The new B.A. degree would not require a senior thesis (it would be optional, with permission of the faculty), while the B.S. degree would retain the current thesis requirement. The B.A. degree would require three upper level geology electives and the B.S. degree would require two upper level geology electives, as well as two terms of thesis. The proposed requirements are summarized below, along with the present degree requirements:

	<u>Present program</u>	<u>Proposed B.A.</u>	<u>Proposed B.S.</u>
<b>Geology</b>	GEO 010 or GEO 050 GEO 011 GEO 021 GEO 031 GEO 032 GEO 041	GEO 010 GEO 050 GEO 011 GEO 021 GEO 031 GEO 032 GEO 041	GEO 010 GEO 050 GEO 011 GEO 021 GEO 031 GEO 032 GEO 041
<b>Upper level Geology</b>	any 3 courses (may all be thesis credits)	any 3 courses (thesis credit for one only)	any 2 courses (not thesis)
	Thesis required	Thesis optional (by permission)	2 credits of thesis
<b>Mathematics</b>	2 courses	2 courses (1 may be statistics)	2 courses
<b>Chemistry</b>	2 courses	2 courses	2 courses
<b>Biology</b>	2 courses	2 courses	
<b>Physics</b>	or 2 courses (or one of each)	or 2 courses (or one of each)	2 courses

No changes are contemplated for interdepartmental majors or geology minors.

## **Budgets**

"B" budgets have been growing consistent with the needs of the Department. The addition of a fourth faculty member and the consequent increase in courses and field trips will require some additional increases for supplies. Last year we were faced with additional extraordinary expenses associated with the visit of N.V. Sobolev. (especially in the form of telephone charges to Russia). His position as director of the Institute of Mineralogy and Petrology at Novosibirsk necessitated frequent calls to Russia, which had not been included in our budget request. We were able to "get by" for the year by internal reallocation of funds. The two visitors we have this year, from Moscow and Romania, do not require quite as much support, but do represent a real draw on some of our resources. We may not be able to participate in the East European Visiting Scholars program in the future without provision of extra funding to the Department to support the visitors. While we are able to maintain the ICPMS through regular allocations, we have been supplementing normal funds with grant money for some maintenance costs. This will probably continue into the future.

"C" budgets have generally been adequate, although the interruption of 1989-90 resulted in some delayed purchases. Budgets had nearly recovered their 1988-89 levels when the freeze of the present year set us back again. If "C" budgets return to normal and can be reliably maintained they should be adequate. The Department has developed a preliminary plan for instrument acquisition and has made significant progress in obtaining equipment. Our needs were considerable in view of the hiatus in geology activity at Union (hence the need to replace outdated equipment), and the advances in instrumentation used in geology over the past twenty years. The appended list indicates that our present equipment inventory is significant, but there is more that needs to be added. Ongoing C budget requests and continued support from the Kresge endowed funds should provide for important acquisitions.

## **Space**

The Geology Department presently occupies slightly more than 3100 square feet (assignable, net) on the second floor of Butterfield Hall (see Appendix IV). This does not include about 150 square feet of narrow storage space of marginal utility behind Room 202, any of the "storage" space in the basement of Steinmetz Hall (ca. 750 sq ft, low utility), or the space in the Engineering Lab (ca 200 sq ft). Even with no changes in the makeup of the Department, this space will require substantial renovation in order to accommodate a modern Geology Department. The laboratories, in particular, are quite inadequate, even for the wet chemistry for which they were originally built.

The area "under the Alps" is currently used for rock sample preparation, storage of part of the mineral and paleontology collections, and utility space for the technician. The space is divided into cubicles of minuscule dimensions and is poorly laid out for practical use. Some improvements could be made to the space, but it would require major changes to accommodate laboratory equipment.

Available office space is adequate for a faculty of three, but significant squeezing would be necessary to accommodate a secretary. The arrival of the fourth faculty member this coming

summer will leave us short of office space. Our total space requirements for the Department we are aiming at are as follows:

<b>Function</b>	<b>number</b>	<b>square feet</b>	<b>total sq ft</b>
<u>Offices</u>			
Faculty offices	4	150	600
Chair office	1	200	200
Visitor's office	1	150	150
Secretary (and office eqpt.)	1	120	120
Senior student offices	1	220	220
<u>Teaching laboratories</u>			
Teaching lab (large) (w/ computer facilities)	2	1000	2000
Teaching lab (small)	2	500	1000
<u>Instrument/Teaching laboratories</u>			
Rock/Sample preparation	1	500	500
Clean Room Chemistry lab	1	600	600
ICP-MS	1	400	400
High pressure	1	500	500
Fission Track Lab	1	500	500
Paleontology prep	1	500	500
Research Microscope room (w/ fluid inclusion stage)	1	250	250
Seismograph room	1	100	100
<u>Support facilities</u>			
Shop (with office for tech)	1	500	500
Field equipment storage and staging	1	500	500
Map room	1	400	400
Collection storage/display	1	2000	<u>2000</u>
<b><u>TOTAL</u></b>			<b>11040</b>

The total space projected (11040) compared to space currently used (ca. 4400) indicates that substantial new space additions are necessary for the envisioned Geology Department. Two years ago the science and engineering Departments reviewed the space available for teaching and research, Department by Department. One conclusion of this effort was the confirmation that there was a substantial need for new space to house the present Geology Department. A proposal to a private foundation for a new building was recently rejected, and efforts are currently underway to find a source for building funds. External funding appears to be the only option available to the college.

## Appendices

### **Appendix I. Bulletin Copy - Geology Department**

#### **Department of Geology**

#### **Professor Shaw (Chair); Associate Professor Hollocher; Assistant Professors Garver and Rodbell**

**Requirements for the Major:** Nine courses in the department including Geology 10, 11, 21, 31, 32, 41, and at least one other geology course. In addition, students are required to take two terms of 195-198 courses.

Also required are two terms each of mathematics, chemistry, and biology or physics. Majors are strongly encouraged to take at least two courses beyond the introductory level in at least one related subject: chemistry, physics, biology, mathematics, or engineering. A summer field course or its equivalent is strongly recommended.

**Requirements for Interdepartmental Majors:** Students taking geology as part of an 8-6 or 8-4-4 interdepartmental major program in which the eight courses are in geology will take the seven required geology courses listed above, plus any other geology course. Students in an interdepartmental 8-6 or 8-4-4 program in which either four or six courses are in geology should take Geology 10 plus any other three or five geology courses, respectively.

Normally at least six science courses in mathematics, the sciences, and engineering will also be taken. These other courses and courses in geology should be chosen in consultation with a geology advisor as part of a coherent plan of study and integrated with subjects taken in the other departments of the interdepartmental major.

**Requirements for Minor:** A minor in geology requires 6 courses including Geology 10 or 50, 11, 31 and any three electives.

**Requirements for Secondary School Certification:** Students must complete Psy 50, Soc 52, EdS 10, EdS 20, Psy 240, EdS 214, EdS 180, and EdS 190. Requirements for the geology major who seeks certification in earth science are nine courses in the department including Geology 10, 11, 21, 22, 31, 32, 41, and two other courses. Also required are two terms each in mathematics, chemistry, and biology, or physics; astronomy (Physics 44 or 120); and meteorology and oceanography, as available. Additional courses highly recommended include History 84, 85, or 86; Philosophy 70 and 71; and Sociology 129. All science majors are encouraged to seek certification in more than one science and/or in General Science. Students wishing to add certification in General Science must include at least two courses each from the areas of biology (Biology 16 and 18), chemistry (Chemistry 10 and 12), and physics (Physics 11, 13, or 50).

Geology interdepartmental majors seeking secondary school certification must choose all departments from among the Departments of Biology, Chemistry, Geology, and Physics. Interdepartmental majors completing an 8-6 or an 8-4-4 interdepartmental program in which the eight courses are in geology would take Geology 10, 11, 21, 22, 31, 32, 41, and at least one

additional course in geology (meteorology and oceanography are recommended, when available). Students having geology as the minor element in their interdepartmental major of either six or four geology courses would include at least Geology 10, 11, and 22.

**10. Physical Geology** (Fall; Spring; Staff). Current understanding of the earth's composition, internal structure, age, the processes that affect the earth's interior and surface, and an examination of the evidence. Topics include continental drift, volcanoes, geologic hazards, earthquakes, magnetic field reversals, groundwater, the formation of rocks, and many others. Weekly lab.

**11. The Earth and Life Through Time** (Winter; Garver). The earth's dynamic history and evolutionary changes for the last 4.5 billion years. Includes the geologic evidence for major mountain building events that have affected the continents and the relationship of these tectonic events to the fundamental evolutionary changes in plant and animal life as recorded in the geologic record. Weekly lab.

**15. Geology of National Parks** (Spring; Shaw) (Not offered 1993-94). Basic principles of geology as demonstrated in the rocks of a number of U.S. National parks. Topics include igneous, sedimentary and metamorphic rocks, volcanism, glaciation, erosion, mountain building, and understanding geologic time and geologic history. Five laboratory sessions will involve interpretation and use of geologic and topographic maps to understand geologic process and their affect on landscapes.

**21. Stratigraphy and Depositional Environments of Eastern New York** (Fall; Garver). Tectonic events revealed through the stratigraphy and inferred depositional environments of the Lower Paleozoic sequences in Eastern New York. Stratigraphic and sedimentologic concepts are explored through weekly field studies and comparison to modern depositional systems. Weekly lab. WAC: W3

**22. Evolution of Landscapes** (Not offered 1993-94). Evolution of the shape of the earth's surface, the origin of landscapes as related underlying structure, climate, and other processes affecting landform development. Weekly lab.

**31. Mineralogy** (Winter; Hollocher). External and internal crystal symmetry, crystal chemistry and crystal optics; identification of minerals by physical, chemical, optical, and x-ray diffraction techniques. Weekly lab. Prerequisite: Chemistry 10.

**32. Petrology** (Spring; Hollocher). The origin of igneous, sedimentary, and metamorphic rocks: how processes of melting, crystallization, weathering, sedimentation, heat, pressure, and strain create minerals and rocks. Examination of rock thin sections using a polarizing microscope; interpretation of rock textures, mineralogy, and chemistry, as evidence of rock history and geologic processes. Prerequisite: Geology 31. Weekly lab.

**35. Carbonate Sedimentology** (Fall; offered even numbered years; Garver). The examination of carbonate rocks, carbonate depositional environments, and diagenesis. Lectures, petrographic analysis and field studies focus on the physical processes and sediment constituents in different settings as represented in both outcrop and in modern environments. Examples of modern and

ancient coral reefs, lagoons, tidal inlets, beaches, hypersaline lakes and tidal flats are examined locally and on one extended (14 day) field trip (required). Prerequisites: Geology 10,11, 21; or Biology 16, 18, and 51, 52 or 56; and permission of instructor. WAC:Wl

**41. Structural Geology** (Spring; Garver). The geometry, kinematics, and dynamics of deformed rocks; detailed description and kinematic analysis of several field sites. Topics include stress and strain, folding, faulting, cleavage formation, map interpretation, and the relationship between plate tectonic settings and crustal structure. Prerequisite: Geology 10 and 32. Weekly lab. WAC: W3

**42. Tectonics** (Winter; Staff). The dynamics of plate boundaries, and plate motions; examination of the locations and origin of earthquakes and volcanoes; evolution of the ocean basins and continents with time. Prerequisite: Geology 10 and permission of instructor.

**50. Environmental Geology** (Fall; Staff). The effects of internal and External processes, geologic hazards and resource development on our environment.

**130. Geochemistry** (Winter; Staff) (Not offered 1993-94). The earth as a chemical system; origin of the elements, meteorite age and composition, formation and differentiation of the earth, igneous processes, stable and radioactive isotope systems, geochemistry of near-surface waters and ore solutions. Course will involve theory, chemical analysis of geological materials, and computer modeling of the analyzed geochemical system using the acquired data. Prerequisite: Chemistry 10 and 12 or equivalent. Offered alternate years. WAC: W3\*

**150. Field Geology** (Summer, Fall, Spring; Staff). Study of the geology of a selected area will be followed by a field trip to the area to examine the important geologic features. Areas will vary from year to year and will include the Grand Canyon, Colorado Plateau, southern Appalachians, Canadian mineral districts, Cascade volcanoes, glaciated Rocky Mountains, and others. Additional costs associated with field trip expenses. Permission of instructor.

**160. Introduction to Geophysics** (Fall; Shaw). Gravity and magnetic fields of the earth; gravity and magnetic anomalies; magnetic properties of rocks and paleomagnetism; earthquakes and seismology; internal structure of the earth; precession, density distribution, and earth models; sound propagation in rocks; seismic reflection and refraction; geophysical field methods, data processing, and interpretation; electrical methods; radioactivity, heat flow, and thermal history of the earth; global dynamics and plate tectonics; planetology. Weekly lab and field exercises. Offered alternate years. Prerequisite: Physics 11.

**170. Groundwater Geology and Hydrology** (Spring; Staff). Principles of groundwater geology. Lecture topics include discussion of groundwater in confined and unconfined aquifers, karst/carbonate systems, and fractured bedrock systems. Class project will utilize numerous field and laboratory methods. Lab will include site visits and case studies. Local field trips. Prerequisites: Physical or Environmental Geology, Introductory Chemistry, Introductory Physics, or permission of the instructor. Basic familiarity with IBM and /or Macintosh computers is recommended.

**190-193. Independent Study in Geology** (Fall, Winter, Spring, Summer; Staff). A program of independent study in a particular area of geology under the supervision of a faculty member. Prerequisite: Permission of the instructor.

**195-198. Research in Geology** (Fall, Winter, Spring, Summer; Staff). Geological research under the direction of a faculty member. Prerequisites: Junior standing and the permission of the department chair.

## Appendix II. History of Geology at Union College

Geology began at Union in 1809 when Thomas Brownell was hired to teach a course in mineralogy. At that time mineralogy was closely allied to chemistry, which was also under his purview. Much of the search for new chemical elements at that time was focused on exotic minerals of unusual composition. Brownell was dispatched to Europe to study and to purchase specimens, instructional aids, and apparatus for teaching the new courses. During the following ten years he added to the mineral collection through his own efforts in the field and donations from alumni and others. When he left to become Bishop of Connecticut the collection, for which he had maintained a partial catalogue, numbered about 2000 specimens.

Joel Nott, one of Eliphalet's sons, was added to the faculty about 1820. He took over teaching mineralogy and chemistry upon Brownell's departure. His close association with geology is evidenced by his inclusion in an expedition to the Michigan Territory in 1821.

The records concerning geological instruction are sparse during the late 1820's and early '30's. Joel Nott seems to have left the college during that time. His brother, John Nott, may have been involved in teaching geological subjects as one of the faculty in Natural Philosophy, but this cannot readily be determined. Geology during the nineteenth century was typically included in the broader field of natural history and at Union College the professor of natural history normally would teach botany, zoology, and geological subjects. Mineralogy, however, was taught by a chemist, at least until the latter part of the century.

In 1834 Benjamin F. Joslin is listed as a professor of natural philosophy, a position he held until at least 1838, but he appears to have been mostly, if not exclusively concerned with biological instruction. Mineralogy was almost certainly taught in 1833-36 by Chester Averill, an adjunct professor of chemistry and languages, and he was apparently replaced in 1836 by Edward Savage, an assistant professor of languages and chemistry.

Chester Averill died of tuberculosis in 1836, leaving a wife and infant son, Chester, Jr. The younger Averill completed a degree at Union in 1857. He subsequently became a member of the first Geological Survey of California, headed by Josiah Whitney (after whom Mt. Whitney was named). Whitney clearly had an association with Union College, as curator of the college mineral collection, and as an advisor to Eliphalet Nott concerning Nott's investment in the Bristol Mines in Connecticut. That venture was a financial disaster, but apparently not to the detriment of Whitney's relationship with Nott, for Eliphalet wrote an enthusiastic letter supporting Whitney's candidacy for the directorship of the California Geological Survey.

Edward Savage, of whom little record remains, left the college in 1839, to be replaced by Jonathan Pearson, as assistant professor of natural philosophy and chemistry. Pearson is well known for the diary he kept through most of his considerable time at the college, but he was also of great importance as the curator of the college museum, including the mineral collection.

Starting around 1840 geology became a part of the curricular offering, along with mineralogy, and separate textbooks were used for geology and mineralogy. The advent of a curriculum in engineering in 1845 added a strong practical element, to which geology no doubt contributed through study of ore minerals, mining and metallurgy. In the college catalogue of 1852 a Botany

and Mineralogy Department is mentioned for the first time, likely a reflection of Pearson's main interests. The curriculum and structure of the college was apparently quite fluid throughout most of the latter half of the century, with course offerings and Departmental designations appearing and disappearing from year to year. However, mineralogy remained an important part of the Science Course, as reflected in descriptions of Analytical Chemistry from the college bulletin: "When [the student] has in this manner acquired sufficient confidence in his skill, he can proceed to the actual Analysis of Minerals, Soils, Manures, (etc.)" and "Mineralogists will have access to the College [mineral] Cabinet, and can also take a full course with the blowpipe, and in Qualitative and Quantitative Analysis."

In 1858, the Wheatley Collection was purchased by Edward Delavan and donated to the college. This important collection has been the core of the Departmental collections (described elsewhere) ever since. The close connection between chemistry and mineralogy continued with the addition of the Wheatley collection, and Charles Chandler (appointed to the faculty in 1857 as an assistant prof. of analytical chemistry) became curator of the museum. In 1865 Maurice Perkins took over from Chandler, including duties as museum curator.

Harrison Webster ('62) joined the faculty as a tutor in Natural History in 1868, and soon advanced to a regular faculty position. His responsibility for geology is evidenced by his later assumption of a professorship of geology and natural history at the University of Rochester. Webster was a major actor in the faculty movement opposing President Potter during this time and he left the college for Rochester in 1883. His replacement was another alumnus, James Stoller ('84), first as a tutor then as a professor. Stoller's duties increased with the retirement of Jonathon Pearson in 1885. Webster returned to the College as its president in 1888 (the first non-clergy to hold that position) and he again taught in the Department of biology and geology.

The first full-fledged geologist at Union College was added to the faculty in 1894 in the person of Charles S. Prosser, who as acting Professor of Geology was responsible for the Department of Geology and Paleontology. At this point there was a fairly complete curriculum in geology: Geology, Historical Geology, Paleontology, Economic Geology, Areal Geology, Field Geology, and Mineralogy and Lithology. The Wheatley Collection had become part of the Geology Department in 1890, and during his brief stay at the college (until 1899), Prosser put considerable effort into rehabilitating and adding to the collection, especially with paleontologic specimens. Prosser's ambitions for a strong Geology Department appear to have initially received some support from the trustees and administration of the college, but apparently not to his satisfaction. He left for Ohio State where he soon became chair of the Geology Department.

Stoller resumed responsibility for geology and curation of the collections when Prosser left. Stoller, although primarily trained as a biologist, carried out some very significant early work on the surficial and glacial geology of the Mohawk-Hudson region. Stoller's divided responsibilities led to a reduction in course offerings in geology for the next 20 years, but geology continued as part of the Department of biology and geology.

The importance of fieldwork to a geological education had been recognized at least as early as 1889, and during Stoller's years reached a point where an honors course in glacial geology required at least 60 hours of fieldwork, and in 1916-17 an honors course in field geology required at least 120 hours of fieldwork and a detailed report on an assigned area.

The mineral collections continued to be an important educational asset, and were curated by a volunteer, Dr. D.S. Martin from 1908-1917. The developments of X-ray crystallographic methods, beginning with the Bragg's in 1912, reached Union College in 1919, when a series of special lectures in crystallography and x-rays was taught by Albert W. Hull and Wheeler P. Davy.

As Stoller neared retirement, the need for a successor led to the hiring of Edward Staples Cousins Smith (known to the students by various nicknames, e.g. alphabet Smith). Smith was the Geology Department for thirty-five years, from the retirement of Stoller in 1925 until 1960. During that interval the Department can be characterized as a successful, smoothly functioning entity which produced many fine geologists, who left the college with considerable pride in their Department. The Department structure had finally become formalized about 1920, with courses regularly listed by Department from that time to the present. The Geology Department, however, did not participate in the growth of many of the other Departments during that interval, being comprised of Smith and a young visiting lecturer for much of that time. During the thirties the Department offered a master's degree, and the lecturer was often a graduate student working on his degree, or a recent graduate of the Department.

As Smith in his turn neared retirement, a new assistant professor was hired in 1957. Philip Hewitt took over the Department in 1960, and Leo Hall was hired as a second full time geologist in 1961, expanding the Department to two regular faculty for the first time. Through much of the 1960's these two gradually increased the offerings in geology. The increased interest in geology (partly from increased employment opportunities) coupled with generally increasing enrollments in higher education at that time, encouraged Hewitt and Hall to ask for further increase in the faculty in the Department. This was bolstered by the report of an external examining committee chaired by John Moss, a member of the Geology Department at Franklin and Marshall College. The need for an additional faculty member was apparent to the visiting committee, as was a restructuring of the course offerings in geology. On the basis of the small number of geology majors (averaging five for the decade from '55-'65), and declining enrollments in introductory geology due to changes in curricular requirements, the administration refused to increase the size of the Department. While this decision is thought by some to have been made by the Board of Trustees, there is little or no evidence that they seriously considered the issue, rather that it was an administration decision. Faced with continuation of what they perceived as inadequate support for Geology, Hewitt and Hall resigned in 1967. Courses were taught to remaining geology majors through an arrangement with RPI until 1971. The Geology Department was allowed to "run down" as the majors departed and no new majors were added to the program.

With the demise of the geology major, there remained an interest in having geology courses taught as part of the general education of Union students, but no investment in a full-fledged Department was considered. In 1971 Herman Zimmerman, a marine geologist, was hired to teach introductory level courses in geology and oceanography. For the next 13 years his success was measured, in part, by the number of students who left Union to seek a major in geology at other institutions. Zimmerman was officially a part of the Department of civil engineering, the closest entity available to accommodate a geologist. The "Geology Department" was moved into the second floor of Butterfield Hall when the Civil Engineering Department was moved into the first and third floors, following the construction of the Science and Engineering complex.

During the late '70's and early '80's an effort was made to reestablish a Geology Department and major at the college. This effort was led by Frank Grigg's, the chairman of the civil engineering Department. A group of geology alumni also discussed the possibility of a restart of geology. This movement finally bore fruit through the singular contribution of John S. Wold, a geology major of the class of 1938. In 1984 Wold conferred a substantial endowment upon the college with the understanding that it be used for a chair in geology and for re-establishment of a Geology Department at the college. Interestingly, the report of this gift in college newspaper is rather ambiguous about the purpose of the gift, seemingly a reflection of the ambiguity felt by the administration regarding a restart of geology.

Although one might assume that this backing would result in a rapid renewal of geology, such was not to be the case. The college, during deliberations concerning the possibility of restarting geology, requested advice from an external committee. The committee recommendations, perhaps on the basis of their understanding of what the college considered possible for geology, made what can be best described as "minimal" recommendations. In particular little consideration was given to the needs of a new, modern Geology Department in terms of equipment and space. Even the recommendation of a minimum of three full-time faculty was just that, a bare minimum rather than an estimate of the optimal size. It is clear that the college began the renewal of geology with a substantial underestimate of the costs involved for a quality program. Since the administration was concerned (and so stated) that the new Department should be a quality addition to Union, the new Department was placed in a resource squeeze, especially regarding space. Much of this was simply a lack of appreciation of what a Geology Department really needs for facilities. Indeed, this is a problem extending well back into the Department's history. In the late 1890's Charles Prosser clearly had some difficulty in making his needs known to the administration, and certainly Hewitt and Hall likewise.

The Geology Department was officially re-established in 1985, in conjunction with hiring a new assistant professor, Kurt Hollocher. The new Department was allocated three full time faculty lines and Hollocher was the second, joining Zimmerman, who chaired the new Department. The Department began the process of hiring a third faculty member, but the process was interrupted by Zimmerman's announcement of his intention to resign to take a position with the National Science Foundation. A decision was made to hire a visiting assistant professor to temporarily fill the third position while a search was begun for a new Department chair. Paul Ryberg joined the Department in the fall of 1986 as a visiting professor and the search for a new chair proceeded. The search took two years and ended with the appointment of George Shaw as the John and Jane Wold Professor of Geology and chair of the Geology Department in the fall of 1988. During the 1988-89 academic year the Department hired John Garver as the permanent third faculty member, completing the complement of faculty envisioned for the rebirth of geology at Union. Also during that interval the Department added more than a quarter of a million dollars in new equipment to start it on a path to being one of the best equipped undergraduate Geology Departments in the country. In addition, the first batch of new geology majors began a trend of increasing numbers of majors. Indeed, this history must end just at the point where the Geology Department begins its new life in earnest, perhaps to achieve the promise first envisioned by Charles Prosser.

### Appendix III. Departmental Equipment

EQUIPMENT	VENDOR	AGE (YRS)	REPLACEMENT COST
Scanning electron microscope with energy dispersive analyzer, shared with Engineering, housed in ME Department	A.R.L.	2	130,000
X-ray diffractometer	Philips	3	57,000
Inductively coupled plasma quadrupole mass spectrometer	VG Elemental	2	203,000
Laser Ablation system for ICP-MS	Continuum	1	55,000
12-Channel digital floating point seismic system	Bison	3	30,000
Switch unit for seismic system	Bison	3	3,500
Cable and geophones	Mark products	1,3	5,000
Gravimeter	LaCoste-Romberg	1	25,500
Cathodoluminescence stage	Nuclide	3	11,000
Diode Array spectrometer	Oriel	1	10,000
Proton precession magnetometer EG&G	Geometrics	2	5,000
Field Resistivity Bridge	Bison	1	11,000
Flux-gate magnetometer	Scintrex	1	3,000

#### *High Pressure Laboratory*

Birch-Bridgeman Press with control panel	Harwood	20	88,000
200-T Hydraulic press	Homemade	ca. 30	20,000
Pressure vessel (150,000 PSI, 2" x 9")	Harwood	15	22,000
Pressure vessel (200,000 PSI, 1" x 6")	Harwood	15	2,000
Pressure vessel (35 Kb, 1/2" x 2")	Homemade	15	2,000
Pressure intensifiers (100 KPSI and 200KPSI)	Harwood	15	5,000
Pressure gauges	Heise	5-10	4,000
Manganin cell gauges	Harwood	10	2,500
Misc. valves and fittings	various	var.	2,500
Pulse modulator and receiver w/ plug-in	MATEC	15	8,000
200 MHZ oscilloscope	Tektronix	15	4,000
Misc. electronics (freq. counter, signal generator, digital meters, etc.)	various	15	2,000

#### *Rock sample preparation laboratory*

Thin section trim saw	Ingram	25	5,000
Thin section grinder	Ingram	25	10,000
8" diamond trim saw	Hillquist	3	1,000
24" diamond saw	Hillquist	3	2,500
Shatterbox rock crusher	Rocklabs	1	10,000
Ro-tap sieve shaker	Humboldt	25	1,000

***Fission-track lab***

Magnetic separator	Frantz	25	3,000
Jaw crusher	Denver Fire Clay	25	1,000
Gemini gold table Table	Min. Resources	2	3,500
Polishing machine with diamond laps	Eberbach	25	2,000
Research petrographic microscope	Olympus	1,4	8,000
Research petrographic microscope (transmitted light)	Olympus	1,4	8,000
Stereo zoom research microscope	Olympus	4	3,000
Point count stage	Swift	2	3,500
Automated stage	Kenetek	1	14,000

***Microscopes***

Research petrographic microscopes (3) transmitted (2) and reflected light (1)	Olympus	1,4	22,000
Stereo zoom research microscope (2)	Olympus	1	6,000
Auto-exposure photomicrograph system	Olympus	3	2,000
Student petrographic microscopes (7)	Olympus	1-4	21,000
Student stereomicroscopes (6)	AO	ca. 20	6,000
Refractometer	Bausch and Lomb	25	3,000
Index oils	Cargille	3	1,500
Differential thermal analyzer	Eberbach	25	2,500

***Miscellaneous field and laboratory equipment***

Brunton compasses (7)	Brunton	var.	1,000
Aneroid altimeters(6)	various	var.	1,000
Videotape recorder/monitor, etc.	Toshiba/Sylvania	3	1,000
Videocamera for microscopy	Javeline	3	1,500
Semimicro balance	Mettler	15	2,500
Semimicro balance	Ohaus	3	650
Top loading balance	Ohaus	3	350
Water deionizer	Barnstead	3	2,500
Centrifuge	Sorval	10	7,000
Drying oven(2)	Fisher	1,3	2,000
High temperature furnace	Lindberg	10	1,000
Labware, etc.	various	var	5,000
High purity chem. and isotopic standards	various	1-3	2,000
Stream table	homemade	new	<u>1,000</u>

TOTAL 869,100

***Computer equipment***

IBM PS/2 model 50 (w/ color monitor and printer)	IBM	4	6,000
IBM AT clone (with printer and color monitor)	VTI	3	2,500

IBM 50Mhz-486 clone	Danjen	1	3,600
IBM 16Mhz-386 clone	Danjen	1	2,500
IBM 33Mhz-486	Danjen	1	3,400
IBM RISC 350	IBM	2	22,500
Macintosh Quadra 840w	Apple	2	7,000
Macintosh II (w/ color monitor and printer)	Apple	3	6,000
Macintosh Iix (w/ color monitor and printer)	Apple	2	7,500
Macintosh SE (w/ printer)	Apple	2	2,500
Macintosh SE (w/ printer)	Apple	2	2,500
Laser printer	Apple	2	3,000
Macintosh Iici (5)	Apple	1	22,000
Scanner	Apple	3	1,500
7475A Pen Plotter	Hewlett-Packard	4	1,000
Digitizer	Summagraphics	2	350
Software	Various	var	<u>10,000</u>
TOTAL			103,850

## **Appendix IV. Wheatley and Pfordte Mineral Collections**

The mineral collection in the Geology Department at Union College has been growing since 1809 when mineralogy was first taught. Thomas Brownell began the collection with purchases he made in Europe on behalf of the college. He collected additional specimens during his ten years at Union, and on his departure in 1820 left a catalogue of nearly 1000 samples, and perhaps an additional 1000 uncatalogued samples. Mineral samples from Mt. Vesuvius were added through the efforts of an alumnus traveling in Europe in the 1820's, and a local collector of carbonate cave deposits contributed a number of specimens in the early 1840's. The Wheatley Collection, which is the core of the current collection was donated to the college in 1858.

Edward C. Delavan, a trustee of the college and a close associate of Eliphalet Nott in the temperance movement, bought the collection from Charles Wheatley for the sum of \$10,000. Wheatley was a mine owner and operator at the Bristol Mine in Connecticut and the Wheatley Mine near Phoenixville, Pennsylvania. He was an avid mineral and shell collector. He preserved exceptional specimens from his own mines and from other important mineral localities throughout the world. At the time he sold the collection to Delavan it numbered approximately 6000-7000 specimens, with numerous duplicates, and was considered to be one of the finest private collections in the country. During the next several years many of the duplicate specimens were traded or sold in order to improve the breadth of the collection. At the present time 3000-4000 of the original Wheatley specimens remain at Union. A large proportion of these are quite rare since the deposits from which they were obtained have been mined out for decades. In this sense the collection is priceless, it being virtually impossible to replace most of the specimens. The trust deed by which Delavan transferred the collection to the college specifies conditions for the care and treatment of the mineral specimens to insure their value in perpetuity. Unfortunately the college has not always carried out its responsibilities as delineated in the agreement, and the collection has periodically suffered neglect, and even losses.

In 1938, Otto Pfordte, a mineral collector living in Coxsackie, NY, left his collection to the college. Pfordte was a mining engineer, and this collection emphasizes ore minerals. There were originally about 3000-4000 specimens in the collection, many of which have been preserved as museum specimens, and many have been incorporated into the teaching collection for use in laboratory sessions.

In addition to these major gifts, through the years alumni and friends have made donations of minerals to the college collection. It is almost impossible to say how many specimens have been part of the mineral collections at one time or another, but it appears likely the number is more than 10,000. Recording of the specimens in the collection has been sporadic, usually in response to a major acquisition, as in the case of the Wheatley Collection (which was labeled and catalogued by Josiah Dwight Whitney, subsequently first director of the California Geological Survey), or because a new faculty member took special interest in the collection, as did Prosser when he arrived in 1894.

At the present time the collection is being entirely recatalogued in electronic format, complete with digital images of each specimen. Not only will this provide easier access to information about individual specimens, but it will provide an extra measure of security. The importance of this latter consideration received emphasis in the mid-1970's when a major theft resulted in the

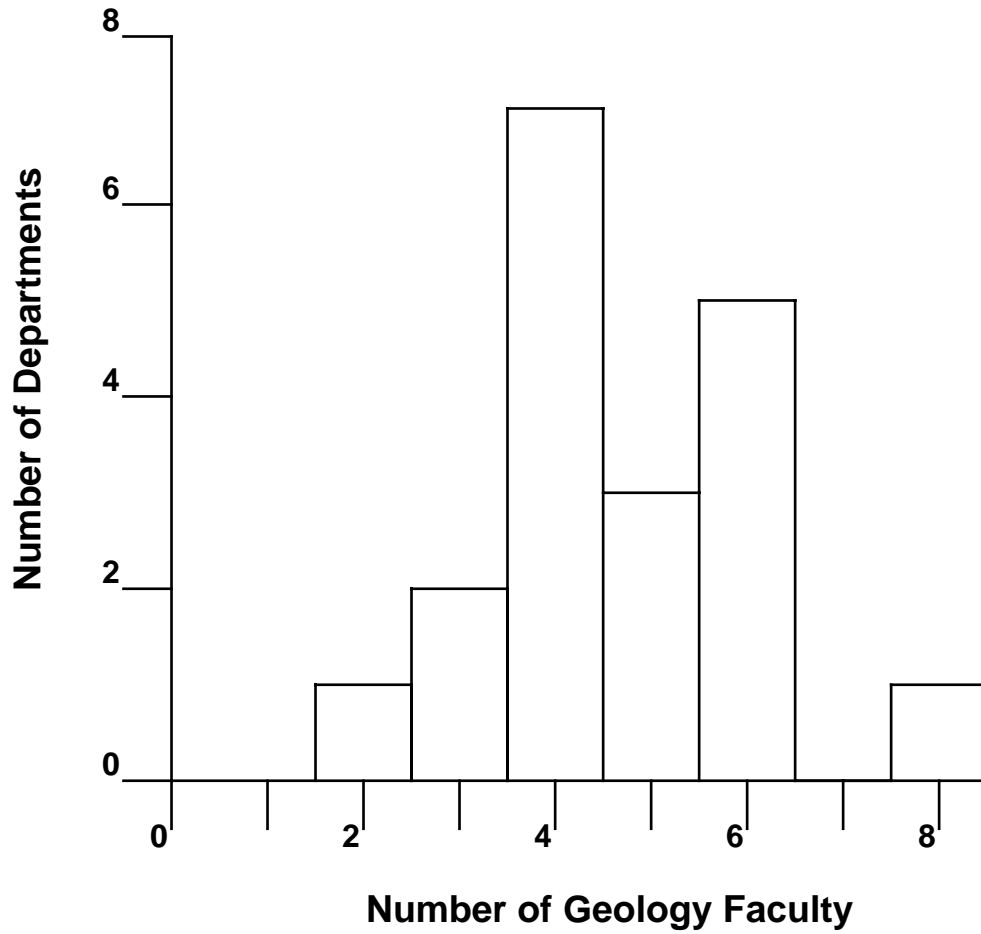
loss of about 100 fine specimens. The loss has been estimated at about \$100,000, and even described as having destroyed the collection. Thankfully, although too many valuable and beautiful samples were lost, the collection, and especially the rarer pieces, remains essentially intact.

Very little of this collection is now on display in the Geology Department. The more valuable specimens have been placed in secure storage since we cannot provide safe display conditions. With the renewal of geology at Union, we hope one day to have suitable display space so this fine collection may be viewed by the public once again.

## Appendix V. Geology Department Space

<u>Room/Function</u>	<u>Square feet</u>
Teaching laboratory, BU 201	704
Sedimentology / geochemistry lab, BU 200	704
Petrology lab, BU 202	382
Offices, BU 203 (two faculty, office machines, drafting, etc.)	440
Chair's Office, BU 203A	187
Under the Alps, (BU 204)	689
High pressure lab, Eng. Lab.	ca. 400
Behind BU 202	ca. 150
Steinmetz basement storage	<u>ca. 750</u>
TOTAL	4406

**Appendix VI. Comparison of Geology Department sizes.**



**Appendix VII a-d. Faculty Résumés**

The following pages are the résumés of the faculty in the Geology Department of Union College.