2006 Laboratory Projects

Three projects were assigned in the Spring 2006 Sedimentology course at Plattsburgh State University;

- Pebble shape in gravel from six Champlain Valley rivers
- Textural analysis of Late Pleistocene proglacial lacustrine and marine deposits
- Sedimentology and stratigraphy of the basal member of the Potsdam Sandstone.

General Project Format

Long-term project-based exercises vary in length and content depending upon learning goals, available resources, methodology and scheduling (e.g. beginning or end of course, available class time or time of year).

Each project begins with an introduction in which a geological question is posed and students are presented with background information, published reference material and guidelines for effective scientific writing. The introductory presentations are followed by a group discussion to formulate the hypothesis(es) to be tested and the determine experimental design, with due consideration to the constraints listed above. It is important that students understand their individual responsibilities and the over-arching purpose and objectives of the study.

In the following weeks, students are provided with the materials and methods they need to conduct the research. Students collect and process their own data whenever possible. Preferably this phase involves field description and collection of samples for later lab analysis but previously collected sediment or rock cores or samples may also be used. The analysis is a class project with each student or student team contributing a component to a larger class-wide database. Workload expectations must be clearly defined and students must conform to a tight timeframe during the analysis portion of the exercise so that the final database is complete and available on schedule. Interim deadlines for data components generally help students stay on schedule during this phase.

Data synthesis and final report preparation are individual efforts. Students are encouraged to be creative in the interpretation and presentation of their results but are warned not to draw conclusions that cannot be supported by their data. Students are expected to discuss how their findings compare, either positively or negatively, with previously published work.

Project 1. Pebble shape in gravel from six Champlain Valley rivers.

This project is designed to introduce the evolution and measurement of particle shape in coarse clastic sediment. The concepts are relatively straightforward and few prerequisite skills needed for students to begin the analysis, making it a good introductory exercise. The short duration of the project allows students to complete all aspects of the study and receive feedback on their performance at an early point in the semester.

Hypothesis:

Particle shape in stream gravel from six Champlain Valley rivers is primarily a function of lithology rather than transport medium.

Concepts/Skills:

1. Particle shape measurement
2. Geological controls on particle shape
3. Sampling and sub-sampling strategies
4. Graphical and statistical treatment of shape data
5. Regional geology and geomorphology

Project Schedule and Methods

Week 1: Introduction and Data Collection

Samples of gravel from six Champlain Valley rivers (three each in New York and Vermont) were collected in 5-gallon buckets prior to the laboratory. Students were given regional geology maps and a map of drainage basins in the Champlain Valley showing sample locations.

Students were grouped in teams of two or three and each group was assigned one or two samples of stream pebbles. A sub-sample of 50 to 100 coarse pebbles (16mm to 64mm or -4ϕ to -6ϕ) was collected from each river sample. Each pebble was assigned a reference number and its long, intermediate and short dimensions were measured with a vernier caliper and recorded in a spreadsheet. Pebble lithology was also noted. The particle-dimension ratios for the Zingg diagram; i.e. short:intermediate (S/I) and intermediate:long (I/L); Krumbein (Wadell) Sphericity, Sneed and Folk Sphericity and Cailleux Flatness Index were calculated for each pebble. Average ratios and shape indices were calculated for each whole river sample. Each group prepared an interim report that contained data tables and a Zingg diagrams showing the plots of individual pebbles and average particle-dimension ratios (with 1σ error bars) for each sample (grouped by river).

Week 2: Data Compilation

The results for individual laboratory groups were combined and the pebbles were grouped into four lithologic classes; 1. high-grade metamorphic or plutonic igneous, 2. low-grade metamorphic, 3. clastic sedimentary and 4. carbonate. The average particle-dimension ratios and shape indices were determined for each lithologic class. Zingg diagrams showing particle-dimension ratio averages (with1σ error bars) grouped by lithology were used to graphically represent the shape data. These averages were compared to the averages for each river data were used to compare shape indices to construct. Data compilation was followed by a cohort discussion of the significance and limitations of the data and the most effective ways to present the results in the final report.

Selected References (Project 1):

Barock, E. J., 1974, Coarse sediment morphometry: A comparative study: Journal of Sedimentary Petrology, V.44, pp.663-72.

Barrett, P. J., 1980, The shape of rock particles, a critical review: Sedimentology, V.27, pp.291-303.

Kondolf, G.M., 1997, Application of the pebble count. Notes on purpose, method and value: Journal of the American Water Resources Association, V.33, No.1, pp.79-87.

Lewis, D.W., and McConchie, D.M., 1994, Analytical Sedimentology: Chapman and Hall, New York, 197p.

Sneed, E. D., and R. L. Folk, 1958, Pebbles in the lower Colorado River, Texas, a study in particle morphogenesis: Journal of Geology, V.66, pp.114-50.

Project 2. Textural analysis of Late Pleistocene proglacial lacustrine and marine deposits in the PSU-1 core.

In this 6-week exercise standard methods for particle size and stratigraphic analyses are applied to the Late Pleistocene sediment record in the Champlain Valley. The PSU core was obtained from vibracoring operations in 2004 as part of on-going study of late glacial history and paleoclimate in the region involving colleagues from the US Geological Survey Binghamton University and Plattsburgh State University. Although I was fortunate to have the core for student use in 2006, I have offered similar projects in previous years using samples collected from field exposures or lake sediments sampled using a home-made vibracore.

Hypothesis:

Deglacial events and changing sedimentary environments are recorded in the textural composition of Late Pleistocene proglacial lacustrine and marine deposits in the Champlain Valley.

Concepts/Skills:

1. Measured sections and stratigraphic columns
2. Sampling and sub-sampling strategies
3. Particle-size analysis (sieve and hydrometer methods)
4. Graphical and statistical treatment of particle-size data
5. Regional geology and geomorphology

Project Schedule and Methods:

Week 1: Introduction, Measured Sections and Stratigraphic Columns

A presentation on the late glacial history of the Champlain Valley and northeastern Adirondack Mountain region was presented in lecture prior to the first laboratory session. The presentation included a discussion of purpose and objectives of the 2004 coring effort and the methods by which the cores were collected.

The core PSU-1 was collected during the summer 2004 and placed in refrigerated storage prior to the analysis. Procedures for measuring stratigraphic sections and constructing stratigraphic columns were introduced at the beginning of the first laboratory session. The core was the opened in the laboratory and each student took a turn describing a portion of the core and collecting samples for later analysis. Each student was responsible for obtaining a complete description of the core and a record of sample locations. A stratigraphic column of the core was due from each student the following week.

Weeks 2-5: Textural Analyses

Students collected a sample of glacial-marine sand and at least one glacial lacustrine or glacial marine mud for textural analyses. Standard methods for particle-size analysis (sieve and hydrometer methods) and the graphical and statistical analysis of particle size were introduced. Sieve analysis was introduced first (Week 2) because it is a relatively simple procedure and students can get started on their sand samples right away. Students determined the moments of the particle size distribution using both the Method

of Moments and the graphical method of Folk and Ward (1957), and calculated the percentages of gravel, sand and fines in their sample(s). A brief interim report their results, including statistical analyses, was due by Week 3. Textural analysis of mud, which involved wet-sieving and combined sieve and hydrometer analyses, was introduced in Week 3. Students worked on their mud analyses in Weeks 3 to 5 and submitted an interim report of their results by Week 6.

Week 6: Data Compilation

The summarized results of textural analyses for all samples were compiled into a single database in Week 5. Data summaries included the depth of the sample in the core, the moments of the particle size distribution and the percentages of gravel, sand, silt or clay in each sample. These data were used to construct bi-plots of the textural indices or plots textural indices versus depth in the core to compare quantitative textural data to the sediment types described in the stratigraphic column earlier.

Selected References (Project 2):

Chapman, D.H., 1937, Late-glacial and postglacial history of the Champlain Valley: American Journal of Science, 5th Series, V.34, No.200, pp.89-124.

Denny, C.S., 1974, Pleistocene geology of the northeastern Adirondack region, New York: United States Geological Survey, Professional Paper 786, 50p.

Franzi, D.A., Rayburn, J.A., Yansa, C.H., and Knuepfer, P.L.K., 2002., Late glacial water bodies in the Champlain and St. Lawrence lowlands and their paleoclimatic implications: in New York State Geological Association/New England Intercollegiate Geological Conference Joint Annual Meeting Guidebook, pp. A5 1–23.

Pair, D.L., and Rodrigues, C.G., 1993, Late Quaternary deglaciation of the southwestern St. Lawrence Lowland, New York and Ontario: Geol. Soc. Amer. Bull., v.105, pp.1151-1164.

Rayburn, J.A., Knuepfer, P.L.K., and Franzi, D.A., 2005, A series of large, Late Wisconsinan meltwater floods through the Champlain and Hudson valleys, New York State, USA: Quaternary Science Reviews, V.24, pp.2410–2419.

Rodriguez, C.G., 1988, Late Quaternary invertebrate faunal associations and chronology of the western Champlain Sea basin: in Gadd, N.R., ed., Quaternary evolution of the Champlain Sea basin, Geol. Assoc. of Canada Spec. Paper 35, pp.155-176.

Project 3. Sedimentology and stratigraphy of the basal member of the Potsdam Sandstone.

Hypothesis:

Dolomitic sandstones and sandy dolostones in the northwestern Champlain Valley represent a transitional facies between Late Proterozoic metamorphic rocks and the arkosic conglomerates of the AuSable Member of the Potsdam Sandstone.

Concepts/Skills:

1. Measured sections and stratigraphic columns
2. Thin-section preparation techniques
3. Sandstone petrography and classification
4. Regional geology and geological history

Project Schedule and Methods:

Note: This project involved field descriptions of outcrops in the Champlain Valley and thus the schedule was changed due to weather conditions.

Week 1: Introduction and Thin-Section Preparation Methods

A presentation on the sedimentology, stratigraphy and tectonic setting of the Potsdam Sandstone was presented at the beginning of the laboratory session. The nature of the basal member, its stratigraphic significance and the purpose and objectives of the class study were discussed following the presentation.

The procedures for preparing thin-sections were introduced and each student was given a sample from one of the outcrops that would be visited in the following weeks. Several weeks were allotted for this step because thin-section preparation is a time-consuming and sometimes difficult process for novice students and access to the rock-preparation equipment was a time-limiting factor. Prepared thin sections were held in reserve for students who were unable to produce a useable thin section. Thin sections were due before the beginning of the petrography exercise in Week 5.

Weeks 2-4: Field Description of Outcrops

- Field Trip 1: The lower Potsdam Sandstone ("basal" and AuSable members)
- Field trip 2: The upper Potsdam Sandstone (Keeseville Member) and overlying Theresa Formation
- Field Trip 3: Trace fossils in the Potsdam Sandstone

Week 5-6: Sandstone Petrography and Final Report

Students prepared a one-page petrographic summary of their thin section to share with the class. The summaries included a labeled sketch of a representative microscope field, estimates of particle-size, sorting, and framework particle composition and descriptions of pore-filling material, sedimentary structures or fabric. Students who completed their petrographic analyses early were able to take photomicrographs of their thin sections. The classification of Williams, et al. (1984) was used to determine the rock name.

Selected References (Project 3):

Bjerstedt, T.W., and Erickson, J.M., 1989, Trace fossils and bioturbation in peritidal facies of the Potsdam-Theresa Formations (Cambrian-Ordovician), northwest Adirondacks: Palaios, V.4, pp.203-224.

Dix, G.R., Hersi, O.S., and Nowlan, G.S., 2004, The Potsdam-Beekmantown Group boundary, Nepean Formation type section (Ottawa, Ontario): A cryptic sequence boundary, not a conformable transition: Canadian Journal of Earth Sciences, V.41, pp.897-902.

Lewis, D.W., 1971, Qualitative petrographic interpretation of the Potsdam Sandstone (Cambrian), southwestern, Quebec: Canadian Journal of Earth Sciences, V.8, No.8, pp.853-882.

Otvos, E.G., Jr., 1965, Sedimentary structures and depositional environments, Potsdam Formation, Upper Cambrian: Bulletin of the American Association of Petroleum Geologists, V.50, No.1, pp.159-185.

Wiesnet, D.R., 1961, Composition, grain size, roundness and Sphericity of the Potsdam Sandstone (Cambrian) in northeastern New York: Journal of Sedimentary Petrology, V.31, No.1, pp.5-14.

Williams, H.F., Turner, F.J., and Gilbert, C.M., 1982, Petrography, an introduction to the study of rocks in thin section, 2nd Edition: W.H. Freeman and Company, San Francisco, 626p.