TEACHING MINERALOGY TO GEOLOGY STUDENTS

Recently, there has been an audible crescendo in the dialog about teaching among geologists. This increased interest in pedagogy can be found across academia and has a variety of causes. Each year new students come to college with experiences, skills, interests, and expectations that are different from those of previous students. Approaches to the classroom that used to work seem to be less effective with each new class. Teachers from the babyboom generation have taught long enough to be bored with the old ways and are confident enough as teachers to try new teaching strategies. Whatever the reasons, a growing number of mineralogy professors are talking about their courses and changing significantly how they teach mineralogy. The overall result of these changes is increased excitement about and enthusiasm for mineralogy by both faculty and students.

My personal involvement in these changes was focused by a workshop on teaching mineralogy held at Smith College last June that I organized with Jack Cheney, Dexter Perkins, and Peter Whelan. The workshop was funded in part by a grant from the National Science Foundation and was attended by 70 college mineralogy teachers. The 10-day workshop

Figure 1. Kase Klein and Peter Buseck evaluating the effect of montmorillonite chemistry on the permeability of a clay-sand mixture in Steve Guggenheim's demonstration lab.

included large and small group discussions of pedagogy, demonstration lab sessions with some participants as teachers, some as students, "test drives" of mineralogy software, and field trips to discuss teaching in the field. Based on participant comments, most of the group left the workshop with new views of mineralogy as a course (see The Lattice, v.12, No.3 at http://scribe.geol.lsu.edu/henry's/lattice.html). Workshop participants have been trying out new teaching strategies and testing specific lab exercises in their courses this year.

If there is a theme to the new activities and courses, it is that mineralogy students should be given opportunities to work with minerals, rather than be told about them. Collection and analysis of mineralogical data as part of course projects should be used to engage students and teach them the concepts and tools of mineralogy. While these are not in themselves new ideas, the real change is the degree to which our revised mineralogy courses are being organized around these activities. Furthermore, the activities are less structured, so that students determine more of the direction and design of their lab work than previously.

Good examples of new mineralogy activities can be found among those presented at our workshop. Stephen Guggenheim had students study the effects of cation-exchange on montmorillonite chemistry and properties by measuring the permeability of clay-sand mixtures.

Dave Mogk had students, in small groups, develop mineral classification schemes based on their observations of a set of mineral specimens, then trade, and test their classification schemes with other groups. Dexter Perkins had students attempt to synthesize various minerals using "off-the-shelf" chemicals and a box oven. (The "failures" are as instructive as the

successes!) Helen Lang and Sid Halsor had students identify asbestos-form minerals in an optics lab that focused on crystal structure and environmental issues. Barb Dutrow's students explored the mineralogy of household products as a means to apply x-ray diffraction and to consider industrial applications of minerals.

Figure 2. Andrew Wulff, Hobart King, Peter Heaney, and Adrea Koziol devising their own mineral classification in Dave Mogk's demonstration lab.

David Bailey had students measure the heat capacity of metals and single crystals of minerals with a simple drop-calorimetry experiment.

Change comes at a cost, and in this case, the price includes lost lecture time and, consequently, lost breadth of coverage of topics. In addition, faculty and/or teaching assistant time is increased. Nevertheless, I firmly believe that the results are worth the payment. In support of this contention, I offer evidence from my own mineralogy class this past fall. Early in this one-semester mineralogy course, I ask the students to choose a mineral sample from a field trip (or the collections) for detailed study. Their choices must be optically anisotropic and a member of a solid solution series. Rather than give them pre-tested samples in labs, they use each newly-learned technique to collect data on their chosen mineral. I don't know what the "correct" results are for their measurements, but they must demonstrate that their data are reasonable for a sample of the mineral being studied. This takes them to sources of mineralogical data with a goal that is more like that of a problem-solving geologist than that of a mineralogy student. They must come to grips with the variation of physical properties with chemical composition and show internal consistency from measurement to measurement. In many cases, they need to re-measure say refractive indices after obtaining a mineral formula from an EDS analysis or to reconcile the difference between their measured specific gravity and the theoretical density based on their measured unit cell dimensions and chemistry. One student, seeking to synthesize her mineral forsterite, found mostly clinoenstatite in a powder

Figure 3. - Guy Hovis and Phil Goddell measuring the heat capacity of copper metal in Dave Bailey's demonstration lab.

diffraction pattern of her run product. This led her to reexamine her experimental procedures (modeled after forsterite synthesis recipes she found in the literature) and to discover that she had calculated and weighed masses of MgO and SiO_2 for enstatite rather than forsterite. This student had an investment and interest in her lab work, not driven by grades, that was absent in my mineralogy students when I taught a more traditional course. Study of olivine in depth gave her an understanding of minerals, evidenced by the final paper presenting her data, that went well beyond what one would expect after one semester of mineralogy

The audience for most introductory mineralogy courses is geology majors. Very few of our students will become mineralogists or petrologists. However, nearly all of them will eventually work on geologic problems involving rocks or sediments and, therefore, will need to collect or use mineralogical data. I believe our obligation to these students is to show them what mineralogy can do to help them solve geologic problems. They should know how to collect, find, and work with mineralogical data. They should be exposed to the resources and tools of mineralogists. By teaching a project-oriented course, I believe these goals can be met in a way that makes mineralogy truly stimulating. The list of topics left out and the minerals not discussed in such a course may make Dana roll over in his grave. The list certainly makes me uncomfortable. But the results are worth the discomfort: a mineralogy course that trains geologists who will see mineralogy as interesting and fun and who will be more likely to use mineralogy in their work.

I maintain a list server for the discussion of mineralogy teaching. Send me an e-mail message (**jbrady@science.smith.edu**) if you would like to join that list. There is also a page of WWW mineralogy teaching resources on the MSA web site at (http://www.science.smith.edu/geology/

msa/Teaching.html). We plan to publish, through MSA, the lab activities presented at the Teaching Mineralogy Workshop in a book designed as a resource for mineralogy teachers. It should be available by the end of the summer. Examples of mineralogy lab activities that I have published may be found in the Journal of Geological Education (v.40, p.116; v.43, 166, 171).

John B. Brady
Department of Geology
Smith College
Northampton, MA 01063
U.S.A.
(413) 585-3953 FAX: (413) 585-3786

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