VOL. 17, NO. 1 FEBRUARY, 2002

ONLINE

Problems in Geology Education: Our High Schools are the Weakest Link

We do not teach enough geology. We do not graduate enough geology majors, and, worst of all, we are not doing enough to educate the public about the geosciences. Colleges and middle schools, for the most part, are doing a fine job of teaching the Earth sciences. But, most high school curricula do not include a substantial geology component. The resulting gap not only has lowered the level of geology literacy in our citizens but also has resulted in too few college students choosing to study geology.

First, let us take a look at the number of recent geology majors. In 1998, 3,066 college students earned Bachelor's degrees in geology. The same year, 65,868 students earned undergraduate degrees in a biological science, while 10,580 earned degrees in chemistry and 3,441 in physics (Center for Educational Statistics, 2001a). Does this reflect the job market or are there, in fact, too few students entering the field of geology?

In his article, *Career Potential in the Sciences, Geology in the High Schools, and Why Would anyone Major in Geology Anyway?,* Holbrook (1997) concluded that there are many more jobs available for geology graduates than for graduates with other science degrees. More recent data from the Bureau of Labor Statistics indicates that the trends he discovered still hold true. There may be fewer industry jobs in geology than in biology, but there are so few students studying geology that each graduate has more than ten times as many jobs available than does a graduate with a biology degree (Table 1).

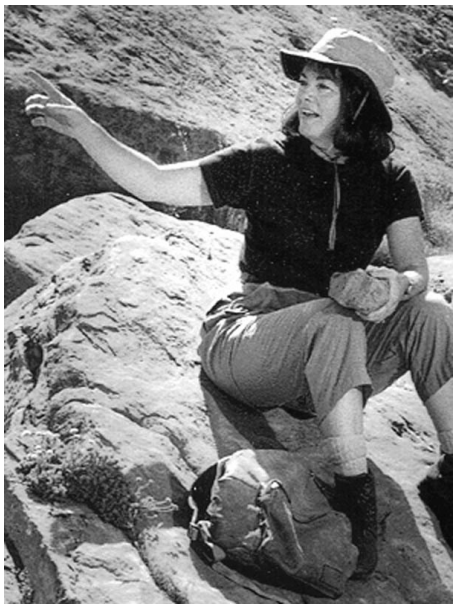
Yet, the number of students earning degrees tells only half the story. Most biologists and almost all physicists need doctorates in order to find employment in their chosen field, while the majority of geologists and chemists can enter their fields with only Bachelors' degrees.

Do differences in the pay scales draw students to biology instead of geology? There are differences, but they are hardly attractive ones to aspiring biologists. According to Bureau of Labor Statistics (2001; Table 2), the average pay for a beginning biologist with a Master's degree is *less* than the average pay for a beginning geologist with only a Bachelors's degree. A biologist would need a Ph.D. in order to earn the same amount as a geologist with a Master's degree. Comparisons with chemistry and physics aren't as dramatic, but they leave no doubt that of all the sciences, geology provides a graduate with the brightest opportunities for finding a job at an attractive salary.

According to the Bureau of Labor Statistics' *Occupational Outlook Handbook* (2001), employment of geologists is expected to grow annually by 15% through 2008. Driving this growth will be the need to comply with increasing numbers of environmental laws and regulations, particularly those regarding groundwater contamination and flood control. The number of geology majors, however, has shown a slight decline since 1995. Clearly, too few students choose to major in geology. Why?

In his research, Holbrook (1997) uncovered one of the major reasons that students choose a science major in a discipline other than geology. He found a strong correlation between the number of people majoring in each science and the number of courses students took in each specialty during high school. Few students who study science in college have taken geology in high school. Why would students choose to enter a field that they have never before encountered? It is hard to find a biologist who didn't study biology in high school, but it is just as hard to find a geologist who did study geology in high school. Instead, the geologist usually fell in love with geology through some fortuituous experience or happy accident. To draw students to the field of geology we shouldn't have to rely upon accidents. We should be introducing students to geology in high school.

Those of us who teach secondary school science have met great resistance to the idea that high school students should learn geology. Ask any high school administrator to name the sciences, and the response is almost certain to be "physics, chemistry, and biology"—what many of us call the "PCB syndrome." A handful of we high school teachers around the country do offer substantial geology courses to college-bound students, but we fight an uphill battle to do so. We often write our own curricula and choose between textbooks designed for middle schools or for colleges; few are written to the high school level.



Wendy van Norden has been a high school science teacher for 27 years, during which time she has taught almost every scientific discipline offered at the pre-university level. After receiving an undergraduate degree in Biology and in the process of earning an MAT at Colgate University, someone suggested that she should know some Earth science to improve her chances of obtaining an entry-level teaching position. Following her introduction to plate tectonics, she was hooked and has been in love with geology every since. When she moved to California, she joined NAGT-FWS, of which she became president of NAGT-FWS in 1994. Since arriving on the west coast, she earned NAGT's Outstanding Earth Science Teacher Award, and best of all, learned much from attending their yearly field trips. She presently teaches at Harvard-Westlake School, an independent school in the Los Angeles area. She is involved with grading AP Environmental Science exams for the College Board, and has initiated a proposal to the College Board to create an AP Geology exam.

TABLE 1—Comparison of occupation and median annual earnings in 1998; data from Higher Education General Information Survey, Table 293 (earned degrees in chemistry, geology, and physics conferred by degree-granting institutions, by level of degree: 1970–71 to 1997–98) and Table 266 (Bachelor's degrees conferred by degree-granting institutions, by racial/ethnic group, major field of study, and sex of student).

Science major	# Graduates 1998	# Jobs in industry 1998	Job/graduate ratio
Geology	3,066	44,000	14.35
Physics	3,441	18,000	5.23
Chemistry	10,580	96,000	9.07
Biology	65,868	81,000	1.23

TABLE 2—Comparison of occupation and median annual earnings in 1998; Occupational Outlook Handbook, 2000–2001 Edition, Bureau of Labor Statistics.

Occupation	Median annual earnings	Education category
Biological scientists	46,140	Doctor's degree
Chemists	46,220	Bachelor's degree
Geologists, geophysicists and oceanographers	53,890	Bachelor's degree
Physicists and astronomers	73,240	Doctor's degree

High school teachers also contend with college counselors who advise top science students against taking geology. Hence, our classes usually are filled with students who are weak in math and do not consider themselves to be "good at science." One of the wonderful things about teaching introductory geology in high school is that we can accommodate these students, often getting them excited about geology and about science, in general. Unfortunately, we rarely get the opportunity to do the same with the more capable science student.

Table 3 shows that, a survey of high school transcripts clearly demonstrates that most high school students don't enroll in geology courses. In 1998, 92.7 % of all high school students earned one credit for a year of biology, 60.4% took a year of chemistry, and 28.8% took a year of physics. Only 20.7% of high school students earned a mere *half* credit for a single semester of Earth science or geology. The table below shows that while in recent years the other sciences have been increasing their enrollments, the numbers in geology/Earth science have been declining (National Center for Education Statistics, 2001b).

These numbers would be disconcerting if they described courses of equal value, but they don't. Most Earth science courses are offered to ninth grade students, while the other sciences are offered to older students. Often the brightest ninth graders are allowed to bypass Earth science to enroll in biology. The numbers, alone, suggest that physics is in a similar situation; yet, most of those who enroll in physics are top students bound for college, while Earth science classes tend to include the least capable students who are unlikely to study science in college. No wonder we have so few geology majors. The best and the brightest science students take biology, chemistry, and physics—and the rest take Earth science. Of course, there are exceptions; nevertheless, these data illustrate, once again, the "rocks for jocks" syndrome that every geology teacher has been fighting since the Paleozoic.

Both the AAAS's *Benchmarks for Science Literacy* and the *National Science Education Standards* for grades 9–12 specify required topics in plate tectonics, erosion, sedimentation, Earthquakes, volcanoes, geologic time, and geochemical cycles. Additionally, paleontological concepts including evolution are required under the auspices of the biological science standards. States usually add more specifics to these standards. These standards are fine, and recent changes in the California state standards indicate they are getting better. Unfortunately, few schools meet these standards. And schools that try to meet them often resort to a broad general science course offered to some of their ninth grade students. Even if the entire course is dedicated to Earth science, the traditional approach is to teach topics in physical geology, paleontology, astronomy, oceanography, and meteorology all in one year or, even worse, in one semester. How much depth of understanding can we expect of students in such a course? There are excellent science curricula available that include Earth science. For example, Foundational Approaches in Science Teaching (FAST), Earth Systems Education, and Integrated Science all include substantial Earth science topics. These curricula, however, are designed exclusively for middle schools.

There is some good news on the horizon. AGI has just completed **Earth System Science in the Community** (**EarthComm**), an NSF-funded curriculum project guided by the *National Science Education Standards* (1995). It already is being instituted in 100–200 schools across the nation. **EarthComm** is inquiry-driven; hence, it covers few topics in great depth. AGI is also completing its middle school curriculum, **Investigating Earth Systems.**

EarthComm probably will do an excellent job of introducing younger high school students to geology, but it is not designed for the top science students in their Junior or Senior years. Even if a more substantial geology course were offered in high school, top science students would be unlikely to choose it when they can take advanced placement courses instead. In the U.S. Department of Education's *National Education Longitudinal Study* of 1988 (National Center for Education Statistics, 2001c), 50% of 12th graders who were asked why they chose their current science course responded that they needed it for Advanced Placement. "AP" courses, designed by the College Board, not only are challenging and rewarding (they usually confer advanced standing and course credit in college), but more impressive than regular science courses to college admissions personnel. When top science students can choose among AP Biology, AP Chemistry, AP Environmental Science, AP Physics B, and AP Physics C, why would they choose geology? More importantly, why *are* there five AP science courses, a new AP course in geography, but, as yet, no AP course in geology? It is a striking omission that a number of us are working to correct.

The geology community strongly has supported a recent initiative to convince the College Board to create an AP Geology course. The professional organizations have rallied behind the cause, and I have received letters and e-mails from hundreds of teachers and geologists eager to be involved. The College Board is now conducting a survey to determine whether the level of interest warrants their commitment to design a new AP course. More information about the status of AP Geology can be found at http://www.bedford.k12.ny.us/flhs/science/apgeohome.html.

With the new **EarthComm** curriculum in development and the possibility of an AP Geology course, there is reason to be optimistic that high schools will become a stronger link in the chain of geology education. If more of our students are introduced to geology in high school, they will be more likely to study geology in college. Elementary school teachers who have taken geology courses will be more enthusiastic about teaching basic Earth science concepts to their students. Best of all, the average citizen will be more informed about a science that is both fascinating and relevant.

—WENDY VAN NORDEN

REFERENCES

BUREAU OF LABOR STATISTICS, 2001, Occupational Outlook Handbook, 2000–2001 Edition, U.S. Department of Labor, Washington D.C., <http://stats.bls.gov/oco/ocos050.htm>

HOLBROOK, J., 1997, Career Potential in the Sciences, Geology in the High Schools, and Why Would Anyone Major in Geology Anyway?: PALAIOS, v. 12, p. 503–504.

NATIONAL CENTER FOR EDUCATION STATISTICS, 2001a, U.S. Department of Education, Washington, D.C., <http://nces.ed.gov/pubs2001/digest/dt266.html>

NATIONAL CENTER FOR EDUCATION STATISTICS, 2001b, National Assessment of Educational Progress: Department of Education, Washington, D.C., <http://nces.ed.gov/pubs2001/digest/dt142.html>

NATIONAL CENTER FOR EDUCATION STATISTICS, 2001c, Digest of Education Statistics:1999: U.S. Department of Education, Washington D.C., <http://nces.ed.gov/pubs2000/digest99/d99t141.html; <http://nces.ed.gov/pubs2000/digest99/d99t143.html>

TABLE 3—Percentage of high school graduates taking selected science courses in high school: 1982 to 1998 from the Digest of Education Statistics: 1999, Table 141 (percentage of high school graduates taking selected mathematics and science courses in high school, by sex and race/ethnicity: 1982 to 1998).

Science	Credits	% Graduates 1982	% Graduates 1990	% Graduates 1998
Biology	1.0	77.4	91.0	92.7
AP/honors biology	1.0	10.0	10.1	16.2
Chemistry	1.0	32.1	48.9	60.4
AP/honors chemistry	1.0	3.0	3.5	4.7
Physics	1.0	15.0	21.6	28.8
AP/honors physics	1.0	1.2	2.0	3.0
Geology/earth science	0.5	13.6	24.7	20.7