Name of course: Geology of Virginia

Geology of Virginia (2006 & 2007)

Course Instructors: Brent Owens (College of William and Mary); Nathan Shotwell (Mills E. Godwin High School)

Location: MathScience Innovation Center, Richmond, VA

Abstract: This two-week course is designed as a second level geology course for middle and high school earth science teachers. The focus obviously is the geology of Virginia, but numerous concepts of basic earth science are reviewed and reinforced in this context. The overall framework of the class is that of the physiographic provinces of Virginia, each of which contains a somewhat unique set of geologic features (e.g., topography, rock types, ages of rocks, structural style, resources, etc).

Course development: The course followed the ideas that were mutually developed by all participating instructors and administrators (Julia Cothron, Heather Macdonald, etc.). With respect to this particular section, a considerable amount of time was spent in seeking out appropriate field trip locations, as well as in planning the field trips.

Demographics of participants: Fourteen teachers participated in this class, and they were evenly divided among middle and high school teachers. One was in something of a class by herself in that she is primarily a special education teacher. The class represented a wide range in terms of experience, from teachers with only a few years of teaching under their belt to those with more than 30 years experience. Despite the Richmond location, only four students teach in the immediate area. Other more distant counties represented included Bland, Lancaster, Amelia, Spotsylvania, Mecklenburg, and New Kent. With respect to background, only one teacher had a degree in geology. Thus, most teachers are teaching earth science with minimal educational preparation, and with what I perceived as an understandable lack of confidence in handling the material.

Materials used in course: see syllabus below

Description of course: the syllabus is shown below; some additional text follows

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Virginia Earth Science Collaborative
Geology II: Geology of Virginia
Summer 2006 & 2007
College of William and Mary Edition

Instructor #1: Brent Owens, College of William and Mary
Office phone: 757-221-1813

Home phone: 757-564-8205
e-mail: beowen@wm.edu

Instructor #2: Nathan Shotwell, Mills E. Godwin High School, Richmond
e-mail: nshotwell@henrico.k12.va.us

Course Materials:

The Geologic Map of Virginia, 1993. Virginia Division of Mineral Resources, Charlottesville, Virginia (with accompanying explanation)
Laminated generalized geologic map of Virginia (plus small paper copy)
Geologic map of the Coastal Plain of Virginia, 1989. Mixon, R.B., Berquist, C.R., Jr., Newell, W.L., Johnson, G.H., Powars, D.S., Schindler, J.S., and Rader, E.R. U.S.G.S. Miscellaneous Investigations Series, Map I-2033.
Geologic map of the Willis Mountain Quadrangle, Virginia, 1980. Marr, J.D., Jr. Virginia Division of Mineral Resources Publication 25.
Geological Highway map of the Mid-Atlantic Region, 1989. American Association of Petroleum Geologists.
Physiographic diagram of Virginia, 1991. Bingham, E., Virginia Division of Mineral Resources Publication 105.
Laboratory Studies in Earth History, 8th ed., 2004. Brice, J.C., Levin, H.L., and Smith, M.S., McGraw Hill, New York (selected labs only).
Field notebook
Hand lens

Course Goals:

1. Identify common rocks and explain their origin in terms of the rock cycle, concentrating on major sediment and rock types in Virginia.
2. Describe the distribution, origin, and economic and environmental importance of renewable and nonrenewable resources in Virginia. (ES 6abc, ES 7)
3. Analyze geologic maps, cross-sections, and outcrops for the purpose of describing rock sequences and geologic structure and interpreting geologic history using topographic, structural, petrologic, and historical relationships.
4. Explain basic plate tectonic processes, infer past tectonic settings from relationships in the geologic record, and analyze evidence for specific plate tectonic processes in Virginia. (ES 8a)
5. Synthesize the sequence of geologic events from geologic maps, cross-sections, and/or outcrops applying information from both relative and absolute dating methods.
6. Describe the origin, development, and relationships of the physiographic and geologic provinces in Virginia and synthesize the geologic development of Virginia from the geologic, paleontologic, climatic, and marine records. (E8a)
7. Utilize the tools and techniques of geologists in an authentic way (e.g., record notes in field notebook, make detailed observations and give interpretations that are based on the observations, read topographic and geologic maps).
8. Develop and implement inquiry-based lessons that reflect an increased capacity to engage and stimulate students in a confident and reflexive manner.

Evaluation:

Miscellaneous lab activities	30%
Field notes (as recorded in field books)	10%
Post-test	30%
Final project	30%

Course Schedule:

Monday, July 31	Morning: introductions, overview of course, pre-test, intro. to physiographic provinces and geology of Virginia Afternoon: Geochronology I - relative time, fossils and time, teaching wrap-up
Tuesday, Aug. 1	Morning: mineral and rock review, rock types in Virginia Afternoon: Geochronology II – absolute time (radiometric dating), teaching wrap-up
Wednesday, Aug. 2	Morning: plate tectonics and rock associations, relate to geologic map of Virginia Afternoon: overview of Blue Ridge, Valley and Ridge, and Appalachian Plateau Provinces, teaching wrap-up (focus on final project ideas)
Thursday, Aug. 3	Field trip in the Blue Ridge (Skyline Drive); overnight in Staunton
Friday, Aug. 4	Field trip in Valley and Ridge
Monday, Aug. 7	Field trip in the Richmond area (Petersburg granite, Triassic seds., etc.) **Initial draft of final project idea due**
Tuesday, Aug. 8	Morning: geologic maps and structures; activity with Willis Mt. map Afternoon: overview of Piedmont and Coastal Plain Provinces, teaching wrap-up (further work on project ideas)
Wednesday, Aug. 9	Field trip in Piedmont
Thursday, Aug. 10	Field trip in Coastal Plain
Friday, Aug. 11	Big picture review; **informal presentation of project ideas**; **post-test** **Final draft of project idea due**

Saturday Fall Follow-up Session: date TBA

Final Project: Teachers will develop a geology activity based on the geology of their home county appropriate for their class.

Explanation/elaboration of syllabus: The above syllabus is relatively self-explanatory as a course description. As noted above, the physiographic provinces of Virginia were used as an over-riding organizational principle for this class. An attempt was made to link every concept in the course to the provinces in some fashion. For example, the presentations on geochronology highlighted various rock units in Virginia for which ages have been determined. This information was then used in turn to highlight some of the key differences among provinces.

Note that on the days spent completely in the classroom, the day was more-or-less divided between a lecture-style presentation in the morning, followed by one or more activities in the afternoon. An additional regular feature was a final hour (approximately) spent on pedagogical discussion or presentation (called "teaching wrap-up" above). This final hour was organized and led by the expert teacher, Nathan Shotwell.

Description of Laboratory and/or Field Experiences: Apart from the field trips, the course included approximately seven lab-style activities. These are briefly described below.

1. Relative time: Students completed a series of relative time questions using exercises from the required lab manual. Principles covered include original horizontality, superposition, cross-cutting relations, inclusions, etc.

2. Fossils and time: Students completed two exercises emphasizing stratigraphic ranges of fossils, and how such information can be used to limit the age of a sedimentary unit.

3. Mineral identification: Although largely a review for most students, this standard lab activity reinforced basic mineral properties used for identification. Because all teachers incorporate a similar activity in their course, this provided a chance to discuss common problems/pitfalls.

4. Rock identification: The rock identification exercise was structured in two parts. First, students were provided in succession boxes that contained sedimentary, igneous, then metamorphic rocks. In other words, the first box contained only a variety of sedimentary rocks to identify, the second only igneous and so on. For the second part of the exercise, students were presented with 20 random rock samples to identify. All samples were from Virginia, and students were required to first give the proper main type (igneous, sedimentary, or metamorphic), then give a more specific name (e.g., sandstone, basalt, granite, etc.). Following completion of the exercise, each sample was reviewed with respect to rock type and where it came from in Virginia.

5. Absolute time: Nathan Shotwell reviewed a commonly used activity for illustrating radioactive decay that utilizes M & M candies. All teachers participated in the activity, which provided a nice opportunity to highlight potential problems. In addition, some teachers are already using a similar activity, and they shared their experiences.

6. Geologic maps: One exercise was designed to get students to carefully examine a geologic map (in this case a geologic map of the Willis Mountain 7.5' quadrangle in central Virginia), and answer a series of questions. Key concepts reinforced through this exercise include the geologic time scale, relative time (unconformities, cross-cutting relations, etc.), relationships between bedrock and topography, structural geology (strike and dip, folds, faults), etc.

7. The Big Picture: A block of time on the last day was devoted to putting together the big picture of Virginia's geologic history. We followed an idea developed by Jon Tso (Radford) in which students are assigned on the first day of class a particular block of the geologic time scale, e.g., the Silurian. They are also given a batch of index cards, with each student given a different color. From then on, students are instructed to record on the index cards any geologic feature or

event that occurred during that time interval, as mentioned during the course. On the final day, we reviewed as a group the geologic history of Virginia, placing the cards on a large table as we proceeded, approximately in the right geographic position. Cards can be moved together or overlapped during orogenic events, rifted apart, etc. This activity is very engaging, both on a visual and intellectual level. It also provides a nice way to reinforce many of the concepts covered in the class.

Applications to classroom:

1. As noted above, the final portion of each in-class day was spent on pedagogical matters. As our expert teacher, Nathan Shotwell provided a well-developed project that he planned to implement in his own courses. The project involves an overview of the geology of Virginia, based as in this course on the physiographic provinces. It involves the use of real rock (or sediment or fossil) samples from across the state, as well as maps of Virginia. As envisioned by Nathan, this project will take place over multiple weeks, and is relatively ambitious. Nonetheless, a number of the teachers were excited by his ideas, and plan to implement some version of this assignment into their courses.

2. The final portion of each in-class day also provided an opportunity for teachers to share points regarding the topic of the day, e.g., mineral and rock identification, plate tectonics, geologic time, etc.

3. Final projects: Each teacher was responsible for creating a lesson/activity that focuses on the geology of the county in which they teach. Preliminary versions of these projects were created and presented during the two-week summer class. Final versions were presented at our fall follow-up meeting on Nov. 4. Although this assignment is a good one, by the time of the follow-up meeting only a few of the teachers had actually implemented the lesson or activity. Thus, not all lesson have had the benefit of a "real-world" trial.

Methods of Evaluation & Performance: Methods of evaluation are listed in the syllabus above. Most of the grade was based on the post-test score, the final project, and various in-class exercises. In reality, I didn't have time to grade in detail all of the in-class exercises, so they were essentially just checked for completeness. However, all field books were graded (10% of the grade).

Lessons Learned:

<u>Positive aspects of course</u>

From my perspective as the instructor, these are some the best aspects of the course:

1. Field trips. By design, this course gets the teachers outside to really observe geology as it is best seen. No amount of classroom instruction can take the place of a good field trip stop, and I think the teachers appreciated this component of the course more than anything else. I also think the amount of time in the field (half of the course) was about right, and provided a good balance for those days spent in the classroom.

2. Expert teacher. Having an expert teacher as an assistant was of immeasurable value, particularly in Nathan (Nate) Shotwell who has an undergraduate degree in geology. The teachers soaked up everything he had to say and offer with relish. They clearly recognized that Nate was one of them (in contrast to me!), and had experience in the trenches. In addition, Nate was of constant help to me in keeping the course accessible and useful for the teachers. I found our informal discussions at the end of each day regarding what went well or what didn't to be extremely beneficial.

3. Clarification of misconceptions. Because most of the teachers do not have a background in earth science (or geology explicitly), their grasp of fundamentals is often tenuous or even wrong. For example, I spent one whole morning talking about the connection between various rock types and plate tectonic settings where they might be produced. I noted that basalts are often produced in rift settings, as a precursor to our field trip to the Blue Ridge to observe the Catoctin metabasalt. This discussion ultimately led to a lengthy digression regarding where basalts originate (the mantle), and to clarification of what appeared to be a prevalent misconception that the mantle is largely liquid.

4. Confidence building. This point follows directly from point 3. Even though we touched on numerous aspects of geology that the teachers will probably never cover in their own classes, their overall command of the subject matter is greater. I suspect (and hope) that this will translate not only into more knowledgeable but also more confidant teachers.

5. Camaraderie. I sensed that these teachers, for the most part, had a grand time together. Much of the camaraderie is built on the field trips, so this is another more intangible benefit to the trips. Lots of opportunity for informal interaction means that young teachers gain a lot from more experienced ones, and the older teachers get a jolt of fresh energy and inspiration from the younger ones.

<u>Areas for improvement</u>

1. Although I did not find this to be a major issue, it might be wise to consider the contrasting needs of middle school vs. high school earth science teachers. This course, as I taught it, might be considered over-kill for middle school teachers, who seem to only cover a small amount of geology in their courses. I suppose it all depends on the school system, and the exact point where earth science appears in the curriculum. Another issue concerns the specific motivation for each teacher taking the course – some were not currently teaching earth science, but hope to add it to their repertoire in the future.

2. It would be good to have some better designed in-class exercises that could be graded relatively quickly (i.e., overnight). As noted above, I felt extremely pressed for time, and didn't get much grading done at night. As a personal observation, this course is highly demanding on the instructor, particularly in my case as I chose to drive an hour each way (back and forth from Williamsburg to Richmond). On the other hand, if the course is offered again, my own preparation time would be significantly reduced the second time through.

3. Choice of lab manual. I had originally thought that we would use more of the exercises in the assigned lab manual, but I actually didn't use the manual very much. The teachers still have it as a reference, but that might not be reason enough to include it as required material.

4. Explanation of final project assignment. My description of the final project assignment was relatively short and open-ended (preparation of a lesson or activity focusing on the geology of the local county). I could do better by including more details about expectations, grading criteria, or perhaps even including a minimal grading rubric. Because of minimal elaboration on my part, the final projects ranged fairly widely in terms of both quality and attention to detail.

5. Consider emphasizing the strongly field-based nature of the course in the announcement sent to teachers. A few of our teachers had great difficulty participating in the field, despite the relatively unstrenuous nature of most stops. This had the effect of slowing down the group, and rather significantly at a few stops. In addition, one teacher literally could not participate in one of the trips, given that it required several short hikes. I'm not sure what the best approach would be here, but at a minimum a strongly worded statement about the field requirement should be included.

Some Additional Comments Based on the Second Year (Summer 2007)

The course was taught in essentially the same way the second year. We added one new assignment (see below) and changed some of the field trip stops, but otherwise made few other changes.

Demographics of participants: Nineteen teachers participated in the second year, and once again the class was split fairly evenly among middle and high school teachers. Only one teacher had a college degree in geology, illustrating once again how many teachers are teaching earth science with minimal background preparation. Eight of the teachers are teaching in the Richmond area (Henrico Co. or Richmond City), and other counties represented among the class include Louisa, Orange, Prince William, Danville, Lancaster, Warren, and Stafford. Thus, the course drew from a fairly wide and diverse geographic area. This fact is actually useful in that the geology of these various counties is different, and people could bring their local perspectives to certain course topics.

Materials used in course: Much of the material used in the second year was the same, but I made two slight changes. First, as suggested above, I decided not to have students buy the lab manual. We only really used one exercise from it, so there was no need to have to the whole volume. Second, I provided each student with a copy of the book *Rocks and Rock Minerals* by R.V. Dietrich and B.J. Skinner (1979, John Wiley & Sons). This book is a very handy reference and aimed at just about the right level for people with minimal geology background. I anticipate that it will come in handy for each teacher in the future.

Description of Laboratory and/or Field Experiences: At the suggestion of Nate Shotwell, we added one new assignment in the second year. Each teacher was assigned one field trip stop, with the responsibility to prepare a brief (three or four images) Powerpoint presentation

describing and explaining that stop. We visited more stops than the number of teachers, so I selected particularly interesting or photogenic stops for this assignment. Teachers used digital cameras (some provided by the Math and Science Center) to photograph key elements of their stop, and then took careful notes that could be utilized in preparing the Powerpoint images. Ultimately, each teacher submitted their Powerpoint presentation to Nate on the last day of class. He combined them all onto one CD and made a copy for each teacher. We also viewed all of the presentations following this compilation.

I think this assignment added considerably to the both the field trip experiences and the culminating experience of the last day (where we review the geologic history of Virginia using the index card exercise described above). It insures that at least one teacher is fully engaged at each stop, and the CD provides a nice overview of the field trips for everyone. Not all of the presentations were stellar (and the assignment was not graded), but the sheer fun of doing it made for more lively interactions among all participants.

Final Project Assignments: As noted above, the quality of the final projects in the first year ranged from excellent to mediocre. I'm not sure that I did much differently in terms of explaining the assignment in the second year, but Nate and I both agreed that the overall quality of the projects was much better this second time around. I think we were both sensitive to this throughout the course in the second year, and did a better job of making sure that people were thinking about the assignment each day. As in the first year, most of these lesson assignments had not been "field tested" yet (i.e., actually used in the classroom) by the time of our final meeting, but my sense is that most teachers were indeed going to use their assignments. In both years, we had at least one person in the class who was not actually teaching earth science yet. Thus, their assignments could be described as "hypothetical" at this stage, but nonetheless usable in the future.