Some examples of my past, present, and future use of visualization in teaching (and research) in the Geosciences

Mickey Gunter
Department of Geological Sciences
University of Idaho
Moscow, Idaho 83844-3022, mgunter@uidaho.edu

To me it would seem strange *to not* use visualizations in teaching. When I recall my days as a student, especially in mineralogy and structural geology, I was constantly building models. I built them mainly of toothpicks and clay to help me visualize the 3D relationships I was trying to learn in those classes. As a professor, this trend has shifted to me using those same sorts of real, as well as virtual (i.e., computer generated), models in my teaching. Over the past 15 years I've made extensive use of these "models" in teaching intro physical geology (Geol 101), a large lecture class with approximately 400 students, and in my mineralogy and optical mineralogy course with approximately 20 students.

When I first started teaching Geol 101 in 1989 I struggled for an organizational style to the present the material in the large lecture setting. At that time PowerPoint version 1.0 for the Mac was just released, so I used it to make overheads to present the material. However, I only put 10-20% of the material on the overhead – the rest I hand-wrote in real-time during class. (A pdf version of these notes can be found at www.webpages.uidaho.edu/ ~mgunter/geol101/notes/notes.html.) This seemed well received by the students then, and even more so now. I resist the current trend of placing all the material in PowerPoint and then using a computer projection system during class for static images. However, I developed computer animations in the early 1990's and used a black and white (not even grayscale!) LCD projection panel to show them in class. With time, I've evolved to a grayscale and then color LCD projection panels and finally the stand-alone projection systems. Gunter (1991) details early use of computer demonstrations and Gunter (1993) discusses how to integrate several methods, including visualizations, into teaching the large intro classes.

Along with the standard sort of visualizations used in the intro class, I started using concept maps (even though I had no idea they had a name!) as a visual method to introduce the linkages of different science disciplines. For instance, Figure 1 shows a concept map illustrating how geology is broken into different subdisciplines and, in turn, how one of those subdisciplines, mineralogy, is further linked to other areas outside the field of geology. This figure originally was presented in Gunter (1993). Figure 2 is another example of a concept map that shows some visual links for minerals; it's taken from Dyar et al. (2004) where we discuss several new methods for teaching mineralogy. A static concept map can also be dynamically hyperlinked to other maps, for examples see www.webpages.uidaho.edu/~mgunter/NAGT/vis.html.

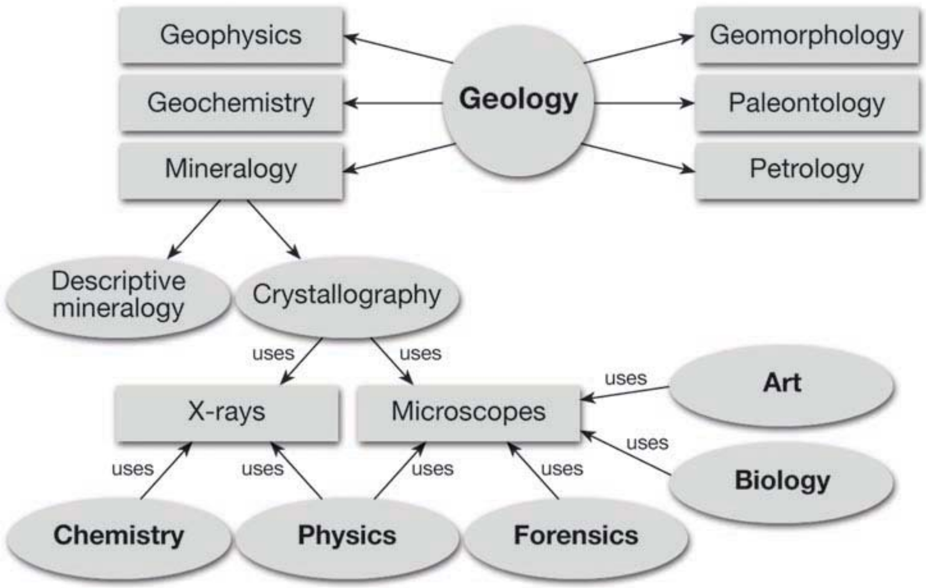

Figure 1: A concept map showing linkages of geology and mineralogy. (From Dyar et al. 2004.)

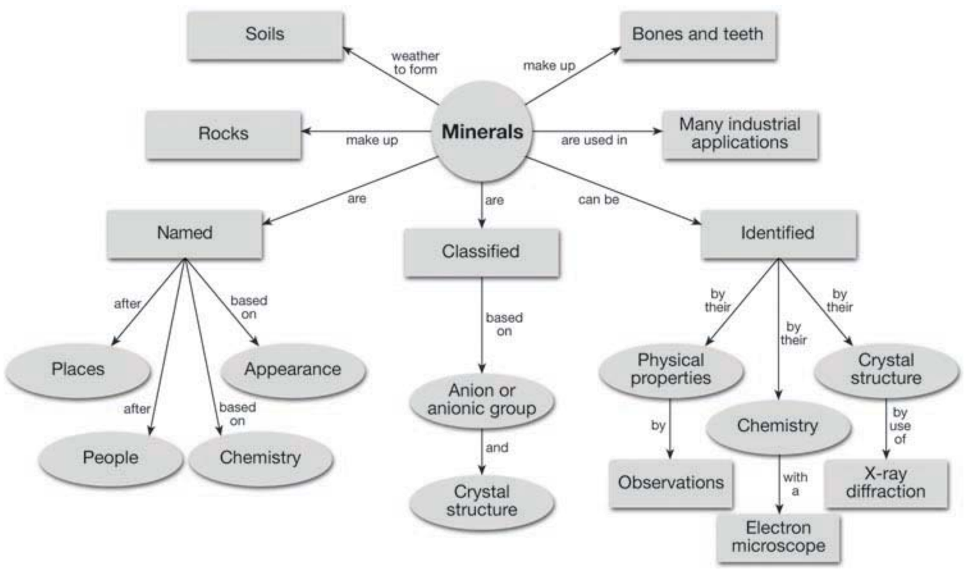

Figure 2: A concept map showing some of the basic linkages of minerals. (From Dyar et al. 2004.)

Currently my main teaching and research efforts are in mineralogy and optical mineralogy; it's really impossible for me to separate by teaching and research components. I am working in collaboration with Darby Dyar and Dennis Tasa on a new mineralogy and optical mineralogy textbook which will also contain animations of all of the images on an included DVD. A basic understanding of the crystal structures of materials is crucial in understanding mineralogy, thus we plan on having 100's of crystal structure drawings in the book and animations on the DVD. In the "old days" it was very time consuming to make such drawings, one drawing might take several hours, and animations would be impossible. Back then we built 3D ball and spoke models as useful teaching and research aids, but it was even more time consuming to make these models, often taking several days to build one model (Gunter and Downs 1991). The ease of making animations of crystal structures should greatly aid in student's understanding of mineralogy. Figure 3 shows an example drawing of a zeolite before and after cation exchange. There are some examples of animated drawings at www.webpages.uidaho.edu/~mgunter/NAGT/vis.html.

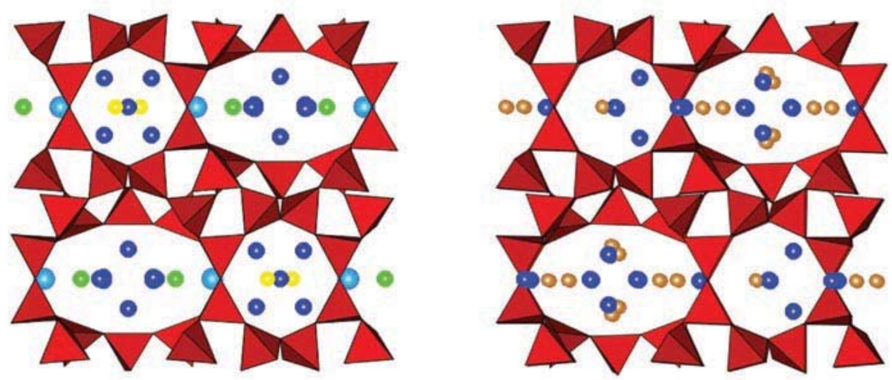

Figure 3: Example drawings of crystal structures of minerals. (left) A natural zeolite and (right) a Pb-exchanged zeolite. The red pyramids represent the tetrahedral framework and the small spheres are the cations and water molecules in the channels. Only by viewing the structure can one visualize the channels in these industrially important minerals. (Modified from Gunter et al. 1994.)

My major research interest still remains in interpretation of the optical properties of minerals, and probably less so with routine mineral identification as done in thin sections. Figure 4 below shows a very useful example of "interpretations." During Pb-exchange experiments we found (Gunter et al. 1994) that the retardation of a zeolite increased drastically. We then used this method to visually determine the migration of Pb into the material with the aid of a polarizing light microscope (PLM). Given this observation, we could determine the diffusion coefficient for Pb, and several other cations.

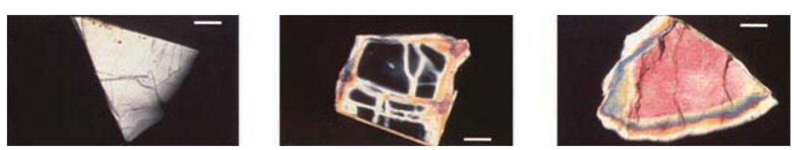

Figure 4: Photomicrographs of a natural (left), partially Pb-exchanged (middle), and fully Pb-exchanged zeolite (right). The changes in the retardation are directly related to the Pb content, thus chemistry can be mapped "visually." (Scale bars are 100 μm, modified from Gunter et al. 1994.)

To aid in the understanding of the orientational dependence of the physical properties of minerals, I've made extensive use of the spindle stage (Gunter 2004), and then correlate these properties to their crystal structures. Also, use of the spindle stage is a major aid to show how optical properties change as a function of orientation (Gunter 1997). (Examples of this are at www.webpages.uidaho.edu/~mgunter/NAGT/vis.html.) The spindle stage and the PLM are also the main tools for studying morphology of minerals, used mainly for asbestos minerals (Gunter 2004). For instance, an amphibole is considered as asbestos based on a "fibrous" morphology, and the best method to judge this morphology is by visual observations with the PLM (Brown and Gunter 2003). These methods can also be extended to 3D views of samples with an SEM (Bandli and Gunter 2001). Interestingly, as show in Figure 5, there is a gradation between non-asbestos amphibole (right side of grain) and asbestos amphibole (left side of grain). Again, the visualization of the image is the only way to distinguish these different morphologies.

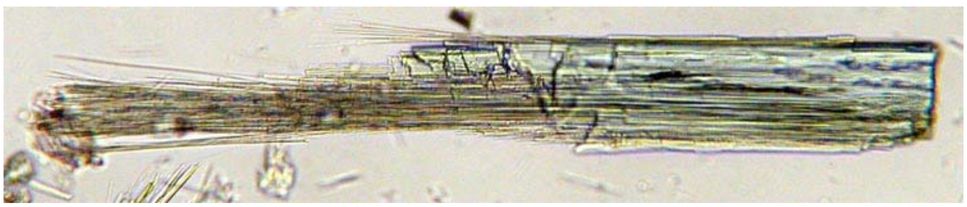

Figure 5: A single particle of amphibole (approximately 500 μm in length) as viewed in an immersion mount with the PLM. The left side of the grain would be considered asbestos based on its morphology, while the right side is non-asbestos. (Modified from Gunter 2004.)

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