Short Articles and Exercises to Teach Scientific Reading Comprehension and Mineralogical Concepts

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Overview

Writing across the curriculum has become an important part of many school curricula. Reading across the curriculum is also important, but students already read a lot, don't they? Maybe, but what do they read? More to the point, what do they understand? In mineralogy courses students usually have a textbook. Most such textbooks are written to pass on information determined by generations past to generations present, conveying general principles and structured information. However, these are really reference books that convey little about what mineralogists do, why they do it, or, to put it differently, what minerals can tell us about the fundamental properties of matter and the environments in which they formed.

I began by looking through The American Mineralogist to find well-written, *short* articles that were clear, concise, narrowly focused, and presented analytical data of some sort. For each article I wrote a one page sheet of questions and tasks as homework for the students as they read the paper. The object was to help guide the students through the paper, highlighting vital information and concepts and emphasizing how the data support the conclusions.

The questions included simple things like geographic location and the geologic environment. More sophisticated questions asked which curves on a graph corresponded to absorption by which atomic or molecular species in a mineral, or what experimental conditions favor dendritic vs. euhedral crystal growth. Many questions were explicitly answered in the articles, but other questions required additional information from their text or class notes. Some tasks included making of graphs, simple algebraic calculations, or careful thought. The idea was to make certain topics more clear, and in some cases to allow interpretation beyond that in the paper.

When the homework is due I usually try to have some kind of discussion. The following method works well. Two students are told, days before the homework is due, that they will give a 5 minute presentation on the paper. I offer help preparing materials and planning the presentation. The other students are required to write two questions and to ask one of them during the discussion, to be answered by the class as a whole. These questions must be submitted to me prior to the discussion. I pay close attention to the submitted questions to see that they involved some thought. For example, "What color is the andalusite?" is not a question that requires much thought if the abstract and the 2nd paragraph in the article give the answer. "What color does andalusite usually have?" is a more interesting question that is not answered in the article but can be answered from information elsewhere. Submission of written questions forces all students to participate in the discussion, to think a bit more about the article.

Although I have chosen these articles to be short and comparatively simple, most students do not find them easy. They are commonly shocked by how carefully they have to read the papers in order to understand the important points. This is quite different from reading some textbooks in which the information density may be so low that a reader can daydream through several paragraphs and not miss much. On the whole, however, students are rightly pleased with themselves after they have read and understood a real scientific paper. They have reported to me that they are glad to see what mineralogists and other materials scientists actually do, and that the work is being done to answer fundamental questions about mineral chemistry and physics, physical properties, and the environments of mineral formation.

By the end of the course, after having read several of these papers, I have noticed that students are more animated during discussions of mineral properties or chemistry than previous classes that never read such papers. I think students gain a deeper understanding of the nature and use of mineralogical research, and themselves become more confident in their understanding of mineralogy.

Articles Used in Mineralogy (in bold is the example exercise given below)

Balan, E., DeVillers, J., Eeckhout, S., Glatzel, P., Toplis, M., Fritsch, E., Allard, T., Galoisy, L., and Calas, G., 2006, The oxidation state of vanadium in titanomagnetite from layered basic intrusions. American Mineralogist, 91, 953-956.

Carlson, W.D., and Rossman, G.R. (1988) Vanadium and chromium-bearing andalusite: occurrence and optical-absorption spectroscopy. American Mineralogist, 73, 1366-1369.

Hazen, R.M., and Sharp, Z.D. (1988) Compressibility of sodalite and scapolite. American Mineralogist, 73, 1120-1122.

Murowchick, J.B., and Barnes, H.L. (1987) Effects of temperature and degree of supersaturation on pyrite morphology. American Mineralogist, 72, 1241-1250.

Parnell, John (1988) Native platinum in pyrobitumen from Fonda, New York. American Mineralogist, 73, 1170-1171.

Rosenberg, P.E. (1987) Synthesis of metastable Ca-Mg carbonates. American Mineralogist, 72, 1239-1240.

Snow, M.R. and Pring, A., 2005, The mineralogical microstructure of shells: PART 2. The iridescence colors of abalone shells. American Mineralogist, 90, 1705-1711.

Solomon, G.C., and Rossman, G.R. (1988) NH_4^+ in pegmatitic feldspars from the southern Black Hills, South Dakota. American Mineralogist, 73, 818-821.

Bonus: List of Articles Used in a Similar Way in Petrology

Berg, J.H. and Klewin, K.W., 1988, High-MgO lavas from the Keweenawan midcontinent rift near Mamainse Point, Ontario. Geology, v. 16, p. 1003-1006.

Hawkins, D.P. and Wiebe, R.A., 2004, Discrete stoping events in granite plutons: A signature of eruptions from silicic magma chambers? Geology, v. 32, p. 1021-1024.

Wilkerson, Amy, Carlson, W.D. and Smith, D.S., 1988, High-pressure metamorphism during the Llano orogeny inferred from Proterozoic eclogite remnants. Geology, v. 16, p. 391-394.

Example exercise:

Special Reading: Sodalite and scapolite compressibility

Hazen, R.M. and Sharp, Z.D., 1988, Compressibility of sodalite and scapolite: American Mineralogist, v. 73, p. 1120-1122.

People generally think of solids as being incompressible, in contrast to gasses which are easily compressible. In reality, all materials are compressible, just some more than others. This paper describes compressibility measurements that were made on the two minerals sodalite and scapolite. As you read the paper, answer the following questions.

1) What are the ideal chemical formulae of Ca-scapolite (meionite), Na-scapolite (marialite), and sodalite?

2) In what geologic environments is sodalite commonly found?

3) In what geologic environments is Ca-scapolite commonly found?

4) Plot on three graphs the following data from Tables 1 and 2 in the paper:
   A) The sodalite a̲ cell parameter a(Å) vs. pressure (P).
   B) The scapolite a̲ cell parameter a(Å) vs. pressure (P).
   C) The scapolite c̲ cell parameter c(Å) vs. pressure (P).

   Put linear regression best-fit lines through the data points. These lines show how the minerals are compressed along each crystallographic axes as the pressure is increased. You may use graph paper or a spreadsheet.

5) The changes in unit cell volumes of sodalite and scapolite with pressure are given in Tables 1 and 2 under the headings V(Å^3). Next to the cell volumes are columns labeled V/V_0, which is the ratio of the cell volume at each pressure to the cell volume at 1 bar (0.001 kbar). This is a relative measure of how the volumes of the minerals change with pressure. Plot on one graph the V/V_0 values vs. pressure for both scapolite and sodalite. Put linear best-fit lines through the values. You may use graph paper or a spreadsheet.

6) Which mineral is more compressible, sodalite or scapolite? What is your evidence?

7) At 1 bar pressure the densities of sodalite and Ca-scapolite are 2.30 and 2.69 g/cm^3, respectively. What are the densities of these two minerals at 26 kbar?

Graphs from questions 4 and 5 in the example reading.