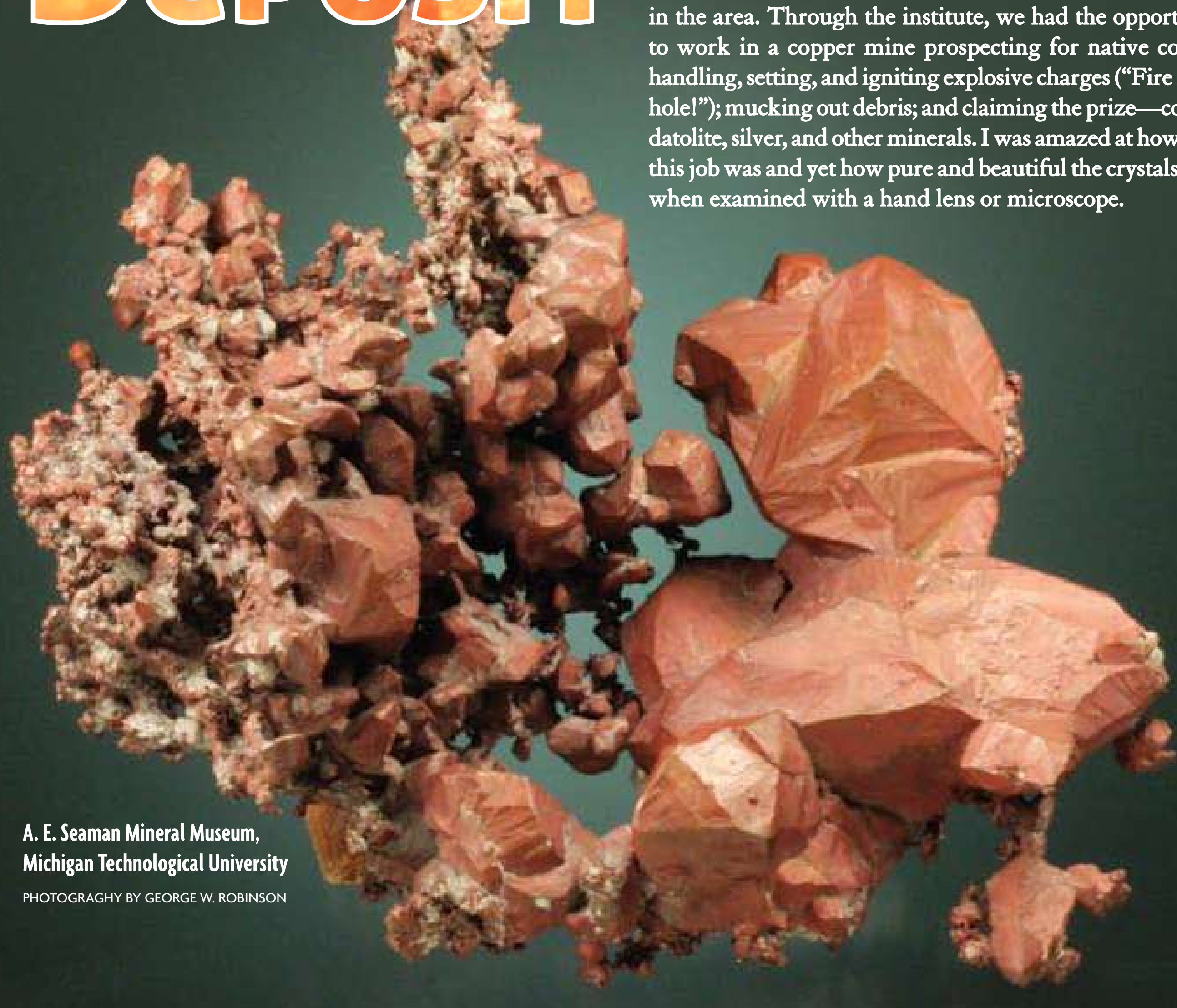
Grow Your Own Copper Deposit

Creating and identifying copper crystals in the classroom

Timothy John Corcoran

Crystals are beautiful structures—yet they occur naturally in dirty and remote places. In many geology and Earth science classes, students grow crystals from carefully prepared solutions, such as alum and rock candy, but I have found these difficult to relate to the natural processes that create the crystals we study in class. These classroom experiences also do not address the formation of a metal mineral deposit, which is central to understanding these structures (see “Minerals and crystals,” p. 46).

During the summers of 2004 and 2005, I participated in the Teachers’ Earth Science Institute (TESI). Along with 22 other high school teachers from across the country, I spent five weeks studying the geology of Michigan’s Keweenaw Peninsula and the processes of mining and refining used in the area. Through the institute, we had the opportunity to work in a copper mine prospecting for native copper; handling, setting, and igniting explosive charges (“Fire in the hole!”); mucking out debris; and claiming the prize—copper, datolite, silver, and other minerals. I was amazed at how dirty this job was and yet how pure and beautiful the crystals were when examined with a hand lens or microscope.



A. E. Seaman Mineral Museum, Michigan Technological University

PHOTOGRAGHY BY GEORGE W. ROBINSON

The focus of the TESI experience was the Keweenaw Peninsula copper mines. In the 19th and early 20th centuries, copper mining played a dominant role in this area's economic life. Many underground mines are located along the stretch from the northern tip of the Keweenaw to the White Pine Copper Mine, approximately 100 miles to the southwest. This native copper formed deposits when hydrothermal solutions flowed toward the surface along permeable zones and deposited copper in the basalts, conglomerates, shales, and other rock formations. The copper in the Keweenaw deposits exhibits a variety of crystal forms, many of which are on display at the A.E. Seaman Mineral Museum at Michigan Technological University, where the TESI took place. These copper crystals and their formation are the focus of the activity presented in this article.

About the activity

I teach a high school geology course that contains a unit on mineral formation and the mining process, and I needed an activity that demonstrated the process of mineral concentration and deposition for my students. When copper crystals are grown in the method described in this article, the process closely mimics that of the Keweenaw copper deposits and other native mineral deposits, such as gold, silver, and lead.

Minerals commonly form in nature when a solution carrying the mineral's components enters a new environment. The new environment causes the minerals to crystallize. One example of this process is black smokers on the ocean floor, in which hydrothermal solutions contact the cold ocean water. In the activity presented in this article, the new environment is much more subtle; when the solution carrying the copper ions contacts nails that are placed in a test tube, it is the iron in the nails that provides the changed environment, causing the copper to form crystals.

Students are introduced to this type of mineral concentration by creating the components of the mineral deposit in a test tube, observing the growth of the copper crystals, and removing the crystal forms and comparing them to cataloged crystals. To begin, solid copper sulfate is placed in the bottom of the test tube and serves as the source of copper ions. This layer represents the copper dispersed in Earth's crust at a relatively low concentration.

A solid sodium chloride layer is placed on top of the copper sulfate and forms a physical barrier through which the copper ions must pass to contact the reducing agent—which, in this case, is the iron found in the nails placed on top of the sodium chloride layer. The water then slowly dissolves the copper in the copper sulfate—allowing the ions to become mobile. These copper ions diffuse throughout the entire solution. When this occurs and the copper ions contact the elemental iron present in the nails, the copper ions are reduced (i.e., gain electrons)

FIGURE 1

Test tube setup.

ALL PHOTOS COURTESY OF THE AUTHOR

FIGURE 2

Copper crystals in the test tube.

FIGURE 3

Cubic crystals.

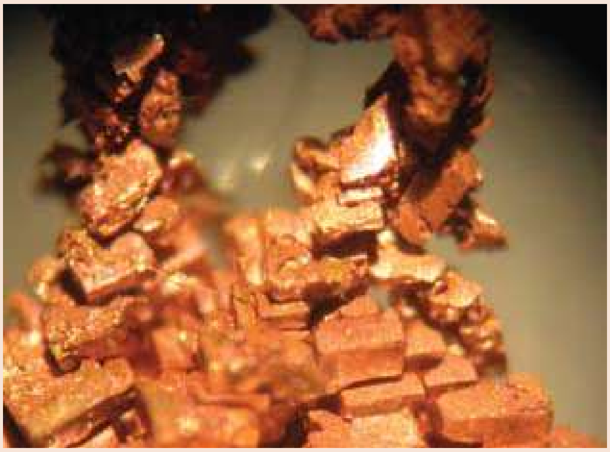


FIGURE 4

Dendritic crystals.

to elemental copper. In the process, the iron atoms are oxidized (i.e., lose electrons). As a result, copper crystals grow from the tips of the nails as more copper atoms are reduced. The salt layer provides a medium in which the copper crystals grow, spreading the crystals over a greater surface area.

Step-by-step instructions

Safety first

Before starting the activity, students should be trained in proper laboratory safety measures. Personal protective equipment (PPE), including indirectly vented chemical-splash goggles, aprons, and gloves, should be worn at all times when working with the materials in the test tube. Review the Material Safety Data Sheets (MSDS) for copper sulfate with students ahead of time. Copper sulfate is harmful if swallowed and can irritate skin and mucous membranes. In case of contact, rinse the skin with water, and if swallowed, provide water and call a physician. No food or drink should be allowed during this activity.

Procedures

A 20 × 150 mm test tube is appropriate for this activity, although larger or smaller sizes also work. The test tube setup is shown in Figure 1 (p. 43). It is important to note that exact quantities of copper sulfate and sodium chloride are not critical—simply giving the approximate depth of the layers is enough to ensure success.

Begin by placing approximately 1–2 cm of solid copper sulfate pentahydrate in the test tube and adding enough water to completely soak and cover this layer. Then lay a disk of filter paper, cut to the same diameter as the inside diameter of the test tube, on top of the copper sulfate. Next, place the same amount of solid sodium chloride in the test tube and add water to soak and cover it. Avoid stirring or agitating these solids so that only minimal dissolving occurs.

The sodium chloride layer should also be topped with a disk of filter paper. Put two or three nails (approximately 4 cm long)—pointed end up—on top of the second piece of filter paper. Finally, add enough water to completely cover the nails. The test tube may be covered at this time, although it does not need to be if the nails remain submerged. More water can be added if necessary.

Store the test tube vertically in a place where it will not be disturbed. Gas bubbles may form that will prevent the copper ions' migration to the top of the solution and thus their contact with the nails. Remove these bubbles by inserting a piece of copper wire into the test tube and gently moving it back and forth—this allows the gas to escape to the surface with as little disturbance to the solid layers as possible.

Observation of copper crystal growth

Once students have assembled their test tube, they begin recording observations. This is best done by drawing the test tube and noting the changes in color. Students should observe that the interface between the copper sulfate and sodium chloride layer has changed color, indicating a migration of the copper ions into the salt layer. After approximately two weeks, a significant amount of copper crystals should be visible in the test tube (Figure 2, p. 43). These crystals first appear in the sodium chloride layer as a pinkish streak emanating from the tips of the nails, and later become visible copper crystals that can be easily observed with a hand lens. During these changes, the copper sulfate layer first becomes black, and then yellow. The formation of the copper crystals is complete when the bottom copper sulfate layer has

FIGURE 5

Grading rubric.

Category	4 Points	3 Points	2 Points	1 Point
Participation	Student used time properly in lab and focused attention on the experiment.	Student used time fairly well and stayed focused on the experiment most of the time.	Student completed the lab but lost focus on several occasions.	Student's participation was minimal, or student was uncooperative about participating.
Crystal growth observations	All observation sessions are noted and completed neatly and accurately.	All observation sessions are completed but need improvement in accuracy and neatness.	Not all observation sessions are completed.	Minimal observation sessions are completed.
Images and identification of crystal forms	Two copper crystal images and two online images are included with correct identification of the crystal forms.	Two copper crystal images and two online images are included, but crystal forms are not correctly identified.	Two copper crystal images are included, but the online images and identification of the crystal forms are missing.	Only one copper image is included.
Comparison to actual mine	Comparison correctly identifies features of the test tube that are similar to an ore deposit.	Comparison is mostly correct with minor errors.	Comparison is inaccurate with major errors.	Comparison is not attempted.

"disappeared," and the copper is deposited throughout the test tube as copper crystals.

After a final observation and drawing of the test tube, students transfer its contents to a beaker. They may need a small spatula or other long probe to remove the solids in the tube; those containing the copper crystals can be removed from the beaker with a spoon and placed on a piece of paper towel to dry overnight. At this point, the copper crystals can be separated from the other solids (e.g., remaining fragments of nails and chlorides of sodium, copper, and iron) with a spoon or spatula and washed with tap water. This will dissolve most of the sodium chloride that can then be disposed of properly. The solid wastes removed from the crystals should be collected and placed in a container for disposal. (**Safety note:** Dispose of container and unused contents in accordance with federal, state, and local requirements. Students should wash their hands with soap and water after completing the activity.)

CAUTION

Examination and identification

Before observing the newly formed crystals, students should be introduced to the expected forms. This can be accomplished by pointing students to the "Copper Crystal Forms" page on the Seaman Mineral Museum's website (see "On the web"). Crystal forms are identified on this site ("Copper Crystal Shapes" page) and images of copper specimens—some of which are labeled with the type of crystal form—can also be found here. The Mineral Society of America website is another helpful reference for crystal images (see "On the web").

After this introduction, students can examine the dried copper crystals—this works best with a binocular microscope under 10× or 30× power. A hand lens may also be used, but higher powered microscopes (30×) allow students to see the crystal structure more easily. At this point in the exercise, students' goal is to find two different crystal types in their sample and match them with an image from the Seaman Mineral Museum or Mineral Society of America websites. (**Note:** I make a few crystals of my own for occasions when a student's sample fails to produce two crystal forms.) Once the two forms have been found, students can print them out to be verified and included in the final report (see "Processing the experience," p. 46).

Obtaining images of the crystals that students create in class may be done with a digital microscope, although I have also had success using a digital camera. Set the camera to "macro close-up" with no flash; using the self-timer function, take the picture directly through the eyepiece of the binocular microscope. The photos in Figure 3 (p. 44) of cubic crystals, and Figure 4 (p. 44) of dendritic crystals, were taken using this method.

At the end of the activity, I collect all of students' copper crystals. These collected crystals can also be used for students whose setup does not form good crystals.

Processing the experience

To finalize the exercise, I have students submit a report that includes observations made while the copper crystals are growing, images of their crystals, and the respective website images. Students must also write a description of the copper concentration process that occurs in the test tube and compare it to the concentration of other economically important minerals in Earth's crust, such as gold, silver, and lead. References to articles or textbook descriptions of economic mineral deposits help students in this process. The report is graded using the scoring rubric presented in Figure 5 (p. 45).

Conclusion

My students enjoy the process of creating their own crystals and using microscopes to examine them, and they often express amazement when they see the final product—beautiful, clean crystals that have grown from a "dirty" test tube. In the end, an understanding of the natural process of mineral formation is obtained, and it is my hope that students experience a sense of wonder at its complexity. ■

Timothy John Corcoran (tcorcora@wisp.k12.wi.us) *is a teacher at Stevens Point Area Senior High School in Stevens Point, Wisconsin.*

Minerals and crystals.

A mineral is a naturally occurring, inorganic solid with a specific chemical composition and specific physical properties. Minerals almost always contain a metal and some other elements, or (as in the case of the copper crystals described in this activity) a relatively pure metal (copper) (Smithsonian Education 2008). The metal mineral deposit presented in this article is the metal copper. Most minerals occur naturally as crystals, deposited over time in the Earth. A crystal is any solid having a regular crystalline structure and can be created in the lab (e.g., sugar crystals). All minerals are crystals, but not all crystals are minerals.

Acknowledgments

This article is based on activities of the Teachers' Earth Science Institute (TESI), funded by the National Science Foundation (award #0227502). Francis Otuonye served as the principal investigator, and Ted Bornhorst led the TESI I attended in 2004 and 2005. The method of growing copper crystals presented in this article was originally described in an article appearing in the *Journal of Chemical Education* (Cortez, Powell, and Mellon 1988). The scoring rubric provided in this article was created using the RubiStar website (see "On the web").

On the web

A.E. Seaman Mineral Museum: *www.museum.mtu.edu/Gallery/copper.html*

Mineral Society of America: *www.minsocam.org/MSA/collectors_corner/vft/mi4a.htm*

RubiStar: *http://rubistar.4teachers.org*

References

Cortez, J.A., D. Powell, and E. Mellon. 1988. Test tube geology: A slowly developing Redox system for class study. *Journal of Chemical Education* 65 (4): 350–351.

Smithsonian Education. 2008. Minerals, crystals, and gems: Stepping stones to inquiry. *www.smithsonianeducation.org/educators/lesson_plans/minerals/minerals_crystals.html*

PHOTOGRAPHY BY JOHN A. JASZCZAK