Activity 18: Crystal Growth by Evaporation

Maine Geological Survey

Objectives:

To introduce students to the following concepts: that crystals, and therefore minerals and rocks, can grow (in the non-biological sense) and that the size of a crystal is controlled by the amount of available material and the duration of crystallization. This exercise can also give students a very general idea of the nature of magma - molten material that eventually crystallizes into igneous rocks.

Time:

This activity is designed to last one 40-50 minute class period.

Background:

Crystals are naturally occurring, structured substances with a specific chemical formula. Crystals form in two basic ways. One way is for a pure liquid or vapor to suddenly undergo a drop in temperature to a level below its freezing point and crystallize. The second way is for a saturated solution to have its solute - solvent equilibrium shifted so that excess solute is present. This can happen by either the addition of more solute into the system, or the removal of solvent from the system. Solvent is often removed by simple evaporation. The evaporite deposits of borax and other minerals in Boron, California are a classic example.

To make a saturated solution, keep adding the solute (the chemical which will form the crystals) to water at room temperature until no more chemical will dissolve and some solid settles to the bottom. This can be stored from one year to the next.

While the mechanics of crystallization are often very complex, the principle remains the same. As solvent is removed from the chemical system (referred to as the crystal melt), or as the temperature of the system drops, crystals form in direct proportion to the original amount of material.

Crystals and crystal studies are crucial to such diverse activities as the production of silicon chips for computers, lasers for eye surgery, and other high technology items. Additionally, crystal-related information is a significant geological research tool.

In this activity, the potassium dichromate will form orange needles, and the copper II acetate will form blue octahedra. Specific crystallographic shapes and data can be found in the Merck Index.

Materials:

Each CLASS of students will need:

- 100 ml of a solution of potassium dichromate, $K_2Cr_2O_7$
- 100 ml of a copper II acetate solution $Cu(C_2H_3O_2)_2$
- A medicine dropper for each solution
- A metal spatula for each solution
- 2 hot plates.

Each GROUP of students will need:

- 2 glass slides
- A drop of each solution
- A good quality hand lens or a microscope

The potassium dichromate solution is made by dissolving 4.9 grams of the salt in 100 cc of water (preferably distilled); the copper acetate solution is made by dissolving 7.2 grams of the salt in 100 cc of water. The water should be at 20 degrees C. If you do not see crystals on the bottom of each beaker you may need to add 0.50 grams more of each solute.

Procedure:

Using one medicine dropper, students place one drop of potassium dichromate on one end a microscope slide; using the second eye dropper students place a drop of the copper II acetate solution on one end of a second slide (see Figure 1). With the hot plates on the LOW (less than 100 degrees) setting, have the students place the end of the microscope slides containing the drop of the solution on the hot plate; leave them there JUST until the first crystals begin to form. Have the students remove the slides from the hot plate and observe the rest of the crystallization with the hand lens or microscope. Have them sketch the results and answer the associated questions.

Do not mix the solutions. The end of the slide with drop goes on the hot plate.

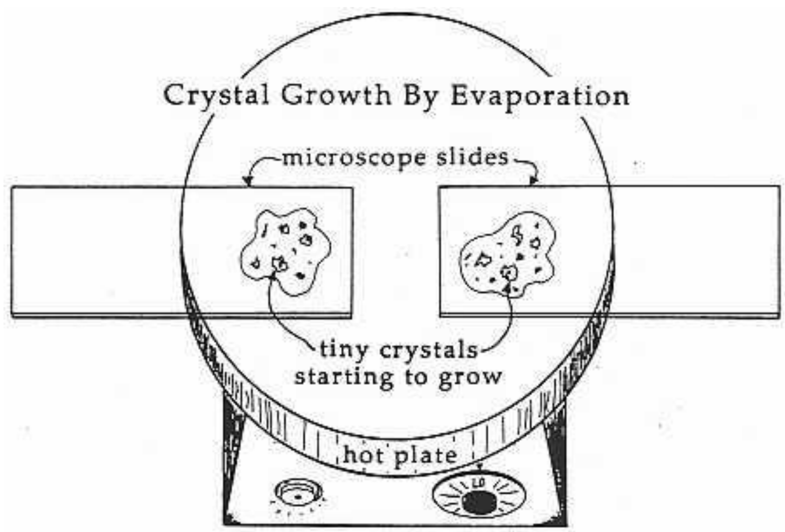

Figure 1. Experimental set-up for the formation of crystals by evaporation.

Special Safety Procedures:

As students will be handling chemical solutions, albeit in small amounts, they should be wearing safety goggles. Caution them NOT to touch the hot plate. The solutions are TOXIC if ingested, but this should not be a problem as no student should EVER eat ANYTHING in the laboratory. When students are done observing their crystals, they can scrape them back into the original beakers eliminating any disposal problems IF these solutions are retained for use next year. If the solutions are not to be saved, disposal should be according to accepted school protocol. Alternative non-toxic compounds which will also crystallize very well, but are less colorful, include alum (aluminum potassium sulfate), salt (sodium chloride), and sugar (dextrose).

Follow-Up:

There is a wealth of crystal related activities that one can pursue. Have a student research Bowen's Reaction series and report back to the class on this topic. Relate this to a brief discussion of Maine pegmatite deposits.

There are a number of excellent books on crystal growing and preservation. These can be used as enrichment activities for certain members of the class.

If samples of mineral crystals of the six crystal systems are available, pass these around for class discussion; discuss crystal systems and how we use them to categorize information about crystals. (See Ward's Introductory Crystal Form Collection or their crystal growing kits).

Find out about the "Crystal Consciousness" movement and how they purport to use crystals. This should be a debunking activity and may have to be handled carefully.

Larger crystals can be grown over a period of several days by first obtaining a small crystal, attaching it to a string and then suspending it in supersaturated solution of the same substance. Keep string from touching sides or bottom of beaker. Larger crystals can be preserved by spraying them with Krylon spray (found in art supply stores) or painting them with clear nail polish.

References:

Activity adapted by Duane Leavitt from materials in the *Earth Science Source Book*, edited by John R. Carpenter (Center for Science Education, University of South Carolina, Columbia, South Carolina, 1987)

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Student Sheet

Purpose:

To observe the growth of crystals from a cooling, saturated solution, as an example of the crystallization of minerals in a cooling magma.

Materials:

Each class will have a 50 ml beaker of potassium dichromate, a 50 ml beaker of copper II acetate, a medicine dropper and metal scoop for each solution, and 2 hot plates - one for each solution. Each group of students will need one drop of each solution, two glass microscope slides, and a hand lens or a microscope.

Procedure:

Make certain that you wear your safety goggles during this activity; do not spill any other solutions; be certain to wash your hands thoroughly at the end of this activity.

Using the indicated medicine dropper, place one drop of potassium dichromate solution on one of your microscope slides; using the OTHER medicine dropper, place one drop of the copper II acetate solution on the OTHER microscope slide. DO NOT mix solutions or place the medicine dropper from one beaker into the other.

With the hot plate on a low setting, (less than 100 degrees), place the end of the slide containing the drop of solution on the hot plate. Leave the slides on the hot plate until the first crystals start to form. When this happens remove the slides from the hot plate and observe under magnification; sketch what you see below. When you finish observing your crystals, scrape them into their respective beakers, rinse and dry the microscope slide, and return all equipment to the instructor.

POTASSIUM DICHROMATE:

COPPER II ACETATE:

Questions:

1. Why did the solution begin to crystallize?

2. What was the role of heat in the crystallization process?

3. Compare the sketch of your crystals with other students' sketches; do crystals of the same material generally have the same shape? If so, why?

4. List one environment where crystals form by evaporation and one where they would form by a drop in temperature. What is supplying the energy of crystallization in each case?