

Identify Your Mineral Treasures Part Four: Chemical Mineralogy Testing Techniques

Knowledge is the most valuable tool for identifying mineral specimens. The scope of that knowledge, much of which has been reviewed to this point in previous issues, provides the foundation upon which minerals reveal themselves as individual and unique compounds.

Such foundation encompasses a thorough understanding of the various aspects of mineralogy, that is:

descriptive mineralogy recognizes the general characteristics of each chemical class of minerals, and the geologic environments in which they are customarily found;

determinative mineralogy involves extensive research to gain familiarity with the geologic environment prior to venturing into the field;

physical mineralogy explores the testable characteristics of all minerals, such as hardness, luster, color, streak, cleavage, etc.;

crystallography defines the observable external habits of mineral compounds produced by the crystalline arrangement of the atoms within;

and finally, *chemical mineralogy* determines the actual elemental content of the mineral species.

While the first three have been extensively presented in previous issues of **Discover Minerals**, chemical mineralogy continues herein from Volume 2 Issue 1, while crystallography remains to be investigated in upcoming issues.

Already we have gained fundamental knowledge of the physical characteristics of minerals (luster, hardness, color, diaphaneity, etc); learned the various specific environments minerals typically occur in; become familiar with the basic characteristics of each class of mineral compounds; and equipped a home lab with the necessary tools and reagents to conduct simple chemical analyses. Now we are ready to perform some simple, but revealing preliminary tests!

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Boss Mine Overlooking Sandy Valley

FUSIBILITY

First, a mineral's fusibility—or degree thereof—can be quickly determined by observing *how* or *if* the test sample melts. Secondly, the elements in the test assay can be oxidized or reduced to produce characteristic results.

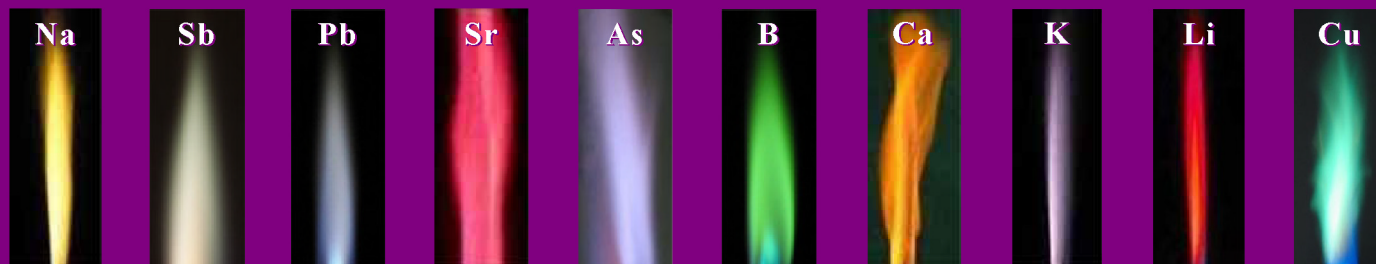
Fusibility is a measure of how readily mineral samples melt, ranging from very easy to completely infusible. For example, most sulfides melt rather easily; most of the other groups, less so or not at all. But keep in mind, although a lack of fusibility may be disappointing from an emotional perspective, it is nonetheless significant by eliminating contenders. Also, while many samples may not fuse at all, some may glow briefly after removal from the heat source (called *phosphorescence*, wherein the material absorbs energy, then releases it relatively slowly in the form of light, usually a faint green). Other infusible specimens can get hot enough to glow brightly while subjected to continued intense heating (called *incandescence*).

For those samples that do melt, the nature of the product is significant and should be noted, as this is often diagnostic for certain mineral species. Some melt to a colorless clear or white bubbly glass; others, to a black glass. Still others may be magnetic, indicating the presence of iron. Swelling is common for borates; vermiculite exfoliates in a fashion reminiscent of expanding pages of a book. Some minerals will break apart violently (*decrepitate*) due to expanding gases in the sample.

Heat a sample on charcoal, or hold a splinter with tweezers at the tip of the visible outer portion of a gas flame (the hottest zone). If the sample decrepitates, either moisten it with water or saliva, or heat it in a test tube until the popping stops, resulting in the sample being left in a powdered form. Then, resume the test on charcoal.

FLAME COLORATIONS

While performing a fusibility test, pay special attention to any color imparted to the flame. Various elements produce characteristic colorations that will immediately suggest chemical content that can then be investigated further with more precise confirmatory tests. A drop of acid on the sample, such as hydrochloric or sulfuric acid, will enhance such colorations after reheating. The most common and distinctive colors include emerald green (copper), light blue (lead, arsenic), yellow-green (boron), persistent and intense yellow (sodium), orange-red (calcium), crimson (strontium), and violet (potassium).



This is a sample of the more common elements likely to be encountered. Most flame colors are the result of the formation of halide salts by moistening the test sample with a drop of hydrochloric acid. A notable exception is boron, which results from a sample that is moistened with sulfuric acid.

CHARCOAL RESIDUES

Roasting samples on charcoal provides added benefits while performing fusibility tests. Many minerals, particularly sulfides, leave distinctive residues on the surface of the charcoal. For instance, a yellow stain close to the assay with white farther away indicates the presence of lead; the same yellow stain that turns white after cooling is a peculiarity of zinc. A white stain some distance from the assay indicates arsenic. In this case, an unmistakable garlic odor will also be produced.

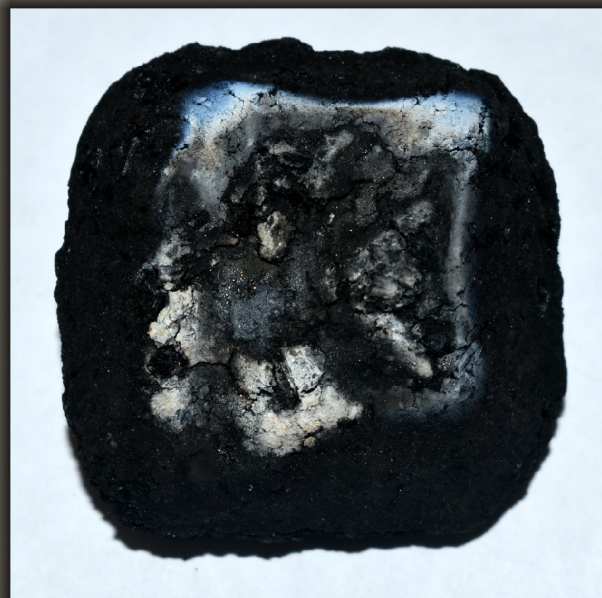
In addition, many sulfides can be reduced with careful heating in such a way as to leave metallic globules in the fused mass. Some minerals, however, need to be fused in a flux, such as sodium carbonate, to accomplish the reduction. Typical globules include gold, silver, copper, and lead.

Distinguishing Assay Results

These two tests show somewhat similar results. Both were conducted by roasting the sample in an oxidizing flame.



This test left a yellow residue near the assay, white farther away. Note the silvery metallic globule. The result is characteristic of lead; the globule is, in fact, elemental lead, which is easily identified by its soft, malleable nature. Sample used was cerussite.



The right sample is white away from the assay with a blue tinge near the edges. Minute, silvery metallic globules are present, but are not malleable. This test provided the typical results expected from antimony-bearing minerals. Specimen was stibnite.

BEAD TESTS

Some elements impart characteristic color when dissolved in certain fluxes, such as sodium carbonate and borax. The color of the resulting fused mass will depend on whether it was heated in the oxidizing or reducing part of the flame, and will often change color upon cooling. Borax bead tests are the easiest and most sensitive, and the cold oxidation/reduction results are very rewarding in determining such elements as manganese (red-violet/colorless), nickel (red brown/opaque gray), uranium (canary yellow/pale green), cobalt (blue/blue), iron (yellow/bottle-green), and copper (blue-green/opaque red).

TUBE TESTS

Tube tests include both open and closed tubes. The purpose is to heat fragments or powdered samples in the tubes and note any reactions, such as fumes or condensation of sublimates on the walls of the tubes.

The open tube is generally used for making oxidizing tests. A small portion of powdered test material is placed in the tube near one open end. The tube is then held at a slight incline over a flame just above, or sometimes directly beneath, the sample. This creates a steady current of air that will oxidize the elements in the specimen if that reaction is possible. If so, various oxides will be produced that will either escape as gases at the other end of the tube, or will condense as sublimates on the cooler areas of the tube.

If, for example, sulfur is present, sulfur dioxide (SO_2), a pungent and very noxious gas, will issue from the upper end of the tube. Arsenic will be oxidized to form arsenious oxide (As_2O_3) that will deposit as white crystals some distance from the assay. Mercury (Hg) forms gray, metallic globules, while antimony oxidizes to a tetraoxide (Sb_2O_4) that settles as a pale yellow (hot) to white (cold), amorphous substance on the bottom of the tube. These are just a few of the more common open-tube reactions.

Reducing conditions are created in closed-tube reactions, in which the mineral is heated in the absence of oxygen. For the most part, no chemical reactions are involved. Two of the better-known reactions involve sulfur and arsenic. Native sulfur and sulfides with a high content of sulfur will fuse to a volatile mass that is red when hot, turning to yellow as it cools. Elemental arsenic forms two rings around the tube, one composed of a black amorphous material; the other, a crystalline, silver-gray “arsenic mirror” substance.

Perhaps the best use of the closed tube test is to determine the presence of water in the mineral, either as water of crystallization (H_2O) or as hydroxyl ions (OH). If water is present in either of these two forms, it will condense as droplets on the inner walls of the tube. Care must be taken to ensure that the water is actually derived from the mineral, rather than from humidity of the ambient air. To do this, gently heat the tube beforehand to drive off any pre-existing water.

These simple testing techniques, combined with knowledge and experience that includes familiarity with the many other characteristics of minerals, produce results that are often all that is needed to identify an unknown sample. Nevertheless, it is inevitable that minerals will be encountered that resist easy identification.

In such cases, more elaborate and time-consuming wet tests must be performed to confirm or deny the presence of various elements in the specimen. Despite these drawbacks, performing chemical tests can and should be rewarding, satisfying, and exhilarating. To this end, the many chemical tests involved in identifying the various elements that combine to form thousands of known minerals—and unknown minerals that have yet to be discovered—will be detailed in Volume 2 Issue 3 of **Discover Minerals**.

Next issue continues with **Testing Techniques**