# VI MINERAL IDENTIFICATION

#146

*This section covers methods of testing for some of the more important properties of minerals. The three articles on specific gravity were originally published over a period of about six years, and there is some repetition, but each approached the subject in a different way, so all were retained essentially as first printed.*

## CLUES TO MINERAL IDENTIFICATION

Every mineral collector has specimens he is unsure of. Most of us rely on the opinion of other collectors, or on visual examination in the hope that we'll see a resemblance to a known specimen or photograph. Even if you have an "in" with someone who has the equipment and ability to test and identify your specimen, you have still learned only what that particular one is, and you're back to the beginning on the next one. It should be emphasized that THERE IS NO ONE TEST THAT WILL IDENTIFY EVERY SPECIES WITH CERTAINTY.

Most collectors know much more about their unknowns than they realize, and they are capable of learning even more by applying a few simple tests and organizing their observations. The form below will serve as a checklist, and by putting all the information together with the help of a little reasoning you may be able to identify one or more of your unknowns with a good degree of certainty.

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Specimen No. | Possible Species:

Locality:

Description (Color, luster, XL shape, etc.):

Associated Minerals/Rocks:

Cleavage, Fracture:

Striations: | Inclusions:

Fluorescence (LW/SW): | Rare Earth Spectrum:

Magnetism: | Conductivity: | Radioactivity:

Specific Gravity: | Hardness: | Streak:

Acid Reaction:

Fusibility: | Flame Color: | Fluoride Etch:

Closed Tube Test:

Other tests or observations:

## THE USE OF HEAVY LIQUIDS FOR DETERMINING SPECIFIC GRAVITY OF MINERALS
#38

Specific gravity (G or S.G.), the ratio of the weight of a mineral (or other solid) to an equal volume of water, is a valuable property for differentiating minerals when used in conjunction with other methods of identification. With large pieces of pure mineral, various weighing methods may be used, but they are seldom sensitive enough for the micromounter. Heavy liquids, on the other hand, can be utilized with only small chips of a mineral, however the useful range is limited to the specific gravity of the heaviest liquid available. The method is based on the principle that a piece of pure mineral, regardless of size, will float on a liquid of higher specific gravity than itself, or sink in a lighter one. A mineral will remain suspended in a liquid when both have the same gravity.

Three commonly used organic solvents and their specific gravity are:

| | |
|---|---|
| Bromoform | 2.89 |
| Acetylene tetrabromide | 2.96 |
| Methylene iodide | 3.32 |

Organic solvents such as these may be subject to decomposition, and should preferably be stored in air-tight brown glass bottles away from light. A few small pieces of clean copper wire placed in the bottles will aid in preventing decomposition. These liquids are volatile, and all have some degree of toxicity, particularly by inhalation, so should not be used for long periods of time, and then only in a well-ventilated area. They are not flammable, though it is inadvisable to smoke while using, as very toxic breakdown products may be produced by the heat of the burning tobacco, and inhaled directly into the lungs. They are not miscible with water, so other organic liquids must be used if dilution is desired. Denatured alcohol is suggested as it is readily available and has a gravity of approximately 0.8.

The heaviest liquids which are most practical to use are compounds of thallium as shown with their specific gravities:

| | |
|---|---|
| Thallous formate | 3.4 |
| Thallous malonate-formate (Clerici or TMF solution) | 4.0 - 4.25 |

These liquids are not only heavier than the organic solvents but may be readily diluted with distilled or deionized water to give a wide range of gravities. Since they are not volatile at room temperature, there is little or no hazard from inhalation, but they are poisonous if swallowed, and are the basis of depilatories, so it is important to thoroughly wash hands, containers, or other surfaces with which they have been in contact in order to avoid transfer, especially to mouth or eyes.

Although there are other ways of applying heavy liquids, this discussion will be based on the comparison of minerals with liquids of known gravity. A satisfactory set of liquids may be made up in small tightly-capped glass or plastic vials which may be available from pharmacies or laboratory supply houses. The lowest practical gravity is 2.0, since few minerals are lighter, and of those, most are water-soluble, and would dissolve in the liquid. A gravity difference of 0.2 between each liquid is accurate enough for most work. A mineral species may vary by this amount, so that extreme accuracy is of doubtful value. Impurities and air trapped within a mineral can alter the gravity, so it is important that the piece selected for testing be as clear as possible, and free from inclusions, surface coatings, or cracks which could trap air.

Ideally, dilutions should be prepared with accurate measuring devices such as pipettes or burettes, however good results may be obtained by counting drops from a medicine dropper. To determine the amounts necessary for a certain gravity, the following formula may be used:

$$\text{G of Mixture} = \frac{(\%\text{ heavy liquid} \times G) + (\%\text{ light liquid} \times G)}{100}$$

Obviously the percentages of the two liquids must add up to 100. This formula may be readily plotted on graph paper for convenience. (G of water = 1).

It is important to remember that water used for diluting thallium compounds may evaporate, and that mixed organic solvents may evaporate at different rates, so that the gravity of a liquid may change over a period of time. Whenever an unknown mineral is checked, a solid of known gravity (see table) should be placed in the liquid for confirmation. If loss by evaporation has taken place, water (or solvent) may be added a drop at a time until the proper gravity is reached.

Work should preferably be carried out near a sink, using a tray to prevent contamination of table tops and to contain spills if they should occur.

To carry out a determination, a practical method is to prepare a series of thallous malonate-formate solutions with gravities from 2.0 up to the highest value obtainable, in increments of 0.2. A clean, dry chip or crystal of unknown gravity is placed in the 3.0 liquid and its action noted. Tweezers should be used for handling, and magnification may be necessary for very small pieces. To avoid confusion it is advisable to write down the effect at each gravity, using symbols such as S (specimen sinks), F (specimen floats), and = (specimen is suspended in liquid).

If the specimen floats, the vial should be swirled gently to insure that no air is trapped in the specimen, and that it is completely wet with liquid. If it still floats, it should be removed with tweezers, drained on the side of the container, dipped in alcohol to rinse, and allowed to dry thoroughly. Since its behavior indicates that its gravity is less than 3.0, it is next placed in a lighter liquid such as 2.6. If it sinks, it is cleaned,dried, and placed in a liquid of higher gravity. This process is repeated until it sinks in one liquid and floats on the liquid of next higher gravity. The gravity of the specimen is then between that of the two liquids. If it remains suspended in a liquid, it has the same gravity as the liquid.

With practice the gravity may be more closely estimated. A specimen having a gravity just higher than the liquid will sink rather slowly, and can be temporarily resuspended by swirling the vial. If it is only slightly lower than the liquid, it may sink slightly when swirled, then return to the surface.

When an unknown is suspected of being one of two minerals of differing specific gravity, such as calcite (G = 2.7) or aragonite (G = 2.9) only one determination will be necessary. If the specimen is placed in a liquid of 2.8 G, pure calcite will float and pure aragonite will sink.

The usefulness and accuracy of determining specific gravity of minerals with heavy liquids is up to the individual and his or her care in preparation, application, and constant checking of liquids with known specimens.

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## TABLE OF SUGGESTED REFERENCE MINERALS FOR ESTIMATING SPECIFIC GRAVITY

| Specific Gravity | Suggested Minerals |
|---|---|
| 2.1 | Sulfur |
| 2.2 | Graphite (natrolite) |
| 2.3 | Gypsum, analcime (sodalite) |
| 2.3 - 2.4 | Apophyllite |
| 2.5 | Leucite |
| 2.65 | Quartz |
| 2.7 | Calcite (beryl) |
| 2.8 - 2.9 | (Muscovite) dolomite |
| 2.9 | Aragonite (carbonate-apatite) |
| 3.0 | Danburite (datolite) |
| 3.0 - 3.1 | Elbaite |
| 3.1 - 3.2 | Fluorite, Fluorapatite |
| 3.3 | Vesuvianite, diopside, serandite |
| 3.5 | Diamond, spinel |
| 3.6 | Aegirine, strontianite, topaz |
| 3.7 - 3.8 | (Staurolite), rhodonite, benitoite |
| 3.8 - 3.9 | (Siderite) |
| 4.0 - 4.1 | Corundum, celestite |
| 4.2 - 4.25 | Rutile |

These minerals are suggested for use in a reference set to check specific gravity liquids. Chips or crystals should be selected for clarity and freedom from inclusions, surface coatings, and internal bubbles or cracks. Quartz is said to be one of the most constant, and clear small crystals or chips are fairly readily obtainable. The minerals in parentheses are generally not as constant, or are less readily available in pure form as those listed before them.

## AIDS TO MINERAL IDENTIFICATION: SPECIFIC GRAVITY

SPECIFIC GRAVITY: The ratio of the weight of a mineral to the weight of an equal volume of water.

| SG | Representative Minerals |
|---|---|
| 1 - 2 | Borax and most water-soluble minerals |
| 2 - 2 1/2 | Sulfur, graphite, opal, gypsum, most zeolites, soft minerals. |
| 2 1/2 - 3 | Quartz, feldspars, talc, beryl, calcite, aragonite, micas, carbonate-apatite. |
| 3 - 3 1/2 | Fluorite, apatites, epidote, tourmalines, pyroxenes, amphiboles, many phosphates and silicates. |
| 3 1/2 - 4 | Garnets, topaz, diamond, siderite, sphalerite, many silicates. |
| 4 - 4 1/2 | Corundum, rutile, barite, goethite, chalcopyrite |
| 4 1/2 - 5 | Marcasite, molybdenite, covellite, other sulfides and sulfosalts. |
| 5 - 6 | Pyrite, magnetite, hematite, heavy metal oxides, sulfides, sulfosalts. |
| 6 - 7 | Wulfenite, vanadinite, mimetite, uraninite. |
| 7 -8 | Galena, Pyromorphite. |
| over 8 | Native metals. |

Minerals of non-metallic luster are generally less than 4 1/2. Those over 4 1/2 have metallic, submetallic, or adamantine luster.

### TESTS FOR SPECIFIC GRAVITY (SG)

WEIGHING METHODS: The weight of the mineral and the weight or volume of the water which it displaces are obtained.

Beam Balance. The specimen is weighed in air, then suspended in water from the balance beam and reweighed. The difference in weight is equivalent to the volume of water displaced.

$$SG = \frac{\text{Weight in air}}{\text{Weight in air - weight in water}}$$

Jolly Balance. The relative weights of the specimen in air and in water are obtained by suspending the specimen from a spring and measuring the vertical displacement produced in each case.

Pycnometer. Using a specially designed bottle, which assures a reproducible capacity of water, the weight of the mineral and the weight of water displaced by it are obtained through a series of weighings. (Useful for small specimens, fragments, powders, and sands).

Liquid Displacement. The specimen is weighed, then placed in a graduated cylinder partially filled to a known volume. The increase in the water level is equivalent to the volume of the mineral. (Useful mostly for larger specimens.)

HEAVY LIQUIDS: A mineral will float on the surface of a liquid heavier than itself, sink in a lighter one, and be suspended beneath the surface of a liquid of identical gravity.

Method of Matching Liquids. The mineral is placed in a liquid on which it floats, and a lighter miscible liquid added until the specimen just starts to sink. The specific gravity of the resulting matching liquid mixture is then obtained either by weighing a known volume, by using a Westphal or specific gravity balance, by comparison with solids of known gravity, or by measuring the refractive index, which changes in proportion to the relative volumes of the two liquids. If a known volume of the heavier liquid is used, and the volume of the added liquid is accurately measured, the specific gravity may be calculated or read from a prepared chart.

Sink-Float Method. The specimen is placed in a liquid of known specific gravity and its action observed. If it floats, it is then placed in successively lighter liquids until it sinks; if it sinks, it is placed in successively heavier liquids until it floats. The specific gravity then lies between that of the liquid in which it sinks, and that of the liquid in which it floats.

USEFUL LIQUIDS. There are two general classes of liquids which are commonly used in determining the specific gravity of minerals:

1. Clerici Solution or TMF is a water solution containing thallium malonate and thallium formate, two salts of high specific gravity. The highest practical gravity obtainable is about 4.2, which may be diluted with water to any desired lower value. Above 4.2 the liquid becomes syrupy and tends to crystallize out of solution. Although TMF may be used in the matching liquid method, the sink-float method is to be preferred. Thallium salts are toxic, and this method keeps handling to a minimum. A set of liquids of small volume diluted with water to produce a range of 2.0 to 4.0, in increments of 0.2 is recommended. Few minerals have a gravity of less than 2, and of these most are water-soluble, and thus could not be measured, as they would dissolve in the liquid. Specimen chips may be handled with tweezers to prevent contact of the fingers with the liquids. Chips may often be obtained even from thumbnail or micro specimens with little damage to the parent specimen and observed under magnification.

2. Organic Liquids have often been used in the study of minerals. These include methylene iodide with a gravity of 3.32, acetylene tetrabromide (or s-tetrabromoethane) 2.96, and bromoform 2.89. They are usually diluted with acetone or alcohol to produce solutions of lower gravity, however the specific gravity of solutions so prepared will change fairly rapidly due to the volatility of the solvents. They should be handled carefully and with good ventilation, as they are also toxic, and the lighter solvents used for dilution may present a fire hazard. Organic liquids would be the method of choice where water-soluble minerals are being examined.

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