MINERAL IDENTIFICATION FOR BUDDING MINERALOGISTS

A presentation by Michael Hopkins
At the May 2024 general meeting of
the Contra Costa Mineral and Gem Society

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Much of the information and whole sections have been blatantly lifted from a presentation by Jim Hutchings, Roseville Rock Rollers Gem and Mineral Society. Thank you for the use of your material. I also wish to thank

All minerals have properties when taken together help us to identify them. Today's discussion is to introduce you to basic physical properties and methods we amateur rockhounds use to help us identify minerals and rocks.

ELEMENTS, MINERALS & ROCKS OH MY!

ELEMENT

An element is **a substance that cannot be broken down into a simpler format.** They are distinguished by a unique atomic number. The elements are organized by their atomic number in the periodic table, which highlights elements with similar properties. *(National Geographic Society)*

MINERAL

A mineral is a **naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal form, and physical properties.** *{USGS.gov)* And most importantly, has been exhaustively studied and characterized by mineralogists, declared unique in its composition and structure, and the original specimen(s) that was studied deposited for preservation in a professionally curated museum.

ROCK

A rock is an aggregate of one or more minerals, or a body of undifferentiated mineral matter. *(USGS.gov)*

IDENTIFYING PROPERTIES

VISUAL, COLOR

One of the most important tools we have is visual observation. As we become more experienced with minerals visual observation becomes easier and is a good starting point from which to explore. **Results from simple tests can confirm our initial observation.** But a single observation rarely is sufficient to determine an ID.

Color by itself may give you insufficient information. Approximate percentage of minerals by color: Yellow (32%), White & Brown (29%), Green (27%), Red / pink (24%), Black (19%), Blue (13%), Orange & Violet / Purple (5%), Colorless (29%). *(Mineral Identification, Peck)*

HARDNESS

The atomic structure of minerals will dictate how resistant the specimen is to destruction. **Soapstone** is easy to carve, but **diamond** is not. The relation of a specimen's hardness at its surface is mostly dictated by the arrangement of its atoms. Fredrick Mohs observed and created a scale of mineral hardness in the 18th century. We still use this scale today for determining the "hardness" of a mineral.

The scale is metered at increments of I - I0. The softest of minerals are rated at **1** and the hardest at **10.** Mohs' selected IO minerals that are most readily available and meet the needs of a graded scale for comparison of most other mineral specimens. The scale below articulates the minerals and their position on the scale.

	Mohs' Hardness Scale	
1.	Talc	Talcum powder.
2.	Gypsum	Gypsum is formed when seawater evaporates from the Earth's surface.
3.	Calcite	Limestone and most shells contain calcite.
4.	Fluorite	Fluorine in fluorite prevents tooth decay.
5.	Apatite	When you are hungry you have a big "appetite".
6.	Orthoclase	Orthoclase is a feldspar, and in German, "feld" means "field".
7.	Quartz	Watches, mood stones
8.	Topaz	The November birthstone. Emerald and aquamarine are varieties of beryl (Moh's 8).
9.	Corundum	Sapphire and ruby are varieties of corundum. Twice as hard as topaz.
10.	Diamond	Used in jewelry and cutting tools. Four times as hard as corundum. *(Uni. Of Arkansas)*

Test kits are available (Mineralab) that have picks that match the Mohs' Hardness Scale.

We can also use commonly available materials to do this test.

2.5	*Fingernail*
2.5–3	*Gold, Silver*
3	*Copper penny*
4-4.5	*Platinum*
4-5	*Iron*
5.5	*Knife blade*
6-7	*Glass*
6.5	*Iron pyrite*
7+	*Hardened steel file*

A simple field test helps to narrow the possibilities. (See Relative Hardness procedure Pg 11.)

A **pocketknife** (carbon steel blade) will give a good test of hardness. The pocketknife blade has a hardness of around **5.5** on the scale.

5.5 is **<u>harder</u>** than **Calcite, Fluorite, Gypsum,** and **Talc.** The softer the mineral the easier you can scratch them with greater depth. *5.5* is about the same as **Apatite,** but **<u>softer</u>** than **Feldspar, Quartz, Topaz, Corundum,** and of course **Diamond.** Except Apatite, each of these other minerals will scratch the blade with ease.

STREAK

In mineralogy the term **Streak** is the color of a powdered mineral left on an unglazed tile when the mineral sample is rubbed on the surface. The streak color is often not the color of the bulk sample. Examine the color of a freshly broken surface of the mineral. Scrape the color of the specimen along a piece of unglazed porcelain. Note the color of the specimen and the streak it leaves.

You may find some of the following results:

SPECIMEN	COLOR	STREAK
Magnetite	Iron black	Iron black
Iron Pyrite	Brass Yellow	Greenish black
Chromite	Brown / Black	Grayish brown
Gold	Gold	Gold
Limonite	Yellow	Yellow
Rutile	Red / Brown	Pale yellowish
Epidote	Green	Pale yellow
Chlorite	Dark green	Grayish green
Hornblende	Greenish black	Pale gray green
Biotite Mica	Black / Brown	No streak
Wulfenite	Yellow / Orange	No streak

Field Test kit

- A piece of plain white paper (a blank specimen label works great.)
- Your fingernails (preferable still attached to your fingers!)
- A copper penny (pre-1983; or small – ½ inch – piece of copper; or short piece of heavy copper wire.)
- A small piece of fluorite (a broken cleavage piece is fine.)
- A pocketknife (NOT a Swiss Army knife – the steel in those is harder than in most cheap pocket knives, which can throw hardness tests off.)
- A small section of a steel file (a 2 - 3 inch tip from a triangular file for sharpening chain saws works fine.)
- A piece of a quartz crystal (with at least one good face and a sharp point - a broken section usually has a sharp point on it somewhere, it doesn't have to be a crystal termination.)
- A small piece of a beryl or topaz crystal (with at least one good face and a sharp point or edge.)
- A small piece of a corundum crystal (with at least one good face and sharp point or edge.)
- A "streak plate" (unglazed porcelain tile. A 2-inch square is plenty.)
- A short candle stub and matches or a cigarette lighter.
- A small pair of tweezers.
- A needle in a wooden dowel (for generating cleavage, etc.)
- A small magnet (a refrigerator magnet is fine, but it should be a fairly strong one.)
- A plastic dropper bottle for dilute (10%) HCl acid solution (Please read, understand, and follow the label warnings and Material Safety Data Sheets when working with any hazardous material).
- A 10x hand lens/jeweler's loupe.
- Blank specimen labels.
- Pens or pencils.

(Mindat, Peck)

SPECIFIC GRAVITY

Specific gravity is the density of a mineral or how much it weighs compared to an equal volume of water. The test for specific gravity is a little complicated, but the concept of specific gravity is not hard to understand and apply to the field-testing of a mineral specimen.

A simplified version of the idea: if a certain amount of water is given the value of **1**, (Units are not important) and a specimen of mineral weighs the same as the value of the water, then the specimen has the same density as the water and is rated at **1**. A specimen that has twice the density of water has the specific gravity of **2**.

Most quartz rocks, one of the most common rocks and minerals on the earth, have a specific gravity, (or density) of **2.65**. If you compared an unknown specimen of rock with a quartz rock of equal size, and find that they weigh approximately the same, you can establish the specific gravity of the new specimen at roughly **2.65**.

Gold has a specific gravity of approximately **19**, making it 19 times heavier than water and the one of the heaviest or most densely compacted minerals easily found at the surface of the earth.

EXAMPLES OF THE SPECIFIC GRAVITY OF MINERALS

Hornblende	3.4	Topaz	3.6
Gypsum	2.3	Tremolite	< 1
Scheelite	6.1	Calcite	2.7
Sulphur	2	Iron	7.3
Halite (Salt)	2.1	Magnetite	5.2
Fluorite	3.1	Iron Pyrite	5
Opal	2.2	Silver	10
Garnet	3.56-3.73		

Need: Pad, Pen, Calculator, Paper clip, Scale, Container, Distilled water

- Set scale, ’Zero out’.
- Weight of specimen, ‘Dry weight.’.
- Container w/water on scale, zero out. (Terr).
- Suspend specimen in water, ‘Wet weight’.
- Dividing dry weight by wet weight equals specific gravity.

$$\frac{\text{Dry weight}}{\text{Wet weight}} = \text{Specific gravity}$$

MINERAL HABIT

Minerals that develop into some type of crystal structure have the following descriptive names:

1. **ACICULAR** - Groups of thin parallel needles
2. **BLADED** - Broad flat blades
3. **DENDRITIC** - Tree like or branching form
4. **EQUANT** - Having roughly equal sides
5. **PRISMATIC** - Elongated in one direction
6. **STRIATED** - Having shallow grooves along the surface
7. **TABULAR** - Thick or thin flat plates

MINERAL AGGREGATES

When describing a specimen, the standards used by rockhounds and geologists allow for ease of understanding. Some specimens have aggregates or clusters of crystal forms that can be described by the following:

1. **BOTRYOIDAL** - Resembles a grape cluster
2. **COLUMNAR-** Slender parallel columns
3. **COXCOMB** - Serrated crust like crystals
4. **DRUSE** - Crust of very small crystals
5. **FIBROUS** - Threadlike fibers
6. **GEODE** - Rounded hollow nodule lined with crystals
7. **MAMMILLARY** - Smooth rounded masses
8. **MASSIVE** - No clear crystal structure
9. **MICACEOUS-** Thin flat flakes, easily separated
10. **OOLITIC** - Forming small spheres less than 1/10 inch
11. **PISOLITIC** - Forming spheres larger than 1/10 inch
12. **RADIATING** - Fibers growing from a center point
13. **RENIFORM** - Kidney shaped lobes
14. **STALACTITIC** - Icicle shaped formation
15. **WHEATSHEAF** - Bundles like wheat stalks tied in the middle

LUSTER

Luster is the character of the light reflected off the surface *(Peck)*. Clues to a specimen's identification may be found in its description of its luster. Checking the fresh broken surface of the specimen, record the impression of luster under natural light.

1. **SUB-METALLIC** (hematite)
2. **METALLIC** (galena)
3. **GREASY** (serpentine)
4. **WAXY** (talc)
5. **SILKY** (gypsum)
6. **DULL** (gold)
7. **EARTHY** (clay)
8. **VITRIOUS** (shiny)
9. **ADAMANTINE** (like diamond)

CLEAVAGE

Cleavage planes are flat surfaces along which many minerals break cleanly and easily. Some minerals break or separate easily along flat surfaces *(Peck)*. This should not be Confused with "parting", where two separate pieces are joined and break away.

An example of cleavage is best shown in mica. **Mica** separates into flat thin sheets. This mineral would be known to have "good" cleavage.

The following are the three grades of cleavage:

GOOD **DISTINCT** **POOR**

Some minerals will break along fractures or along seams where there are imperfections in the specimen. These are not natural cleavages.

TENACITY

A mineral may have capacity to resist the stress of crushing, bending, and tearing. These properties are described in the following manner:

1. **BRITTLE** - Easily broken down to powder through hammering or cutting
2. **SECTILE** - Can be easily cut by knife into thin sheets or shavings
3. **MALLEABLE** - Can be hammered into thin sheets like gold or copper
4. **FLEXIBLE** - Can be bent but does not return to its original shape
5. **ELASTIC** - Can be bent but returns to its original shape

FRACTURE

When a specimen is hammered or dropped and breaks, the way it fractures adds clues as to its composition. The most observed fractures are the following:

1. **UNEVEN** - Natural and rough surfaces
2. **CONCHOIDAL** - Appears to be clam shell shaped edges
3. **HACKELY** - Like broken glass or shattered metal
4. **SPLINTERY** - fibrous pieces like splinters of wood

Indian arrowheads make use of the conchoidal fracture of **obsidian** to create the sharp edges for penetration of animals.

Asbestos fibers separated in a splintery manner for use in asbestos insulations.

CRYSTAL FORM

Crystal structure (Morphology) <u>is a complicated science and somewhat difficult</u> to use in the field apart from the most common crystal features on the most common minerals. The rules that are useful are only general and not absolute. There are many anomalies and "laws" that create confusion about what a specimen is, especially when it meets all other physical properties but does not seem to fit the crystal pattern expected.

Don't be discouraged, years of exposure to fine specimens at mineral shows and personal collections will increase familiarity with the subtleties of crystal forms.

Some common crystal structures that are familiar to the rockhound are the following:

1. **HALITE** - CUBES
2. **IRON PYRITE** - CUBES
3. **QUARTZ CRYSTALS** - SIX SIDED COLUMNS
4. **GARNETS** - TWELVE SIDED FACETED CUBES
5. **EMERALD** - SIX SIDED COLUMNS, FLAT ENDS
6. **FLOURITE** - DOUBLE PYRAMIDS
7. **CALCITE** - FOUR SIDED SHORT COLUMNS

ADDITIONAL PHYSICAL PROPERTIES AND METHODS OF IDENTIFYING MINERALS

In addition to the physical properties of identifying minerals, other tests can be performed.

Location - Where was the specimen found? Rock formations within a region tell a lot about various minerals likely to be found in that region. **"Associated Minerals"** is the term used to suggest that other known minerals in a region would predict the likelihood that the unknown specimen is consistent as an associated mineral.

Odor - Striking or scratching a specimen (such as any of the pyrites) may release some minerals such as sulfur.

Taste- Some minerals, such as evaporates (lake or seabed salt crystals) give off bitter, or salty taste.

Feel- The specific gravity of some minerals is significant enough to give it away quickly. Pumice, full of air is far lighter than expected. Corundum, Gold, and Platinum are extremely heavy for their small size.

Magnetism - Magnetite is readily magnetic, other Iron minerals can be made magnetic after heating and then cooling.

Chemical reactions - Some evaporates are water soluble, most all Carbonate containing minerals (such as Calcite), when in contact with a mild acid solution, will effervesce (bubble).

Fluorescents and Phosphorescence - Some minerals when exposed to fluorescent lights of short or long wavelengths will glow a color other than that of natural light. The mineral Scheelite (ore of tungsten) can be prospected by using fluorescent lights. Many minerals fluoresce and phosphoresce due to contamination introduced during their formation rather than the chemical composition of the mineral itself.

Blowpipe analysis - Many of the metals, when powdered and burned in a blowpipe flame, can leave a colored halo on a charcoal block, indicating the precious metal content.

Spectrum analysis - The most modern and absolute method of determining the mineral content of any specimen is the use of a spectrum analyzer Or X Ray diffraction. Spectrum analyzers evaporate small quantities of the sample subject and read the chemical wavelengths of the various elements.

GOLD vs. FOOLS GOLD

Suspected gold specimens, particularly free milling visible gold, will have a high specific gravity at 17 - 19. For its size it will be heavy. Gold has a yellow "dull" luster and does not reflect light with a "flash" described as "shiny". Gold is soft like lead with a hardness of 2 ½ to 3. Gold is malleable and will flatten like a lump of lead. Fool's Gold, or pyrite, will be much lighter at 4.9 to 5.2. Pyrite can be shiny, and flash reflected light off its flat surfaces. Oxidation can make it dull or rusty at the surface. A flesh broken surface will show the shine or flash. Pyrite has a hardness of 6 – 6 ½. The knife will not make much of a scratch on the freshly broken surface. Pyrite is brittle and will fracture into uneven fragments or powder with a blow from the rock hammer.

Small mica sheets are found at the surface of streams and lakes and can appear very gold in color. The first clue is that they are at the surface of gravel and sand. Gold with a high specific gravity will always sink out of sight in a water and gravel environment. A close inspection of the mica with a loupe will show that they are just that, flakes of mica. They are flexible and will bend or break easily.

METEORITES and METEOR WRONGS

Nickel Iron meteorites are found by anybody who picks up a dark rock and feels the high specific gravity. Metal detector operators and gold miners find dark heavy rocks while looking for gold. Generally, these victims will know enough to check for magneticity. <u>Most meteorites are not "magnets". They will not stick to metal or cause a compass needle to move</u>. However, a magnet will stick to them. The next step to identify meteorites is to use the streak plate. The unglazed surface of any porcelain product will work. White is the best for making accurate streaks. Rubbing the suspect on the streak plate will generate one of three colors. The black streak will be earth bound magnetite. A red or reddish-brown streak will indicate hematite. <u>**Hematite** is not usually magnetic but does become magnetic under some circumstances</u>. A meteorite will streak silver due to the high concentrations of nickel in the stone. Some meteorites can rust heavily over long periods buried in soils, giving a reddish-brown streak.

Removing the rust layer with sanding will expose a fresh surface. Is it a meteorite? Well maybe not. Many manmade materials, like bearings, jaw crushing teeth, and other industrial metals can be magnetic and streak silver. The best these tests can do is identify earth bound minerals for sure. With the positive tests, the specimen could be rated as a "Meteor Maybe" and sent out for further testing. The specimen will be cut with a diamond blade. The exposed surface will be immersed in acid which will dissolve some of the Iron leaving a distinctive pattern of blocky Iron and Nickel crystals known as **Widmanstätten** figures or lines.

ONLY DIAMONDS WILL CUT GLASS

Testing for diamond by scratching glass is a popular myth, but untrue. Glass processing requires the use of Borax to soften the glass and make it flow better into the forms and presses. Due to the Borax, the Silica (quartz) loses its hardness of 7 and drops to a 6 or 6.5. With that, a quartz specimen will scratch glass. Synthetic gemstones such as Cubic Zirconia, and YAG are clear and harder than glass.

Due to diamonds atomic structure, it possesses a property of heat transfer unlike most anything else known. Placing a diamond on your tongue causes heat to transfer to the far side of the stone immediately. The sensation is akin to putting a small chip of ice on your tongue. That is why diamonds are called "ice" by some. Clean the stone, let it go to room temperature and then place it on your tongue. None of the other clear stones will create that sensation.

RELATIVE HARDNESS TEST IN THE FIELD

Relative hardness is a procedure for testing field minerals when they are highly suspected of being rather common minerals. This procedure is for confirming what you already suspect.

The most prominent: Gypsum (Selenite), Calcite, Fluorite, Feldspar, and Quartz.
The Carbon steel pocketknife (the darker metal knife) has a hardness of around 5.5. This would be harder than the Gypsum (2), Calcite (3), and Fluorite (4) and yet softer than the Feldspar (6) and Quartz (7). Using the Carbon steel pocketknife scratch the material or scratch the flat surface of the knife with the material.

Test In this order.
Gypsum(2) will scratch and powder with no effort, it will also scratch with your fingernail.

Calcite (3) will scratch and powder with very little effort. Your fingernail will just about meet its match with calcite, but you can make a scratch on one or more surfaces.

Fluorite (4) will scratch but will require a good deal of pressure. Fluorite can scratch your fingernail if you push hard enough with a sharp comer.

Feldspar (6) will scratch the knife but will require some stiff pressure to make a good cut in the knife.

Quartz (7) will easily cut the knife surface with very little pressure.

Once you practice on known materials and then field minerals, you will quickly become very experienced at this procedure and very confident in your determination. Having mastered the feel of the scratch with these materials, it becomes much easier to use the mineral handbook to identify other mineral specimens and use "Relative Hardness" along with Relative Specific Gravity" to make a very good guess at a suspect mineral. If all other descriptions indicate a specific mineral, and the hardness is about right, and the **heft** is about right, you can identify a possible mineral worth bringing home for further evaluations.

RELATIVE SPECIFIC GRAVITY (DENSITY OR HEFT)

Along with relative hardness, some experience with common minerals will allow you to recognize by "feel" any significant density variations in a specimen from that of the standard. The standard is water. If you had one cup of water, and one cup of quartz, the cup of quartz would weigh in at 2.65 times the weight of the water. One cup of gold would weigh 17-19 times the weight of a cup of water. Familiarize yourself with the "heft" of a chunk of quartz. Knowing that the quartz is roughly at 2.5, any mineral specimen of an equal size to that of the piece of quartz, and hefts more than the quartz, would have a higher Specific Gravity. Specimens weighing in much less than an equal size chunk of quartz would have a lower Specific Gravity. These provide a general feel for the density of the specimen and can help identify some minerals, especially those laden with metals.

RESOURCES FOR MINERAL IDENTIFICATION

ON-LINE

Mindat.org, Mineral & Locality database.

Geology.com, For all things geology!

The-Vug.com, Directory of websites, resources

Minerals.net

PERIODICALS

The Mineralogical Record

Rock & Gem Magazine

Rocks & Minerals

BOOKS

Mineral Identification -A practical guide for the Amateur Mineralogist
by Donald B Peck

Handbook of Rocks, Minerals, and Gemstones
by Walter Schumann Dr.

Simon & Schuster's Guide to Rocks & Minerals
by Martin Prinz, George Harlow, et al

Field Guide to North American Rocks and Minerals
by the Audubon Society

Roadside Geology of Northern California (Series)
by David Alt and Donald Hyndman

Gem Trails of Northern California (Series)
by James R. Mitchell

MINERAL ID PROGRAMS (Phone APPs are not accurate, can be 30-40% correct)

Mindat Advanced Mineral Search (Mindat.org)

MINERAL ANALYSIS

Date: ____________________

Location found: ____

____

Mindat.com: ____

Associated Minerals: ____

Color: ____

Hardness: ____

Streak: ____

Specific Gravity: (1) _______, (2) _______, (3) _______, (4) _______, (5) _______ __________

Habit: ____

Mineral Aggregate: ____

Luster: ____

Cleavage: ____

Tenacity: ____

Fracture: ____

Crystal Form: ____

____

Other tests ____

Magnetism: ____

'Acid' Test': (For carbonates): ____

Notes: ____

Michael Hopkins 4-2024

A DISCUSSION OF MINERAL IDENTIFICATION FOR BUDDING MINERALOGISTS

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OUTLINE & MATERIALS

PAGE

1 Introduction

Go to pg 12 & 13, Sign-up sheets (2)

Pg 4, Field Test Kit, ?????????????????????????

2 Elements, Minerals & Rocks OH MY!

Focus: Mineral definition

Mineral samples: **E**- Gold/ Sulfur/ ________

M- QUARTZ, ________, ________

R- Jasper, Conglomerate,

Massive Quartz, Silicon/ Oxygen, **Ask if rock?**

2 Identifying Properties

2 Color, visual

Focus: One observation is not enough

Mineral sample: Malachite, Rosasite, _______, Green quartz

3 Hardness

Focas: Technique

DEMO, Materials (Kit), sq's of quartz, Calcite, Fluorite, ________

4 Streak

Focus: Technique

DEMO, Materials (Kit), tile (Blk & At), Mineral samples ________, ________, ________

5 Specific gravity

Focas: Technique

DEMO, Scale, Clr glass, Wire, Calculator (Enlarge formula)

6 Mineral habit

Focus:

Mineral sample: __________, __________

Mineral aggregates

Focus:

Mineral sample: __________, __________

7 Luster (Gloss over)

Cleavage

Tenacity

8 Fracture

Crystal form

Focus:

Mineral sample: __________, __________

9 Additional physical properties and methods of identifying minerals

Magnetism – Strong / weak, Meteorite, (Kit - Mag on fabric)

DEMO:

Mineral sample: __________, __________

'Acid' Test

Focus:

DEMO: Technique, Magnifying glass, light, HCL, vinegar

10 Gold vs. fool's gold

Meteorites and meteor wrongs

Only diamonds will cut glass.

11 Field test - Relative hardness

Field test - Relative specific gravity (density or heft)

12 Resources for mineral identification

Focus: Mindat Advanced Search

Color screen shots (2 sheets), 4 sets ea

13 Form – Mineral Analysis

Request for further information, FORM, 2 copies