Today we will discuss identifying minerals in the field by their physical characteristics. I recommend looking into the science of mineral identification through thin section and laboratory analysis.

“The Physical properties of minerals are used by Mineralogists to help determine the identity of a specimen or mineral class. Some of the tests can be performed easily in the field, while others require laboratory equipment”. Common ID tools: magnifying loop or lens, magnet, scratch plate, steel nail, penny, UV light, HCL 10% acid
Rocks

3 Types: Igneous, Metamorphic and Sedimentary

- Rocks are composed of minerals; rocks are a natural substance, a solid aggregate of one or more minerals or mineraloids.

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Minerals

A naturally occurring chemical compound, usually of crystalline form and not produced by life processes.

- A mineral has one specific chemical composition
Basic definition

1. **Naturally Occurring** (anthropogenic compounds are excluded).

2. Must be a **Solid** (Stable or metastable at room temperature (25 °C).

3. Definite **Chemical Composition**/chemical formula.

4. **Crystal Structure** (ordered atomic arrangement) [keep in mind mineraloids i.e. amorphous crystal structure such as opal is not a ‘mineral’]

5. **Inorganic**
Minerals are classified by:

- **Group**: family grouping of mineral species with common and physical properties, and crystal lattice

- **Series**: defined by a range of chemical composition; biotite series is represented by variable amounts of the endmembers phlogopite, siderophyllite, annite, and eastonite

- **Species**: defined by unique chemical and physical properties. For example, quartz is defined by its formula, SiO$_2$, and a specific crystalline structure that distinguishes it from other minerals with the same chemical formula (termed polymorphs).

Naming: Finally, a *variety species* is a specific type of mineral species that differs by some physical characteristic, such as color or crystal habit. An example is *amethyst*, which is a purple variety of quartz.
8 Mineral Classes

1. **Native Elements**: Metals/Nonmetals (silver)
2. **Silicates**: $\text{SiO}_4$ (Quartz, Feldspar etc.)
   - Tectosilicates (Quartz, Zeolites)
   - Phyllosilicates (micas)
   - Inosilicates (amphibole, pyroxene)
   - Cyclosilicates (Beryl)
   - Sorosilicates (Epidote)
   - Orthosilicates (Olivine)
3. **Oxides/Hydroxides**: $\text{O}_2^-$ (Magnetite)
4. **Sulfides**: $\text{S}_2^-$ (Pyrite, Galena)
5. **Halides**: anions (fluorine, chlorine, iodine, or bromine) [Fluorite]
6. **Carbonates**: $\text{CO}_3$ (Calcite)
7. **Phosphates**: $\text{PO}_4$ (Wavellite, Pyromorphite, Turquoise)
8. **Sulfates**: $\text{SO}_4$ (Gypsum, Baryte)
Chemistry

- Minerals are classified by a specific chemical formula.

- For example, the olivine group is described by the variable formula \((\text{Mg, Fe})_2\text{SiO}_4\), which is a solid solution of two end-member species, magnesium-rich forsterite and iron-rich fayalite.

  - The abundance and diversity of minerals is controlled directly by their chemistry.

  - Eight elements account for most of the key components of minerals due to their abundance in the crust:

    - oxygen, silicon, aluminium, iron, magnesium, calcium, sodium and potassium

  - Oxygen and silicon are by far the two most important – oxygen composes 47% of the crust by weight, and silicon accounts for 28%.

  - Earth's surface, the most abundant minerals would be Quartz, Feldspars, Clay minerals, Ice, Chlorite, etc. In the Earth's crust, the most abundant minerals are Feldspars (about 40-60%) and Quartz (about 30-50%). The remaining 10% would be Micas, Pyroxenes, Amphiboles, Olivine, etc.
A Diagram representing Mineral Crystallization in Temp/Pressure environments

**Bowen’s Reaction Series**

- **High Temperature**
  - olivine
  - pyroxene
  - Amphibole
  - biotite
  - muscovite
  - potassium feldspar
  - quartz
  - first silicate minerals to crystallize
  - discontinuous series of crystallization

- **Low temperature**
  - last to crystallize

**Composition**
- Intrusive/extrusive rock types
  - Ultramafic: peridotite/komatite
  - Mafic: gabbro/basalt
  - Intermediate: diorite/andesite
  - Felsic: granite/rhyolite
Mineral Series

• Mineral Chemistry composition may vary between species of a solid solution. For example the feldspar mineral series:
  • plagioclase feldspars comprise a continuous series from sodium-rich end member albite (NaAlSi3O8) to calcium-rich anorthite (CaAl2Si2O8) with four recognized varieties between them (given in order from sodium- to calcium-rich): oligoclase, andesine, labradorite, and bytownite.
  
• In nature, minerals are not pure substances, and are contaminated by whatever other elements are present in the given chemical system. As a result, it is possible for one element to be substituted for another.

“Polymorph” are minerals with the same composition but different crystal form; changes in coordination numbers leads to physical and mineralogical differences; for example, at high pressure and/or temperature, such as in the mantle, many minerals, especially silicates such as olivine and garnet, will change to silicon in an octahedral coordination. Other examples are the aluminosilicates kyanite, andalusite, and sillimanite.
The following physical properties of minerals can be easily used to identify a mineral:

- Color
- Streak
- Hardness
- Cleavage or Fracture
- Crystalline Structure
- Diaphaneity or Amount of Transparency
- Tenacity
- Magnetism
- Luster
- Odor
- Taste
- Specific Gravity
Properties of Minerals

• Color

• Most minerals have a distinctive color that can be used for identification. In opaque minerals, the color tends to be more consistent, so learning the colors associated with these minerals can be very helpful in identification. Translucent to transparent minerals have a much more varied degree of color due to the presence of trace minerals. Therefore, color alone is not reliable as a single identifying characteristic.

➢ Streak

• Streak is the color of the mineral in powdered form. Streak shows the true color of the mineral. In large solid form, trace minerals can change the color appearance of a mineral by reflecting the light in a certain way. Trace minerals have little influence on the reflection of the small powdery particles of the streak.
• The streak of metallic minerals tends to appear dark because the small particles of the streak absorb the light hitting them. Non-metallic particles tend to reflect most of the light so they appear lighter in color or almost white.

Because streak is a more accurate illustration of the mineral’s color, streak is a more reliable property of minerals than color for identification.
There are degrees of crystalline structure, in which the fibers of the crystal become increasingly difficult or impossible to see with the naked eye or the use of a hand lens. Microcrystalline and cryptocrystalline structures can only be viewed using high magnification. If there is no crystalline structure, it is called amorphous. However, there are very few amorphous crystals and these are only observed under extremely high magnification.

Crystalline Structure

- Mineral crystals occur in various shapes and sizes. The particular angles and crystal shape is determined by the arrangement of the atoms, molecules or ions that make up the crystal and how they are joined. Crystal Structure is an excellent mineral indicator.
- The crystal Structure or crystal lattice are classified in six families of crystal habits: Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic, and Triclinic.

<table>
<thead>
<tr>
<th>Crystal family</th>
<th>Lengths</th>
<th>Angles</th>
<th>Common examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isometric</td>
<td>a=b=c</td>
<td>α=β=γ=90°</td>
<td>Garnet, halite, pyrite</td>
</tr>
<tr>
<td>Tetragonal</td>
<td>a=b≠c</td>
<td>α=β=γ=90°</td>
<td>Rutile, zircon, andalusite</td>
</tr>
<tr>
<td>Orthorhombic</td>
<td>a≠b≠c</td>
<td>α=β=γ=90°</td>
<td>Clivine, aragonite, orthopyroxenes</td>
</tr>
<tr>
<td>Hexagonal</td>
<td>a=b≠c</td>
<td>α=β=90°, γ=120°</td>
<td>Quartz, calcite, tourmaline</td>
</tr>
<tr>
<td>Monoclinic</td>
<td>a≠b≠c</td>
<td>α=γ=90°, β≠90°</td>
<td>Clinopyroxenes, orthoclase, gypsum</td>
</tr>
<tr>
<td>Triclinic</td>
<td>a≠b≠c</td>
<td>α≠β≠γ≠90°</td>
<td>Anorthite, albite, kyanite</td>
</tr>
</tbody>
</table>

Diaphaneity or Amount of Transparency

Tenacity-Tenacity is the characteristic that describes how the particles of a mineral hold together or resist separation (one a scale of 1-10). Such as brittle(1), sectile, malleable, flexible, elastic, soft, tensile, fragility (10)
# Mohs Hardness Scale

<table>
<thead>
<tr>
<th>Mineral Name</th>
<th>Scale Number</th>
<th>Common Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond</td>
<td>10</td>
<td>Masonry Drill Bit</td>
</tr>
<tr>
<td>Corundum</td>
<td>9</td>
<td>(8.5)</td>
</tr>
<tr>
<td>Topaz</td>
<td>8</td>
<td>Steel Nail</td>
</tr>
<tr>
<td>Quartz</td>
<td>7</td>
<td>(6.5)</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>6</td>
<td>Knife/Glass Plate</td>
</tr>
<tr>
<td>Apatite</td>
<td>5</td>
<td>(5.5)</td>
</tr>
<tr>
<td>Fluorite</td>
<td>4</td>
<td>Copper Penny</td>
</tr>
<tr>
<td>Calcite</td>
<td>3</td>
<td>(3.5)</td>
</tr>
<tr>
<td>Gypsum</td>
<td>2</td>
<td>Fingernail</td>
</tr>
<tr>
<td>Talc</td>
<td>1</td>
<td>(2.5)</td>
</tr>
</tbody>
</table>
Mineral Characteristics Continued

- **Magnetism** is the characteristic that allows a mineral to attract or repel other magnetic materials. It can be difficult to determine the differences between the various types of magnetism, but it is worth knowing that there are distinctions made.

- **Luster** is the property of minerals that indicates how much the surface of a mineral reflects light. The luster of a mineral is affected by the brilliance of the light used to observe the mineral surface. Luster of a mineral is described in the following terms:
  - **Metallic** The mineral is opaque and reflects light as a metal would.
  - **Submetallic** The mineral is opaque and dull. The mineral is dark colored.
  - **Nonmetallic** The mineral does not reflect light like a metal. Nonmetallic minerals are described using modifiers that refer to commonly known qualities.
  - **Waxy** The mineral looks like paraffin or wax.
  - **Vitreous** The mineral looks like broken glass.
  - **Pearly** The mineral appears iridescent, like a pearl.
  - **Silky** The mineral looks fibrous, like silk.
  - **Greasy** The mineral looks like oil on water.
  - **Resinous** The mineral looks like hardened tree sap (resin).
  - **Adamantine** The mineral looks brilliant, like a diamond.
Cleavage/ Fracture

- **Cleavage & Fracture**: describes the quality of the cleavage surface. Most minerals display either uneven or grainy fracture, conchoidal (curved, shell-like lines) fracture, or hackly (rough, jagged) fracture.

- Minerals tend to break along lines or smooth surfaces when hit sharply. Different minerals break in different ways showing different types of cleavage.
  - Cleavage is defined using two sets of criteria. The first set of criteria describes how easily the cleavage is obtained.
  - Cleavage is considered **perfect** if it is easily obtained and the cleavage planes are easily distinguished. It is considered good if the cleavage is produced with some difficulty but has obvious cleavage planes. Finally it is considered **imperfect** if cleavage is obtained with difficulty and some of the planes are difficult to distinguish.
  - The second set of criteria is the direction of the cleavage surfaces. The names correspond to the **shape** formed by the cleavage surfaces: Cubic, rhombohedral, octahedral, dodecahedral, basal or prismatic. These criteria are defined specifically by the angles of the cleavage lines as indicated in the chart below:

Cleavage Type Angles:
- Cubic Cleaves in three directions at 90 degrees to one another.
- Rhombohedral Cleaves in three directions but not at 90 degrees to one another
- Octahedral Cleaves in four directions
- Dodecahedral Cleaves in six directions
- Basal Cleaves in one direction
- Prismatic Cleaves in two directions
Mineral Characteristics Continued

• Odor
Most minerals have no odor unless they are acted upon in one of the following ways: moistened, heated, breathed upon, or rubbed (Sulphur Crystals can smell like rotten eggs. You should not test for this property.).

• Taste
Only soluble minerals have a taste, but it is very important that minerals not be placed in the mouth or on the tongue. You should not test for this property.

• Specific Gravity
Specific Gravity of a mineral is a comparison or ratio of the weight (density) of the mineral to the weight of an equal amount of water.

• Acid Reaction
• UV (fluorescent)
• Radioactivity
Mineral ID Advice: Review Guide Books

- there are 3800 known minerals
- Research the geology you are rockhounding
- USE ROCK Guide books there are hundreds:
  - Smithsonian Handbooks: Rocks & Minerals (Smithsonian Handbooks) (DK Smithsonian Handbook)
  - Sedimentary, Metamorphic and Igneous Geologic Field Guides

- Geology Field Manuals and reports/maps
- Mindat.org
- MINERAL GUIDES
- Practice identifying