GEOLOGY 17.01: Mineralogy

LABS 1A and 2A:

PROPERTIES OF MINERALS IN HAND-SAMPLE

During the first two weeks of class, complete this lab assignment concurrently with Labs 1 and 2. Use the sample standards to become familiar with common forms of luster, cleavage, fracture and habit. When you are comfortable with the terms described in this lab, determine the physical properties of Unknowns A through F.

LUSTER:

Luster is the appearance of the fresh surface of a mineral in white light due to reflection. It is dependent upon a translucent mineral's refractive index (RI) and other physical properties that affect the reflection of light. (Refractive Index is the ratio of speed of light in vacuum to speed of light in the mineral.)

NON-METALLIC LUSTERS (RI < 2.6)

- **Adamantine**: 1.9 < RI < 2.6 (*e.g.*, diamond, cinnabar)
  Brilliant, sparkly appearance due to internal reflections

- **Resinous**: 1.9 < RI < 2.6 (*e.g.*, sphalerite, sulfur)
  Essentially the same as adamantine but for more deeply colored minerals.

- **Vitreous**: 1.3 < RI < 1.9 (70% of minerals, including quartz)
  Glassy appearance.

- **Pearly** (*e.g.*, talc, muscovite)
  Due to the presence of internal microscopic separations parallel to the mineral surface.

- **Greasy** (*e.g.*, chlorite, nepheline)
  Due to the presence of a thin film of altered material of different RI than the underlying fresh mineral.

- **Silky** (*e.g.*, chrysotile, fibrous gypsum)
  Shinier in a certain direction due to the presence of parallel micro-fibers.

- **Dull** (*e.g.*, kaolinite)
  Due to low reflectivity associated with materials where individual crystals are very small.

METALLIC LUSTERS (RI > 2.6)

Associated with opaque minerals, and are dependent upon the percentage of light reflected from the mineral's surface

- **Submetallic**: 2.6 < RI < 3, 8-20% reflectance (*e.g.*, magnetite, chromite)

- **Metallic**: RI > 3, >20% reflectance (e.g., galena, pyrite, gold)

COLOR:

The appearance of a mineral based upon which wavelengths of light are absorbed by the mineral, and which wavelengths are reflected. The main control on color is the mineral's chemical composition. Small amounts of certain elements (*chromophores*), particularly the transition metals, may give a mineral its color. The electrons in the d-orbitals of transition metals are very efficient at absorbing particular wavelengths of visible light. Iron, copper, titanium and chromium are some of the most abundant chromophores. Color may also be caused by the transfer of electrons between ions when they are energized by photons. Finally, defects in the crystal structure of a mineral may also affect its color.

In some cases color may be diagnostic (*e.g.,* pyrite), but more often it can be ambiguous or misleading.

Mineral Name	Gem Name	Color	Origin of Color
Fluorite		Purple	Imperfection
Halite		Blue, yellow	Imperfection
Topaz		Blue, yellow	Imperfection
Corundum	Ruby	Red	Cr^{3+}
Corundum	Sapphire	Blue	Charge Transfer: $Fe^{2+} \leftrightarrow Ti^{4+}$
Garnet	Spessartine	Yellow-orange	Mn^{2+}
Garnet	Demantoid	Green	Cr^{3+}
Garnet	Almandine	Red	Fe^{2+}
Beryl	Emerald	Green	Cr^{3+}; Charge Transfer: $Fe^{2+} \leftrightarrow Fe^{3+}$
Beryl	Aquamarine	Blue-green	Mn^{2+}
Beryl	Morganite	Pink	Charge Transfer: $O^{2-} \leftrightarrow Fe^{3+}$
Cordierite			Charge Transfer: $Fe^{2+} \leftrightarrow Fe^{3+}$
Kyanite			Charge Transfer: $Fe^{2+} \leftrightarrow Ti^{4+}$
Tourmaline	Rubellite	Pink	Mn^{3+}
Quartz	Amethyst	Purple	Imperfection (Fe)
Quartz	Citrine	Yellow	Imperfection (Fe)
Quartz	Rose Quartz	Pink	Charge Transfer: $Fe^{2+} \leftrightarrow Ti^{4+}$
Quartz	Smoky Quartz	Brown	Imperfection (Al)
Turquoise		Blue	Cu^{2+}

STREAK:

The color of a mineral when it is finely powdered. Powdering removes color variation due to crystal defects and trace elements, and therefore provides a more consistent color. It is particularly useful for identification of opaque minerals (oxides and sulfides). Note that any mineral harder than 6.5 will not streak on porcelain.

HABIT:

The overall shape of a crystal or aggregate of crystals. May result from preferential growth in certain directions because of the crystal lattice, competition between neighboring grains, or fluid flow patterns.

- **Equant**: approximately the same size in all directions (*e.g.*, garnet)

- **Blocky**: equant crystals with square cross-section (*e.g.*, feldspar)

- **Prismatic**: elongate crystals (*e.g.*, hornblende, apatite)

- **Platy**: thick sheets stacked together (*e.g.*, gypsum)

- **Bladed**: elongate crystals that are flattened in one direction (*e.g.*, kyanite)

- **Acicular**: needle-like crystals (*e.g.*, actinolite, sillimanite)

- **Fibrous**: composed of hair-like crystals (*e.g.*, chrysotile)

- **Massive**: solid mass without distinguishing features

- **Granular**: composed of individual grains

- **Radiating**: crystals emanating from a common point

- **Botryoidal**: having a form like a bunch of grapes

- **Colloform:** Spherical or hemispherical shapes composed of radiating crystals

- **Drusy:** surfaces covered in fine crystals

BREAKAGE:
The shape of broken surfaces on a mineral crystal is controlled by the strength of chemical bonds in various directions.

CLEAVAGE

Cleavage is a form of smooth, planar breakage parallel to planes along which there are atomic structural weaknesses. Cleavage is generally described by the number of distinct directions, the angle between them, and the quality of the break.

- **Perfect**: difficult to break the mineral in any other direction (*e.g.*, galena, calcite).
- **Good**: breaks easily along cleavages but can be broken in other directions as well (*e.g.,* orthoclase).
- **Imperfect**: Breaks somewhat more easily along cleavage planes than along other directions, and cleavage surfaces tend to be small and much interrupted (*e.g.,* diopside).
- **Basal or Pinacoidal**: one well-developed planar cleavage (*e.g.,* micas).
- **Prismatic**: two cleavages (*e.g.*, feldspars).
- **Cubic**: three cleavages at right angles (*e.g.*, halite).
- **Rhombohedral**: three cleavages not at right angles (*e.g.*, calcite).
- **Octohedral**: four cleavages (*e.g.*, fluorite).

PARTING

Parting is a less smooth and less pervasive form of planar breakage that is due to twinning, deformation or alteration of a given mineral crystal. Whereas cleavage will be present in all samples of a particular mineral, parting will be exhibited only by some examples of a given mineral. Common in corundum.
See garnet (110)

FRACTURE

Fracture is a non-planar, irregular form of breakage.

- **Irregular**: rough surface.
- **Concoidal**: curved surfaces like broken glass (*e.g.*, quartz).
- **Hackly**: jagged and sharp (*e.g.*, copper)
- **Splintery**: long sharp splinters (*e.g.*, kyanite).
- **Fibrous**: long fibers (*e.g.,* chrysotile)

HARDNESS

Hardness is the resistance of a mineral to abrasion. A mineral's hardness is related to the strength of its weakest bond, and minerals may have different hardnesses in different directions. For example, kyanite has a hardness of 5.5 if scratched lengthwise, but a hardness of 6.5 if scratched crosswise (numbers in Mohs scale). Since covalent bonds are stronger than ionic bonds, minerals in which covalent bonds dominate will be harder than those in which ionic bonds are prevalent.

Mineral hardness is classified on the 10 point Mohs Hardness Scale, but for simplicity, minerals can be grouped as follows:

- **Very Soft**: softer than a fingernail (H<2.5)

- **Soft**: harder than fingernail, softer than penny (2.5< H<3)

- **Intermediate**: harder than penny, softer than knife blade (3<H<5.5)

- **Hard**: Harder than knife blade, softer than porcelain (5.5<H<6.5)

- **Very Hard**: harder than porcelain streak plate (H>6.5)
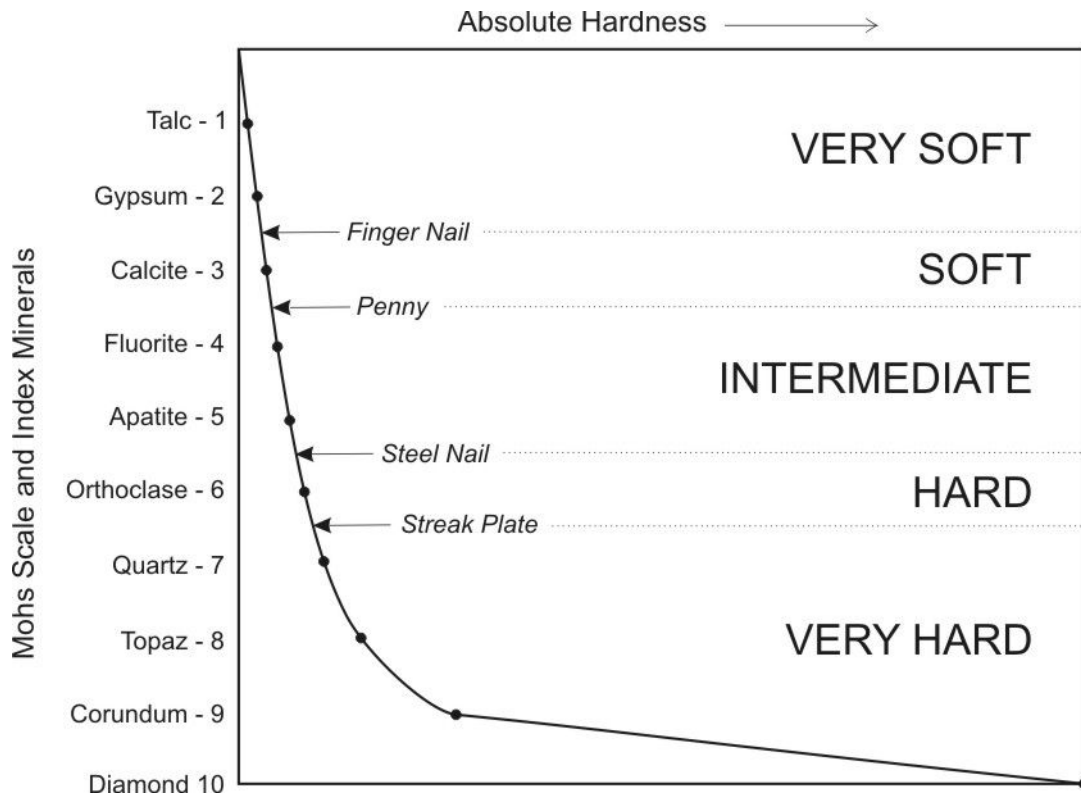
MISCELLANEOUS PROPERTIES

SPECIFIC GRAVITY

The specific gravity of most minerals varies between 2.5 and 3, and is dependent upon both the atomic weight of its constituent atoms, and how closely packed they are. In hand-sample, one can quickly determine if a sample has low, moderate or high density. It is of particular use for unusually dense minerals such as barite ($BaSO_4$) and cerrusite ($PbCO_3$).

MAGNETISM

Magnetism is a property derived from characteristics of electrons. Iron is the only common crustal element that is magnetic. The Fe-bearing minerals magnetite, pyrrhotite and ilmenite will attract a magnet.

ODOR

Freshly broken or heated minerals may emit characteristic odors. For example, arsenic compounds (*e.g.,* arsenopyrite) have a garlic-like smell. Marcasite often has a sulfurous smell, as does native sulfur.

TASTE

Water-soluble minerals (halides, sulfates, borates) may have a distinctive taste. Common examples of minerals with distinct taste are halite (salty) and sylvite (bitter).

FEEL

Soft minerals such as graphite, talc, serpentine and molybdenite often have a greasy feel to them.

STRIATIONS

Fine lines can be caused by the presence of lamellar twins (plagioclase) or the convergence of two adjoining crystal faces during growth of the crystal(quartz, pyrite, tourmaline).

REACTION WITH ACIDS

Acids react with carbonate minerals to release carbon dioxide in an effervescent reaction. Calcite and aragonite react with cold, dilute HCl in the following reaction: |

$$CaCO_3 + 2H^{+1} \rightarrow Ca^{+2} + H_2O + CO_2$$
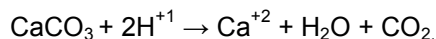
Dolomite will react when powdered or if the acid is heated. Other carbonate minerals such as siderite will effervesce slightly with strong or hot acids. *See calcite (14.111)*

SAMPLE NUMBER: **UNKNOWN A**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

_____

SAMPLE NUMBER: **UNKNOWN B**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

_____

SAMPLE NUMBER: **UNKNOWN C**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

_____

SAMPLE NUMBER: **UNKNOWN D**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

_____

SAMPLE NUMBER: **UNKNOWN E**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

_____

SAMPLE NUMBER: **UNKNOWN F**

COLOR: _____   STREAK: _____

LUSTER: _____   Hardness: VS   S   I   H   VH

CLEAVAGE/FRACTURE: _____

HABIT: _____

OTHER PROPERTIES: _____

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