Physical Properties used in Mineral Identification

1. Color---wavelength of light reflected from the sample to your eye. Least reliable physical property.

2. Streak---color of finely powdered sample.

3. Hardness---resistance to abrasion.

Mohs Hardness Scale

Hardest	**10**	**Diamond (Actually 42)**
	9	**Corundum**
	8	**Topaz**
	7	**Quartz**
	6	**Orthoclase**
		------5 ½ glass plate
	5	**Apatite**
	4	**Fluorite**
	3	**Calcite**
		------2 ½ thumbnail
	2	**Gypsum**
Softest	**1**	**Talc**

4. Crystal faces or form---flat surfaces formed when the mineral grows in an unrestricted environment (Liquid or gas).

5. Rupture---the way a mineral breaks

a. Cleavage---breakage along planes of weak bonding is <u>all</u> examples of the mineral.

Examples:

- **1 direction**
- **2 directions @ 90^{o}**
- **2 directions @ $60^{o}(120^{o})$**
- **3 directions @ 90^{o}**
- **3 directions @ $60^{o}(120^{o})$**
- **4 directions**
- **6 directions**
- **none**

b. Parting---breakage along planes of weak bonding in <u>some but not all</u> examples of the mineral.

c. Fracture---breakage surface is not a plane surface. May be smooth but not a plane.

Examples:

- **Conchoidal---binding force about equal.**
  - **Amorphous materials like obsidian and glass.**
  - **Minerals like quartz.**
- **Smooth---even surface.**
- **Rough---uneven surface.**
- **Fibrous---wood like.**
- **Splintery---in materials where fibers are more compact than fibrous.**
- **Hackly---in metals. Saw-tooth or jagged surfaces.**

6. Tenacity---cohesiveness. Behavior of mineral toward stress.

Examples:

- **Brittle**
- **Tough**
- **Elastic---regains original shape when stress removed**
- **Plastic---stays bent when stress removed**
- **Malleable---hammered into flat sheets**
- **Ductile---drawn into wires**
- **Sectile---cuts into sheets**

metals

7. Specific gravity (no units) or density (units)---only quantitative property. Comparison of the weight of equal volumes of water and the mineral.

Jolly balance
Beam balance
Pycnometer
Heavy liquids

$$\text{Density} = \frac{\text{Weight of sample in air}}{\text{Loss of weight of sample in } H_2O}$$

grams/cubic centimeter gms/cc
pounds/cubic foot lbs/ft^3

$$\text{Specific gravity} = \frac{\text{Density of mineral}}{\text{Density of } H_2O \text{ at } 4^{\circ}C}$$

$$d_{obs} = \frac{Z \times M}{N \times V}$$

Where Z = number of molecules per unit cell
M = molecular weight
N = Avogadro's number ($6.022 \times 10^{23} mol^{-1}$)
V = unit cell volume

Round off Z to nearest whole number, calculate back to determine d_{calc}. Used to determine accuracy.

8. Luster---appearance of the mineral in reflected light, fresh surface.

Examples:

- **Metallic**
- **Sub-metallic**
- **Non-metallic (2 part answer)**
  - **Adamantine---like a polished diamond**
  - **Vitreous---glassy**
  - **Resinous**
  - **Silky**
  - **Satiny**
  - **Waxy**
  - **Greasy**
  - **Pitchy**
  - **Matte**
  - **Dull** ┐
  - **Earthy** ┘ — **no light reflected**

9. Diaphaneity---appearance of mineral in transmitted light, thin edge.

Examples:

- **Transparent---transmits light and image**
- **Translucent---transmits light but not image**
- **Opaque---transmits neither light nor image**

10. Luminescence---emission of light which is not a direct result of incandescence.

Examples:

Fluorescence---UV, X-ray, cathode rays. Stops when the source is shut off.
Phosphorescence---glows on after source is shut off.
Thermoluminescence---heat generated.
Triboluminescence---pressure generated. Scratched, crushed, rubbed.

11. Reaction to acid.

12. Double refraction.

13. Electrical properties.

Piezoelectricity---pressure
Pyroelectricity---heat

14. Magnetism.

15. Striations---fine parallel lines on surface of either crystal faces (growth) or cleavage surfaces (twinning). Used to tell orthoclase (no striations) from Na-rich plagioclase (has striations).

16. Other senses:

Feel---talc, graphite
Taste---halite, sylvite, soda niter
Smell---clayey odor
Hearing---sulfur

17. Crystal habit:

a. Minerals in isolated or distinct crystals may be described as:

1. **Acicular---slender needlelike crystals**
2. **Capillary or filiform---hairlike or threadlike crystals**
3. **Bladed---elongated crystals flattened like a knife blade**

b. For groups of distinct crystals, the following terms are used:

1. **Dendritic---arborescent, in slender divergent branches, somewhat plantlike**
2. **Reticulated---latticelike groups of slender crystals**
3. **Divergent or radiated---radiating crystal groups**
4. **Drusy---a surface covered with a layer of small crystals**

c. Parallel or radiating groups of individual crystals are described as:

1. **Columnar---stout columnlike individuals**
2. **Bladed---an aggregate of many flattened blades**
3. **Fibrous---aggregate of slender fibers, parallel or radiating**
4. **Stellated---radiating individuals forming starlike or circular groups**
5. **Globular---radiating individuals forming spherical or hemispherical groups**
6. **Botryoidal---globular forms resembling, as the word derived from the Greek implies, a "bunch of grapes".**
7. **Reniform---radiating individuals termination in rounded kidney-shaped masses**
8. **Mammillary---large rounded masses resembling mammae, formed by radiating individuals**
9. **Colloform---spherical forms composed of radiating individuals without regard to size; this includes botryoidal, reniform, and mammillary**

d. A mineral aggregate composed of scales or lamellae is described as:

1. Foliated---easily separable into plates or leaves

2. Micaceous---similar to foliated, but splits into exceedingly thin sheets, as in the micas

3. Lamellar or tabular---flat platelike individuals superimposed upon and adhering to each other

4. Plumose---fine scales with divergent or featherlike habit

e. A mineral aggregate composed of grains is Granular

f. Miscellaneous terms:

1. Stalactitic---pendent cylinders or cones; stalactites are formed by deposition from mineral-bearing waters dripping from the roofs of caverns

2. Concentric---more or less spherical layers superimposed upon one another about a common center

3. Pisolitic--rounded masses about the size of peas

4. Oolitic---a mineral aggregate formed of small spheres resembling fish roe

5. Banded---a mineral in narrow bands of different colors

6. Massive---compact material without form or distinguishing features

7. Amygdaloidal---a rock such as a basalt containing almond shaped nodules

8. Geode---a rock cavity lined by mineral matter but not wholly filled; Geodes may be banded as in agate, due to successive depositions of material and the inner surface is frequently covered with projecting crystals

9. Concretion---masses formed by deposition of material about a nucleus; some concretions are roughly spherical whereas others assume a great variety of shapes

18. Radioactivity

CRYSTAL SYSTEM---CONSISTS OF ALL THOSE CRYSTALS WHICH MAY BE REFERRED TO SIMILAR COORDINATE OR CRYSTALLOGRAPHIC AXES (6 OF THEM).

CRYSTAL CLASS---INCLUDES ALL THOSE CRYSTALS WHICH HAVE THE SAME EXTERNAL SYMMETRY; IS THE BASIC UNIT OF CLASSIFYING; 2 OR MORE IN EACH CRYSTAL SYSTEM (32 OF THEM).

CRYSTAL SYSTEM DEFINED BY SYMMETRY; NAMES DERIVED FROM AXES AND SYMMETRY.

1. TRICLINIC CRYSTAL SYSTEM--INCLUDES ALL CRYSTALS WHICH HAVE NO SYMMETRY (1) OR WHICH HAVE ONLY A CENTER OF SYMMETRY ($\bar{1}$ OR c); 2 CRYSTAL CLASSES.

3 CRYSTALLOGRAPHIC AXES WHICH ARE MUTUALLY INCLINED TO EACH OTHER AND NOT AT 90^{O}

UNITS---a, b, c (ALL DIFFERENT)
ANGLES---$\alpha \neq \beta \neq \gamma \neq 90^{O}$

2. MONOCLINIC CRYSTAL SYSTEM---INCLUDES ALL CRYSTALS WHICH HAVE ONLY A PLANE OF SYMMETRY (m) OR ONLY ONE TWO-FOLD ROTATION AXIS (2) OR A COMBINATION OF THESE (2/m); 3 CRYSTAL CLASSES.

3 CRYSTALLOGRAPHIC AXES; 2 AT 90^{O}; 1 INCLINED TO THE OTHERS (NOT AT 90^{O})

UNITS---a, b, c (ALL DIFFERENT)
ANGLES---$\alpha = \gamma = 90^{O} \neq \beta$
β = obtuse

3. ORTHORHOMBIC CRYSTAL SYSTEM---INCLUDES ALL CRYSTALS WHICH HAVE 3 AND ONLY 3 TWO-FOLD ROTATION AXES (222) OR WHICH HAVE ONLY 1 TWO-FOLD ROTATION AXIS AND 2 MIRROR

PLANES (mm2) OR WHICH HAVE ONLY 3 TWO-FOLD ROTATION AXES AND 3 MIRROR PLANES (2/m 2/m 2/m); 3 CRYSTAL CLASSES.

3 CRYSTALLOGRAPHIC AXES AT RIGHT ANGLES (90^O) TO EACH OTHER

UNITS---a, b, c (ALL DIFFERENT)
ANGLES---$\alpha = \beta = \gamma = 90^0$

4. TETRAGONAL CRYSTAL SYSTEM---INCLUDES ALL CRYSTALS WHICH POSSESS 1 AND ONLY 1 FOUR-FOLD AXIS (EITHER FOUR-FOLD ROTATION AXIS OR FOUR-FOLD ROTARY INVERSION AXIS); 7 CRYSTAL CLASSES.

3 CRYSTALLOGRAPHIC AXES AT RIGHT ANGLES (90^O) TO EACH OTHER

UNITS---a AND b ARE EQUAL, c IS DIFFERENT; a_1 a_2 c
ANGLES---$\alpha = \beta = \gamma = 90^0$

5. HEXAGONAL CRYSTAL SYSTEM---

a. TRIGONAL (RHOMBOHEDRAL) DIVISION---INCLUDES ALL CRYSTALS WHICH POSSESS 1 AND ONLY 1 THREE-FOLD AXIS (EITHER THREE-FOLD ROTATION AXIS OR THREE-FOLD ROTARY INVERSION AXIS); 5 CRYSTAL CLASSES.

b. HEXAGONAL DIVISION---INCLUDES ALL CRYSTALS WHICH POSSESS 1 AND ONLY SIX-FOLD AXIS (EITHER SIX-FOLD ROTATION AXIS OR SIX-FOLD ROTARY INVERSION AXIS; 7 CRYSTAL CLASSES.

4 CRYSTALLOGRAPHIC AXES; 3 AT 120^O TO EACH OTHER AND PLANE CONTAINING THESE THREE IS AT 90^O TO THE c AXIS.

UNITS---a LENGTHS ARE THE SAME; c IS DIFFERENT; a_1 a_2 a_3 c
ANGLES---$+a_1 \wedge +a_2 \wedge +a_3 = 120^O$; $\wedge$ BETWEEN PLANE CONTAINING a AXES AND c AXIS = 90^O

6. ISOMETRIC CRYSTAL SYSTEM---INCLUDES ALL CRYSTALS WHICH INCLUDE A MINIMUM OF 3 TWO-FOLD AND 4 THREE-FOLD AXES; 5 CRYSTAL CLASSES.

3 CRYSTALLOGRAPHIC AXES AT RIGHT ANGLES (90^O) TO EACH OTHER

UNITS---a, b, AND c ARE EQUAL; a_1 a_2 a_3
ANGLES---$\alpha = \beta = \gamma = 90^0$

NOTE: TETRAGONAL, HEXAGONAL, AND ISOMETRIC CRYSTALS MAY HAVE MORE SYMMETRY (MIRRORS, TWO-FOLD ROTATION AXES, ETC.) BUT THESE ARE NOT NECESSARY FOR SYSTEM IDENTIFICATION.

Geology 2500--List of minerals and rocks

Minerals

Native elements
- **Diamond**
- **Graphite**
- **Native sulfur**

Sulfides
- **Pyrite**
- **Chalcopyrite**
- **Galena**
- **Sphalerite**

Oxides
- **Corundum**
- **Bauxite**
- **Hematite, specular**
- **Hematite, oolitic**
- **Magnetite**
- **Limonite**
- **Pyrolusite**

Carbonates
- **Calcite**
- **Dolomite**
- **Siderite**

Halides
- **Halite**
- **Fluorite**
- **Sylvite**

Sulfates
- **Gypsum, alabaster**
- **Gypsum, satinspar**
- **Gypsum, selenite**
- **Barite**

Phosphates
- **Apatite**

- **Silicates**
  - **Tectosilicates**
    - **Olivine**
    - **Staurolite**
    - **Kyanite**
    - **Topaz**
    - **Garnet group**
      - **Almandite**
  - **Sorosilicates**
    - **Epidote**
  - **Cyclosilicates**
    - **Beryl**
    - **Tourmaline**
  - **Inosilicates**
    - **Single chain**
      - **Pyroxene group**
        - **Augite**
    - **Double chain**
      - **Amphibole group**
        - **Hornblende**
  - **Phyllosilicates**
    - **Talc**
    - **Mica group**
      - **Muscovite**
      - **Biotite**
    - **Chlorite**
    - **Clay mineral group**
      - **Kaolinite**
      - **Montmorillonite**
      - **Illite**
    - **Serpentine**
  - **Tectosilicates**
    - **Feldspar group**
      - **Orthoclase**
      - **Plagioclase series**
        - **Albite**
        - **Oligoclase**
        - **Andesine**
        - **Labradorite**
        - **Bytownite**
        - **Anorthite**

Silica group

- **Quartz, Microcrystalline**
- **Quartz, Milky**
- **Quartz, Rose**
- **Quartz crystal**

Igneous Rocks

- **Basalt**
- **Basalt porphyry**
- **Diorite**
- **Dunite**
- **Gabbro**
- **Granite, gray**
- **Granite, pink or red**
- **Obsidian**
- **Porphyritic granite**
- **Pumice**
- **Rhyolite**
- **Scoria**
- **Syenite**
- **Volcanic breccia**

Sedimentary Rocks

- **Arkose**
- **Bituminous coal**
- **Breccia**
- **Chert**
- **Conglomerate**
- **Coquina**
- **Limestone, crystalline**
- **Limestone, fine grained (micrite)**
- **Limestone, fossiliferous**
- **Limestone, oolitic**
- **Rock gypsum**
- **Rock salt**
- **Quartz sandstone**
- **Shale**
- **Travertine**

Metamorphic Rocks

Gneiss
Marble, coarse-grained
Marble, fine-grained
Phyllite
Quartzite, pink
Quartzite, white
Schist, biotite
Schist, garnet muscovite
Slate

Abundances of chemical elements in the earth's crust*

Element and symbol	Percentage by weight	Percentage by number of atoms	Percentage by volume
Oxygen (O)	46.6	62.6	93.8*
Silicon (Si)	27.7	21.2	0.9
Aluminum (Al)	8.1	6.5	0.5
Iron (Fe)	5.0	1.9	0.4
Calcium (Ca)	3.6	1.9	1.0
Sodium (Na)	2.8	2.6	1.3
Potassium (K)	2.6	1.4	1.8
Magnesium (Mg)	2.1	1.9	0.3
All other elements	1.5		
	100.0	100.0†	100.0†

*Note the high percentage of oxygen in the earth's crust.

†Includes only the first eight elements.

(Based on B. Mason, *Principles of Geochemistry*, New York, John Wiley & Sons, Inc., 1966.)

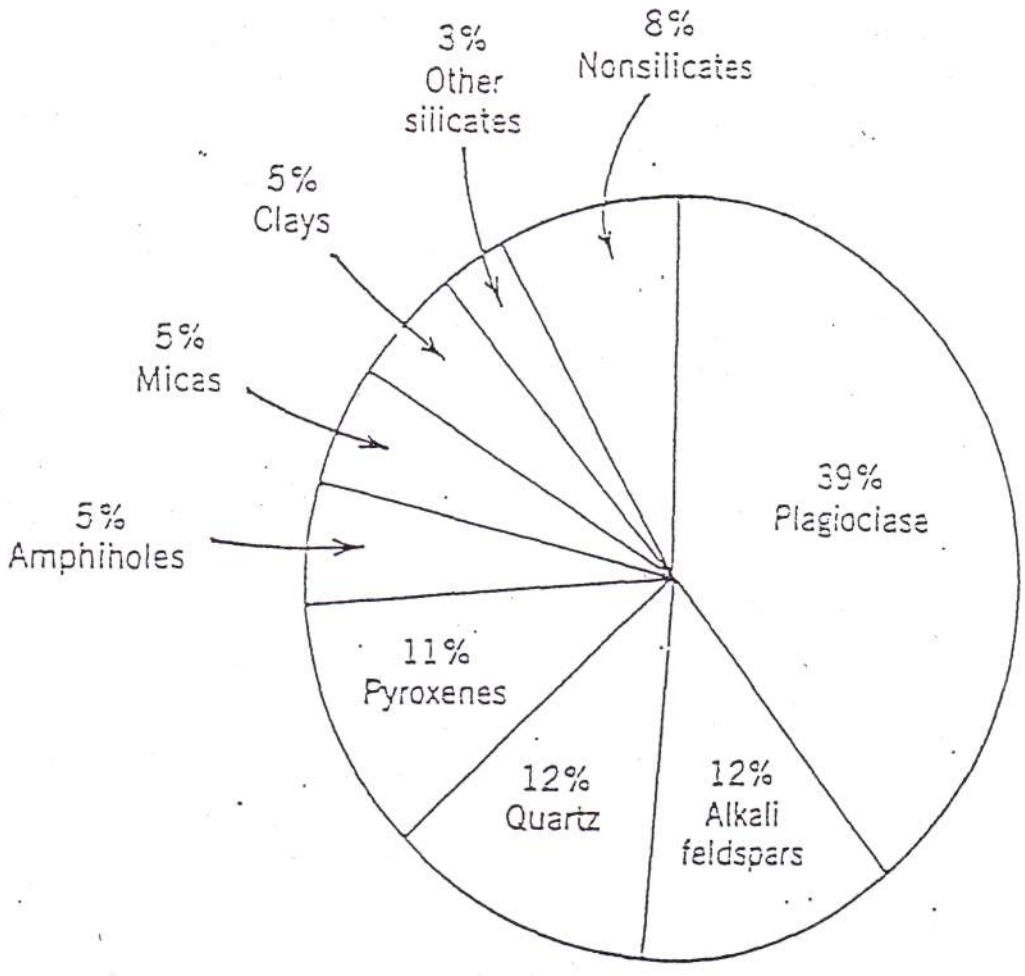

FIG. 13.1. Estimated volume percentages for the common minerals in the Earth's crust, inclusive of continental and oceanic crust. Ninety-two percent are siiicates. (From Ronov, A. B. and Yaroshevsky, A. A., 1969, Chemical composition of the Earth's crust. American Geophysical Union Monograph no. 13, p. 50.)

SILICATE CLASSIFICATION

SUBCLASS	ARRANGEMENT OF SiO_4 TETRAHEDRA	RATIO Si : O	NUMBER OF SHARED CORNERS	EXAMPLE
Nesosilicates	Isolated (island)	1 : 4	None	Olivine $(Mg, Fe)_2SiO_4$
Sorosilicates	Bow-tie	2 : 7	1 of a pair	Hemimorphite $Zn_4(Si_2O_7)(OH)\cdot H_2O$
Cyclosilicates	Ring	1 : 3	2	Beryl $Be_3Al_2(Si_6O_{18})$
Inosilicates	Single chain	1 : 3	2	Pyroxene group minerals
	Double chain	4 : 11	2 1/3	Amphibole group minerals
Phyllosilicates	Sheets	2 : 5	3	Talc $Mg_3(Si_4O_{10})(OH)_2$
Tectosilicates	Framework	1 : 2	4	Quartz SiO_2

Table 2-3. LUSTER: Metallic or Sub-metallic

Streak	Hardness	Color	Sp. Gr.	Remarks and uses	Name and composition
Black	1	Steel gray	2	Soft, marks on paper, greasy feel, 1direction cleavage. Used in refractory crucibles, lubricants and pencil leads.	GRAPHITE C
Black	1-2	Black	4.8	Radiating fibers, granular masses, or dendritic, sooty. An ore of manganese.	PYROLUSITE MnO_2
Yellow Brown	1 to 5 1/2	Yellow brown to dark brown to black	3.3 to 4.0	Flattened crystals, massive, reniform or stalactitic. Secondary mineral in rocks and soils. An ore of iron.	LIMONITE $FeO(OH)•nH_2O$
Red brown to Indian red	1 to 6 1/2	Steel gray to black	4.8 to 5.3	Massive, radiating, micaceous. Crystalline varieties harder than earthy. An ore of iron.	HEMATITE Fe_2O_3
Gray	2 1/2	Gray	7.6	Occurs in cubes; may be massive or granular; heavy; cubic cleavage. The main ore of lead.	GALENA PbS
Greenish-black	4	Brass yellow	4.3	Often tarnished purple or gray, yellower and softer than pyrite. An ore of copper.	CHALCOPYRITE $CuFeS_2$
Black	6	Black	5.2	Strongly magnetic. An ore of iron.	MAGNETITE Fe_3O_4
Black to greenish	6 to 6 1/2	Pale brass	5.0	Often in crystals. Massive, granular. Common name: "Fool's gold." Sometimes mined as a source of sulfur.	PYRITE FeS_2

Table 2-4 LUSTER: Non-metallic
Section A. **STREAK** definitely colored

Streak	Hardness	Color	Sp. Gr.	Remarks & Uses	Name and composition
Yellow brown	1 to 5 1/2	Yellow brown to dark brown	3.6 to 4.0	Earthy. Secondary mineral in rocks and soils. Typical lusters: earthy to dull to submetallic. An ore of iron.	LIMONITE $FeO(OH)•nH_2O$
Red brown to Indian red	1 to 6 1/2	Red, vermillion	4.8 to 5.3	Earthy; frequently as pigment in rocks. Massive, radiating. Crystalline varieties harder than earthy. An ore of iron.	HEMATITE Fe_2O_3

TABLE 2-4. LUSTER: Non-metallic
Section B. **STREAK** colorless or light colored
PART 1. **Hardness:** < 2 1/2 (can be scratched with thumbnail)

Hardness	Cleavage Fracture	Color	Sp. Gr.	Remarks and Uses	Name and composition
1	Good cleavage in 1 direction	White, green, pink	2.7	Flexible but not elastic; foliated; slick. Used in paints, ceramics, rubber, insecticides, paper.	TALC Hydrous Mg-silicate
1-2	No macroscopic cleavage	White, tan, light to dark gray	2-3	Earthy; clay odor; swelling clay. Used to stop leaks in soils, rocks, dams and basement walls.	MONTMORILLONITE Complex Ca, Na, Mg Aluminosilicate
1-3	Uneven fracture	Yellow brown to red	2-3	Dull to earthy luster; in rounded grains – pisolitic; not truly a mineral. An ore of aluminum.	BAUXITE Al_2O_3+ impurities
1 1/2 - 2 1/2	Conchoidal to uneven	Yellow	2.1	Characteristic yellow color; crackles when held in hand close to ear because of thermal expansion. Used to make sulfuric acid, fertilizers, insecticides, explosives and medicines.	NATIVE SULFUR S
2	1 direction perfect	Pale, brown green, yellow	2.8	In foliated masses and scales; transparent, flexible and elastic sheets. Used to insulate electrical equipment and as fireproofing material.	MUSCOVITE Hydrous Silicate of Al, K
2	No macroscopic cleavage	White, often colored by impurities	2.6	Earthy; clay odor; non-swelling clay; sticks to tongue. Used in refractories, china, pottery and as a filler in paper.	KAOLINITE $Al_2(Si_2O_5)(OH)_4$
2	1 direction, perfect, 2 directions good	Colorless, white, gray, gray-brown pink reddish	2.3	As crystals and broad cleavage flakes (Selenite); as compact masses showing no cleavage (Alabaster); as fibers with satiny luster (Satinspar). Used to make plaster of Paris and wallboard.	GYPSUM $CaSO_4 \cdot 2H_2O$
2	3 directions, perfect, cubic	Colorless, white blue, yellow, red	2.0	Water soluble; bitter salty taste. A source of potassium.	SYLVITE KCl
2-2 1/2	1 direction	Dark green to green-black	2.7	Flexible sheets. Luster typically resinous, waxy, vitreous or dull.	CHLORITE Mg, Fe, Al Silicate
2-3	Wavy, uneven fracture	Green and white	2.5	Platy or fibrous, waxy luster when massive. Used as insulating material against heat and electricity.	SERPENTINE (Asbestos) $Mg_6Si_4O_{10}(OH)_8$

TABLE 2-4. LUSTER: Non-metallic
Section **LIGHT STREAK** *Colorless or light colored*
PART 2. Hardness: 2 1/2 - 3 1/2
(cannot be scratched with thumbnail; will not scratch penny)

Hardness	Cleavage Fracture	Color	Sp. Gr.	Remarks and Uses	Name and composition
2-3	Wavy uneven fracture	Green and white	2.5	Platy or fibrous, waxy luster when massive. Used as insulation against heat and electricity.	SERPENTINE (Asbestos) $Mg_3Si_2O_5(OH)_4$
2 1/2	3 directions perfect, cubic	White when pure; may be red, blue, pink, etc.	2.1 to 2.3	In granular cleavable masses or cubic crystals. Soluble in water; salty taste. Common salt. A source of sodium and chlorine for sodium compounds and hydrochloric acid; used to salt highways in winter; a seasoning.	HALITE NaCl
2 1/2 to 3	1 direction perfect	Dark brown, green to black	3.0	As irregular foliated masses and scales; transparent, flexible and elastic sheets. Pearly to vitreous luster.	BIOTITE Hydrous silicate of Al, K, Mg, Fe
3	3 directions, perfect, rhombic	White or colorless, but may be pink, blue, brown, etc.	2.7	Crystals in many forms. Occurs in large granular masses (limestone or marble) and fine granular or fibrous masses in in which cleavage not prominent; compact masses. Effervesces in cold, dilute HCl. Used in the manufacture of cement; crushed stone; agricultural lime.	CALCITE $CaCO_3$
3 to 3 1/2	1 direction perfect 2 directions, good	White or gray	4.5	Crystals usually tabular; very heavy for a nonmetallic. Luster: vitreous, pearly, dull. Used to give weight to drilling muds to prevent "blow-outs" of oil and gas wells.	BARITE $BaSo_4$

TABLE 2-4. LUSTER: Non-metallic
Section B. **STREAK** Colorless or Light Colored
PART 3. **Hardness:** 3 1/2-5 1/2 (will scratch penny; will not scratch glass)

Hardness	Cleavage Fracture	Color	Sp. Gr.	Remarks and Uses	Name and composition
3 1/2 to 4	3 directions perfect, rhombic	White, pink, brown, gray, etc.	2.9	Usually harder than a penny. As crystals with curved faces (twisted rhombs). As granular masses (dolomitic marble, dolostone). Effervesces in cold, dilute HCl if powdered. Used as a building and decorative stone.	DOLOMITE $CaMg(CO_3)_2$
3 1/2 to 4	Perfect cleavage in 6 directions	Yellow to brown, black reddish brown	4	Resinous luster. Usually massive. All six cleavages rarely seen at same time. Ore of zinc.	SPHALERITE ZnS
3 1/2 to 4	3 directions, perfect, rhombic	Light to dark brown, maroon	4	As crystals with curved faces. Usually cleavable; sometimes granular masses. Effervesces in dilute HCl only if powdered. Minor ore of iron.	SIDERITE $FeCO_3$
4	Good in 4 directions, octahedral	Purple, green to yellow, colorless	3.2	Well-formed cubic crystals, also massive. Used as a flux in steel-making, and in the production of hydrofluoric acid.	FLUORITE CaF_2
5	Poor cleavage 1 direction	Green to brown	3.2	Massive or granular. Vitreous luster when in large yellow crystals.	APATITE $Ca_5(PO_4)_3(F,Cl)$
5 to 6	2 directions good, at approx. 56º and 124º	Green to black	3.0 to 3.3	Crystals slender, fibrous. Commonly in cleavage fragments or granular masses.	AMPHIBOLE GROUP (Hornblende) Hydrous silicate of Ca, Na, Mg, Fe, Ti, and Al
5 to 7	Good in 1direction	Blue to green	3.6	In bladed aggregates. Used to make spark plugs and other highly refractory porcelains.	KYANITE Al_2SiO_5
5 1/2 to 6	2 directions poor to fair at 87º and 93º	Green to black	3.1 to 3.5	Crystals "stubby" with rectangular cross section. Commonly in granular, crystalline masses.	PYROXENE GROUP (Augite) Alumino-silicate of Ca,Mg and Fe

TABLE 2-4: LUSTER: Non-metallic
Section B. **STREAK** Colorless or light colored
PART 4. **Hardness:** > 5 1/2 (will scratch glass)

Hardness	Cleavage Fracture	Color	Sp. Gr.	Remarks and Uses	Name and composition
5-6	2 directions good, at approx 56º and 124º	Green to black	3.0 to 3.3	Crystals slender, fibrous. Commonly in cleavage fragments or granular masses.	AMPHIBOLE GROUP (*Hornblende*) Hydrous silicate Ca, Na, Mg, Fe, Ti and Al
5 to 7	Good in 1 direction	Blue to green	3.6	In bladed aggregates. Used to make spark plugs, highly refractory porcelains.	KYANITE Al_2SiO_5
5 1/2 to 6	2 directions poor to fair at 87º and 93º	Green to black	3.1 to 3.5	Crystals "stubby" with rectangular cross section. Commonly in granular, or crystalline masses.	PYROXENE GROUP (Augite) Alumino-silicate Ca, Mg and Fe
6	2 directions good at right angles	Colorless, white, pink, red, gray, green, etc.	2.5 to 2.6	As cleavable masses or irregular grains in rocks. As crystals in pegmatites and some igneous bodies. Luster generally vitreous to pearly.	FELDSPAR GROUP (Orthoclase) $KAlSi_3O_8$
6	2 directions good at approx 87º and 93º	Colorless, white, various shades of gray	2.6 to 2.8	In cleavable masses or irregular grains. Striations are common. Luster generally vitreous to pearly.	FELDSPAR GROUP $NaAlSi_3O_8$ $CaAl_2Si_2O_8$
6 1/2	Uneven fracture	Red to brown	4.3	Usually in 12 or 24-sided crystals, also massive. Resinous luster. May exhibit parting. Used as an abrasive, and as a gemstone.	GARNET (Almandite) $Fe_3Al_2(SiO_4)_3$
6 1/2 to 7	Conchoidal fracture	Olive green to yellow green	3.3 to 3.4	Usually as disseminated grains in mafic igneous rocks; as granular masses with saccharoidal texture (like sugar). Vitreous luster. Mined for refractory sand in the casting industry.	OLIVINE $(Mg,Fe)_2SiO_4$
7	Conchoidal fracture	Colorless or white when pure but may be any color.	2.6	As crystals with hexagonal cross section; often striations on prism faces. As crystalline masses, granular aggregates, irregular grains. Vitreous or greasy luster, varieties - *milky*: white, opague; *smoky*: gray to black; *rose:* pink; *amethyst:* violet. Used as a gemstone, flux, filter, abrasive.	QUARTZ SiO_2
7	Conchoidal fracture	Various colors	2.6	Varieties – *Agate:* massive to banded. *Flint:* dark color; *Chert*: light color, white to gray, *Jasper:* red, *Opal:* milk-white, yellow, green, red, etc., waxy luster, *Chalcedony:* brown to gray, fibrous.	MICROCRYSTALLINE QUARTZ SiO_2

TABLE 2-4. LUSTER: Non-metallic
Section B. PART 4, Continued

Hardness	Cleavage Fracture	Color	Sp. Gr.	Remarks and Uses	Name and composition
7 to 7 1/2	Cleavage not prominent	Varied; black common	3.2	Usually in trigonal prismatic crystals; striations prominent. Used as a gemstone.	TOURMALINE Complex silicate
7 to 7 1/2	Cleavage not prominent	Red-brown to brownish-black	3.7	Cross-shaped twin crystals common ("Fairy crosses.") Also elongate bladed crystals with rhombic cross-sections.	STAUROLITE Complex Fe Aluminosilicate
8	Imperfect cleavage	Green to yellow	2.7	Hexagonal, prismatic crystals. Used as a gemstone, and a source of beryllium for metal alloys.	BERYL $Be_3Al_2Si_6O_{18}$
8	1 direction poor	Colorless, pink, yellow	3.5	Prismatic crystals, crystalline or granular masses. Luster generally vitreous. High quality crystals used as gemstones.	TOPAZ $Al_2(SiO_4)(OH,F)_2$
9	Basal parting	Brown, pink, ruby-red	4.0	Barrel-shaped crystals; hexagonal prisms; basal parting common. Used as an abrasive and as a gemstone (red – ruby, and blue – sapphire.)	CORUNDUM Al_2O_3
10	4 directions, octahedral	Colorless, pale, yellow	3.5	Adamantine luster, uncut crystals have a characteristic greasy appearance. Used as an abrasive and a gemstone.	DIAMOND C

MINERAL IDENTIFICATION

Sample Number	Luster	Streak	Hardness	Color	Cleavage/Other Properties	Mineral Name And Composition

MINERAL IDENTIFICATION

Sample Number	Luster	Streak	Hardness	Color	Cleavage/Other Properties	Mineral Name And Composition

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