

a10 Physical properties of common rock forming minerals

< see, feel, taste, smell, hear >

Werner in 1780, added to the curriculum at Freiberg mining academy, Germany, a course in which he taught practical or deterministic mineralogy. He divided his classes into small groups to provide individual instruction and to teach the recognition of minerals from hand samples. This was at a time when mineralogists lectured to hundreds. According to a student of his, at one point in the lecture hall when a box of specimens was being passed from hand to hand, someone jostled it and nearly spilled the content to the floor, at which point, Werner turned pale and could not speak ... it was seven or eight minutes before Werner could command his voice. However, when one considers the central role of his specimens to his mineral classification system, Werner was not being eccentric. His reaction might be better compared with that of a curator of the standard yardstick near Paris who comes across an assistant about to use it as a crowbar.

—Mott T. Greene, *Geology in the Nineteenth Century*, 1982.¹

Each named mineral is distinguished by the dual criterion of a *crystal structure that is definite* (does not vary from one specimen to the next) and a *chemical composition that is characteristic* (can vary as its chemical formula shows but not cause a change of crystal structure). Each named mineral variety is a part of a mineral's chemical range. These criteria for mineral classification are most readily known by means of X-ray diffraction (for structure) and X-ray fluorescence (for composition) and so postdate Wilhelm Röntgen's accidental discovery of X-rays in 1895.² For practical reasons, only readily observable physical difference were, and are, used for field determinations of minerals.

Abraham Gottlob Werner (1749-1817) is considered to be the Founder of Mineralogy because he was the first to systematically classify minerals (during 1771³-1800) by their obvious "external" (physical) characters such as *color, luster, streak, crystal form, crystal habit, cleavage, and hardness*.

A mineral's little then known internal characters (chemical composition and crystal structure) and those not readily determined in the field (as specific gravity and fusibility) were not used by Werner.

Color, specific color Color categories are black, dark gray, yellow, brown, red, blue, green, light gray, white, and colorless. Field keys for the identification of minerals that follow Werner's pragmatic approach, use color as the first criterion. This is because the human eye has the ability to see an enormous variety of colors and, although some minerals can have a wide variety of colors (for example, quartz varieties are colorless, milky, smokey gray, black, yellow, amethyst, or rose), their *specific color* is not easily confused (except for 1 in 12 men and 1 in 120 women who colorblind see grey for red and green)⁴ with other minerals in the same color category (the rose pink of quartz is different from Werner's "flesh red"—a combination of crimson red and yellowish white—often shown by potassium feldspar). Olivine is usually a distinctive olive green but it can be brown or yellow. Garnet is usually thought of as a red mineral and with that color it is often a substitute for ruby. However, garnet occurs in seemingly every color and shade, from black to colorless. A mineral's specific color once seen is easier to recall than to describe. For example, the mineral malachite (a common copper-carbonate ore mineral) occurs only as a green mineral (not the patina on copper or bronze which is a copper-sulfate mineral). However, Werner's description of its specific color as "leek green" is surely only useful after a sample of malachite has been shown.

(Figure a9.1 cont.) 5) stronger bonds are formed by orbitals that overlap more with other atom orbitals and 6) the stronger bonds are formed by the orbitals which are closest to the nucleus of the atom.

In 1988, Linus in a conversational mood after having given the keynote speech at the UCLA-Sloan winter school on molecular evolution, mentioned to Jim Lake that one day his wife had surprised him by asking "why he hadn't solved the structure of DNA." His reply had been "I don't know, I guess that I always thought that the DNA structure was mine to solve, and therefore I didn't pursue it aggressively enough."⁷

Luster All the common rock forming minerals have a nonmetallic luster. That is, they do not look like metals. Olivine and garnet look glassy (vitreous). Quartz looks glassy or greasy and is sometimes splendent (sparkly). The feldspars and pyroxene and amphibole can look glassy but they usually look pearly. The same is so of the micas but they can be splendent (their mirror-like appearance can look metallic but not so a thin piece which will be seen to be transparent), and muscovite in tiny flakes looks silky. Clay, and the mineraloid limonite, look dull or earthy.

Some minerals look metallic or submetallic because they are native minerals of metal (“native” refers to the composition being one element). A nugget of gold (Au) always looks metallic because gold does not tarnish. The mineral silver (Ag) in a stream deposit looks submetallic as its surfaces tarnish black. Some minerals that are not native metals can look metallic. For example galena (PbS) looks like silver, pyrite (FeS₂) and chalcopyrite (CuFeS₂) look like gold (so much so, they are called “fools gold”). What fools are highlights on the shiny opaque mineral with the color of the metal (white in the case of galena, yellow in the case of pyrite) regardless of the color of the illuminating light. Magnetite (FeO·Fe₂O₃) looks like iron. Graphite (C) (the one nonmetal that is a good conductor of electricity) can look metallic and sphalerite (Gk. treacherous rock) (ZnS) can look submetallic.

Streak Streak is the color of a mineral that has been crushed to a powder. The streak of a mineral is usually obtained by rubbing the mineral on a streak plate (a piece of unglazed white or black porcelain). Streak is more consistent than the specific color of a mineral. The streak of common rock forming silicate minerals is white to pale grey or, in the case of the pyroxene and amphibole, a pale grey green. This can be seen by bruising a rock with a hammer.

For the identification of the metallic minerals, especially as these can be compounds and not native metals, streak is the second most important diagnostic property. For example, the streak of the metallic-yellow mineral pyrite (fool’s gold) is dull black whereas the streak of gold is metallic yellow. The streaks of a metallic silver-appearing galena and graphite are dull black and of metallic silver-appearing hematite (Fe₂O₃) (variety called *specularite*) is red. Sphalerite, looks submetallic when black, characteristically has a pale-yellow streak.

Crystal form Observations of the external crystal forms of minerals finds 32 geometric classes of symmetry. Interfacial angles are independent of the size of the crystal or of its faces (Steno’s Law).

Crystal habit The characteristic crystal shape (for example: platy, equant, granular, cubic, stubby, lath shaped, tabular, columnar, pyramidal, prismatic, blade-like, needle-like) of a mineral is its habit. Even when the mineral is small, its habit (shape due to growth) can aid in its identification in rock. For example, the habit of quartz, olivine, pyroxene, and garnet is granular. In rock, quartz crystals are typically irregular in outline whereas olivine, pyroxene, and garnet are often geometric in outline, feldspar is lath shaped, amphibole is blade or needle shaped, and mica is platy.

Cleavage Mineral cleavage is exhibited when *visible flat surfaces* result from breakage. Some minerals that do not exhibit cleavage are quartz, olivine, garnet, magnetite and pyrite. When these are broken the fracture surfaces are irregular or curved (conchoidal). Asbestos splinters into threads.

Hardness A mineral’s hardness a measure of its ability to withstand abrasion by other substances. Friedrich Mohs (1773-1839), a student and successor in 1818 of Werner at Freiberg mining academy, published in 1820 a comparative hardness scale⁵ (the resistance of a mineral’s smooth surface to scratching by a sharp part of another or the blunting of it). For his scale, he selected ten commonly available minerals of contrasting hardness and ranked them in increasing hardness (H): 1 talc, 2 gypsum, 3 calcite, 4 fluorite, 5 apatite, 6 feldspar, 7 quartz, 8 topaz, 9 corundum (ruby and sapphire when precious), and 10 diamond (bort when not precious) (The Girls Can Flirt And Other Quaint Things Can Do). On this scale, your skin is 1.5 (so talc cannot scratch it, and talc feels soothing as a powder), a copper penny is 3.5 (and rubbed on it, or on calcite, galena, being softer, leaves a black powder and fool’s gold, being harder, shines it, or scratches calcite to produce a white powder), and window glass is 5.5 as is a steel knife blade (which, depending on how it is rubbed on harder feldspar or quartz. can be either blunted or sharpened). As the scale is approximately logarithmic,⁶ diamond in ordinary terms is super-hard. Metal picks of Mohs hardnesses are available. □