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Diaphaneity/Light Transmission

The degree to which a material transmits light is generally termed **diaphaneity**. A few people incorrectly call this property opacity.

Transparent: Said of materials capable of transmitting light and through which an object can be seen clearly.

Translucent: Said of materials capable of transmitting light but through which an object cannot be discerned, except possibly in outline and generally distorted. Most translucency depends on either absorption of light because of a material's dark color or scattering of light within the material.

Opaque: Said of materials that are incapable of transmitting light.

Diaphaneity is correlative with luster and consequently with, for example, predominant bond type. In general, materials with metallic lusters are opaque, whereas those with nonmetallic lusters are not.

Luster

Luster, an optical property, closely related to reflection and refraction, can be defined as the appearance of a material in reflected light. Two classes of luster are prevalent and recognized in minerals—those termed **metallic** and those termed **nonmetallic**. Strictly speaking, however, no sharp division can be made between the two classes, and minerals that appear to be neither, or either, are usually said to be **submetallic**.

The impression luster is produced by the amount and nature of light reflected from the surface of a mineral. It depends largely on the character of the surface and the quantity of reflected light. It is quite apparent that a smooth cleavage surface will reflect more light than an uneven fracture will, even if both are the same mineral; in fact, every detail of surface configuration is important. It is also quite obvious that different crystallographic directions, especially in anisotropic minerals, are likely to absorb different percentages of light and consequently reflect different amounts of incident light; thus, even different surfaces of individual specimens of a single mineral may have different lusters.

In general, the greater a mineral's refractive index, the higher the luster.

Metallic luster: Minerals that absorb visible radiation strongly, being opaque or nearly opaque even in very thin fragments (although they may be transparent to infrared radiation), generally have metallic luster. Their refractive indices are 3 or greater. The native metals and most of the sulfides are in this group.

Figure 1: A pyrite mineral showing metallic luster.

Submetallic luster: Minerals with refractive indices between 2.6 and 3; most of them being nearly opaque or opaque, generally have submetallic luster. Examples are cuprite (n=2.85), cinnabar (n=2.9), and hematite (n=3.0).

Figure 2: A sphalerite sample showing submetallic luster.

Nonmetallic luster (several varieties are recognized):

Adamantine luster: The brilliant luster typical of a diamond. It is characteristic of minerals with refractive indices between 1.9 and 2.6. Examples are zircon, cassiterite, sphalerite, diamond, and rutile.

Figure 3: Adamantine luster of diamond.

Resinous luster: The combination of a yellow or brown color with refractive indices between 1.9 and 2.6 produces a resinous luster, a luster like that of a resin.

Figure 4: Resinous luster of amber.

Vitreous luster: The luster of glass. It is characteristic of minerals with refractive indices between 1.3 and 1.9. This range includes about 70 percent of all minerals, comprising nearly all the silicates, most other oxysalts (carbonates, phosphates, sulfates, etc.), the halides, and oxides and hydroxides of the lighter elements such as Al and Mg.

Figure 5: Vitreous Luster of a variety of quartz.

Greasy, waxy, silky, pearly, and dull lusters: Variants of nonmetallic luster, caused by the character of the reflecting surface. Diamonds often have a somewhat **greasy** luster, evidently s the result of a microscopically rough surface that scatters the reflected light. Cleavage surfaces of halite have a vitreous luster when fresh, but they take on a **greasy** or **waxy** appearance after exposure to damp air, which produces a slightly roughened surface. The **greasy** luster is common in nepheline is due to a beginning alteration. Cryptocrystalline and amorphous minerals, such as chalcedony and opal, often have a **waxy** luster. Minerals occurring in parallel-fibrous aggregates, such as asbestos and some varieties of gypsum, are said to have **silky** luster. Transparent minerals with layer-lattice structures and accompanying perfect lamellar cleavage have characteristically **pearly** luster produced by reflection from successive cleavage surfaces, examples are talc, the micas, and coarsely crystallized gypsum. Porous aggregates of a mineral, such as the clays, scatter incident light so completely that they seem to be without luster and and are described as **dull** or **earthy**.

Figure 6: Greasy luster of an opal sample.

Figure 7: Waxy luster of jade.

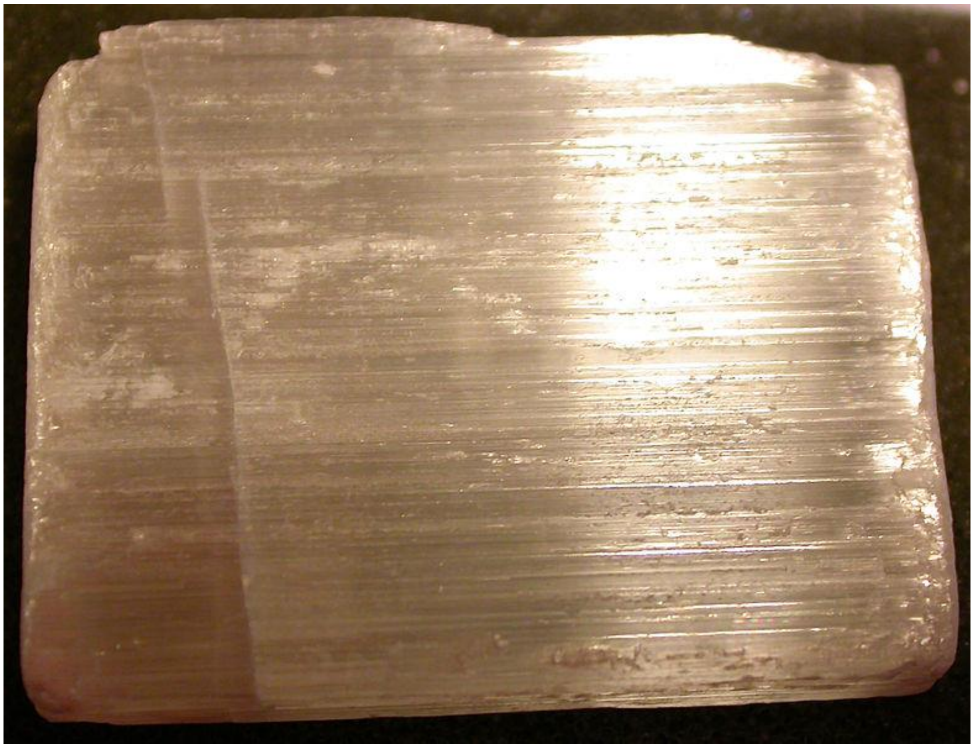

Figure 8: Silky luster of a variety of gypsum.

Figure 9: A muscovite mineral showing pearly (black) luster

Figure 10: Dull or earthy luster of Kaolinite mineral.

It can be shown that a mineral's refractive index and light absorption, and thus reflectivity (luster), can be roughly correlated with its predominant bonding as follows: the indices of refraction are high, moderately high, and low for materials with predominantly metallic, covalent, and ionic bonding, respectively; the absorption of light is high, moderately low, and low for materials with these bonds, also respectively; consequently, the luster tends to be high, moderate and low with these kind of bonds respectively. This relationship has been tabulated in Table 1.

Table 1: Correlation of minerals' refractive index, light absorption, and luster with predominant chemical bonding.

Type of bonding	Absorption of light	Refractive indices	Luster
Metallic	High	High	High
Covalent	Moderately low	Moderately high	Moderate
Ionic	Low	Low	Low

Luster can also be roughly correlated with color and light transmission in that most minerals that have dark colored streaks and/or are opaque have metallic or submetallic lusters.

The luster of minerals has an economic aspect, as is evidenced by gemstones. The qualities of beauty attributed to several gemstones include luster as well as color and transparency. Luster, in fact, is generally responsible for the brilliance of a gemstone so that, other things being equal, the higher the luster (and refractive index) of a gemstone, the greater its brilliance and its beauty.

Streak

Streak is the color of a powder of a mineral and is obtained by rubbing the mineral across an unglazed porcelain tile called a streak plate. The streak is frequently different from that of the massive mineral and often more consistent for any one mineral, whatever its color in hand specimen. A mineral powder diffuses light falling on it and thereby yields a more reliable color hue. It should be noted that a mineral streak is more diagnostic for opaque minerals with metallic lusters than it is for the more commonly encountered vitreous luster minerals with white streak mineral powders. More precisely, it is less useful for silicate minerals, most of which have a white streak or are too hard to powder easily. If no streak seems to be made, the mineral's streak is said to be white or colorless.

The apparent color of a mineral can vary widely because of trace impurities or a disturbed macroscopic crystal structure. Small amounts of an impurity that strongly absorbs a particular wavelength can radically change the wavelengths of light that are reflected by the specimen, and thus change the apparent color. However, when the specimen is dragged to produce a streak, it is broken into randomly oriented microscopic crystals, and small impurities do not greatly affect the absorption of light.

The hardness of the streak plate (6.5) limits the range of minerals that can be tested. Its usefulness is also limited to minerals present as large crystal pieces or as the main constituent of a rock.

Some minerals leave a streak similar to their natural color, such as cinnabar and lazurite. Other minerals leave surprising colors, such as fluorite, which always has a white streak, although it can appear in purple, blue, yellow, or green crystals. Hematite, which is black in appearance, leaves a red streak. Galena, which can be similar in appearance to hematite, is easily distinguished by its gray streak.

Figure 1: Shows streak of two minerals.

(N.B.: Diffuse color is the most instinctive meaning of the color of an object. It is that essential color that the object reveals under pure white light. It is perceived as the color of the object itself rather than a reflection of the light.)

Luminescence

Luminescence is the emission of light as the result of any process other than incandescence. Such light is dependent on energy conversions. It can be caused by chemical reactions, electrical energy, subatomic motions, or stress on a crystal. This distinguishes luminescence from **incandescence**, which is light emitted by a substance as a result of heating. The kinds of energy thus far shown to cause luminescence include those usually referred to as electromagnetic (optical and nuclear), electric, mechanical, chemical, and biochemical energy.

The term 'luminescence' was introduced in 1888 by Eilhard Wiedemann. The dials, hands, scales and signs of aviation and navigational instruments and markings are often coated with luminescent materials in a process known as 'luminising'. Actually, at least 15 different kinds of luminescence, each named on the basis of the source of excitation, have been recognized and described.

The luminescence most frequently observed in minerals is generally termed **photoluminescence**. It is usually stimulated by irradiation with ultraviolet light and is best observed in total darkness. **Fluorescence** is the emission of light at the same time as the irradiation. In most cases, the emitted light has a longer wavelength, and therefore lower energy, than the absorbed radiation. A very useful property that has may striking examples in the mineral kingdom where ultra-violet radiation is re-emitted in the visible spectrum. **Phosphorescence** is continued emission of light after the irradiation is terminated.

The fundamental law of luminescence, **Stoke's Law**, states that the wavelength of the luminescence that is emitted is longer than the wavelength wavelength of the exciting radiation or, to state it otherwise, the energy of the luminescence that is emitted is less than the energy of the exciting radiation.

Sometimes the absorbed energy is "frozen in" and is released only up on heating of the material; this process is known as **thermoluminescence**.

Another interesting type of luminescence that is met with occasionally in minerals is termed **triboluminescence**. This luminescence is induced by pressure, crushing, scratching, or rubbing. Aragonite, barite, calcite, dolomite, fluorite, gypsum, halite, lepidolite, quartz, rutile, sphalerite, etc. minerals are reported to show this phenomenon.

When color is generated under the bombardment of electrons in a high vacuum environment, this phenomenon is termed **cathodoluminescence**. This is the term used to describe the color generated in television picture tubes (cathode ray tubes).