PROPERTIES OF MINERALS

Minerals have many properties. The main ones are composition, crystal structure, hardness, density, fracture, lustre and colour. We have already talked about two of those and now we will consider the others in this Topic 4.

Hardness

Hardness is not a fundamental property and so there is no scale or unit defining it. In 1812, a German mineralogist, Friedrich Mohs, devised a scale for measuring the **relative hardness** of minerals and other brittle materials. His scale was based on the observation that a particular mineral could scratch a softer mineral and be scratched by a harder one. Now known as Mohs Scale, it remains the main means of measuring the hardness of a mineral. Essentially, Mohs realised that diamond was the hardest of the known minerals and talc the softest. He assigned a hardness of 10 to diamond and 1 to talc, then added 8 other minerals with intermediate hardness. Here is the Mohs Hardness Scale. <u>You need to know it.</u>

Hardness Number	Mineral
1	talc
2	gypsum
3	calcite
4	fluorite
5	apatite
6	orthoclase
7	quartz
8	topaz
9	corundum
10	diamond

For example: using this scale, a mineral that will scratch orthoclase but be scratched by quartz has a Mohs hardness of between 6 and 7. If it is more easily scratched by quartz than it scratches orthoclase, the hardness will be closer to 6 than 7. Such observations enable intermediate hardness to be assessed.

Density

Density, also called Specific Gravity, is the weight per unit volume of any substance and has units such as grams per cubic centimetre (g/cm^3). The metal osmium has the highest density (22.59 g/cm^3), and hydrogen has the lowest (0.000090 g/cm^3). Density is a fundamental property and is determined by weighing a piece of material, then measuring its volume. Weight is easy and although volume can be tricky there are experimental methods that enable it to be determined with precision. Consequently, the density of minerals can be known with precision and this property is important in the characterisation of minerals, as is hardness..

Fracture

Under stress, some minerals split over flat planes and is called cleavage. Micas have perfect cleavage, other minerals such as calcite cleave on multiple planes. Other minerals break in a rough, jagged or conchoidal manner called fracture. When a mineral is stressed it will cleave or fracture in one of those ways and this behavior is also important in the characterisation of minerals.

Lustre

Lustre is the character of light reflected from a surface. It is independent of colour but related to the inherent roughness of the surface. Lustre is classified as metallic (very shiny), submetallic (weathered metal) and non-metallic which can be adamantine, resinous, vitreous, pearly, silky or waxy. This appearance is another factor in the characterisation of minerals.

Colour
We finish with the most obvious property – colour.
Our eyes receive electromagnetic radiation, transmit it through the optic nerve to our brain which interprets it as colour. The colour perceived depends on wavelength of the radiation with 400 nanometres (nm) interpreted as violet, 700 nm as red and all wavelengths between as the other colours of the rainbow.

White light from the sun or a lamp is simply a mix of all wavelengths. We perceive it as colourless. If this light passes through a transparent object or is reflected from the surface of an opaque object some wavelengths are absorbed by electrons in or in the surface of the object. When that light reaches our eyes and brain it is interpreted a having colour depending on which wavelengths were absorbed.

So what determines the colours we perceive for different minerals? With respect to colour, there is three types – idiochromatic (self-coloured), allochromatic (other-coloured) and pseudochromatic (false-coloured)

Idiochromatic minerals are self-coloured by chemical composition and crystal structure. As these properties are constant for a specific mineral that mineral must have a specific colour. Examples are azurite, malachite, crocoite, rhodonite, rhodochrosite, molybdenite, pyrite and schorl.

Allochromatic minerals would normally be colourless but are other coloured by foreign inclusions. Inclusions can be small pieces of another mineral such as (brown) hematite in quartz or (green) actinolite in quartz. Or, the impurity can be dissolved in a mineral. The most influential impurities are the elements in the first long period of the periodic table. Here are a few examples.
For beryl +chromium -> green emerald, +iron -> blue aquamarine
For corundum +chromium -> red ruby, + iron & titanium -> blue sapphire
For topaz +chromium -> pink, +iron -> blue. There are many other examples.

Pseudochromatic minerals are coloured by optical effects of diffraction, reflection, refraction and interference. Here are two examples. Iridescence on some sulphides is caused by interference of light reflected from thin films of surface tarnish. And, opal has a structure of sub-microscopic balls of $SiO_2.nH_2O$ in a close packed array. Diffraction of light from the regular array to produce fire can occur if the size of the balls is in the range of 100 to 400nm (nano-metres) where 1nm is one thousandth of one millionth of a metre. If the array is not close packed or the balls are irregular in size, no diffraction can occur and the opal is potch with a dull greenish colour.
So, some minerals have a definite colour, others do not. However, a powdered mineral (streak), has a constant colour and is used in mineral characterisation.

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