MINERAL GROUPS: GARNETS, MICAS, ZEOLITES AND OTHERS

Mineral Groups There are no minerals with the names garnet or mica or zeolite. These are the names of groups of minerals which are similar with respect to one or more properties. Currently, there are 266 such groups and here is some information about five of them – Garnet, Mica, Zeolite, Apatite and Tourmaline.

Garnet Supergroup contains 33 minerals the most common of which are *pyrope*, *grossular*, *spessartine*, *almandine*, *andradite* and *uvarovite*. These all have similar composition, similar cubic crystal structures and form crystals with very similar shapes. Composition: X_3,Y_2 $(SiO_4)_3$ – where X = divalent & Y = trivalent (Al, Fe, Cr or V.) Mohs hardness of 6.5 to 7.5, relative density of 3.4 to 4.6, are brittle, have poor cleavage and uneven splintery fracture. Because the crystal shapes are similar and the colours are usually brownish, except for uvarovite which is green, the others are difficult to identify. Consequently, "a garnet", or "one of the garnets", or "one of the garnet group" is an acceptable name.

Mica Group contains 61 minerals with muscovite, paragonite, phlogopite, biotite and lepidolite being the most common. These have similar compositions and monoclinic crystal structures. The structure is nearly but not quite hexagonal and so they form crystals that look like hexagonal prisms. They all have perfect cleavage on the basal plane of the 'hexagonal' crystal. The relative density is 2.7 to 3.1, and Mohs Hardness is ~2.5 on the cleavage surface but 3 to 4 on the prism face. And so, micas are **anisotropic** with respect to hardness. (look it up).
A trace of Cr in muscovite turns it green, (commonly called fuchsite), and a trace of Ni turns it blue. Iron contamination forms hematite inclusions in the cleavage plane parallel with the near hexagonal axes.

Zeolite Group has about 100 minerals, all hydrated aluminosilicates, with the ratio of (Al + Si):O of 1:2, and many are based on Ca and Na. The water is an essential part of the crystal structure.

Natrolite: $Na_2(Al_2Si_3O_{10})$. 2 H_2O
Stellerite: $Ca(Al2Si_7O_{18})$. 7 H_2O
Stillbite: $NaCa_2(Al_5Si_{13}O_{36})$. 14 H_2O

When a zeolite mineral is heated, this water is liberated causing frothing and bubbling. [Zein = to boil.] Most zeolites are white but *stellerite* and *stilbite* are orange, gmelinite can be red and *phillipsite* can be golden yellow.
Zeolites are abundant and widespread. They are all secondary minerals, many precipitating from hydrothermal groundwater, often in cavities in basaltic rock where they form very attractive specimens. Precipitate at <300ºC.

Apatite Supergroup has 39 members and although apatite remains in the Mohs scale for hardness 5, it is not now the name of a mineral. Mohs original (1812) mineral was probably that now named *fluorapatite* closely related to *chlorapatite* and *hydroxylapatite*.

Tourmaline Supergroup contains about 30 minerals of which only 3 are common. The most important is *elbaite* which is a brilliantly coloured and highly valued gemstone. It is erroneously called tourmaline particularly in USA, South America and Europe. Black *schorl* and brown *dravite* are collectable and found in Australia.

Radioactivity
Some minerals are radioactive because they contain one or more atoms with one or more unstable **isotopes**. Isotopes are also called **nuclides** and there are 339 naturally occurring

terrestrial nuclides. Each nuclide is named by the atom symbol and the number of (protons plus neutrons). Thus, the three nuclides of hydrogen are H-1, H-2 and H-3. And so on for all other naturally occurring elements.
Of the 339 nuclides, 251 are stable and so remain unchanged over vast periods of time. The other 88 are unstable and progressively decay through one or more unstable nuclides until a stable end-product nuclide is reached. For example, U-228 decays to end product Pb-206 in 19 steps. Each decay step is accompanied by the release of energy. The decay process is natural, occurs at a constant rate that cannot be altered and is called **radioactivity**. The energy released during a decay step may be α-rays, β-rays or γ-rays. As α-rays are nuclei of He atoms (2 protons + 2 neutrons) and β-rays are electrons, they are both easily absorbed. But γ-rays are electromagnetic radiation which mostly has high energy and being very penetrating can be used for medical and industrial radiography.

The time taken for half the mass of a radioactive isotope to decay is the **half-life** which varies from very short to exceedingly long. Here are six half-lives;

carbon C-10 19 seconds;
fluorine F-18 2 hours;
beryllium Be-7 53 days
hydrogen H-3 11 years;
carbon C-14 5715 years;
rubidium Rb-87.5 x 10^9 years, plus another 82 unstable nuclides.

Here is an example of a one-step decay: 226/88-Ra -> 222/86-Rn + (4/2 He) showing Radium nuclide 226 losing one α particle (4/2 He) to decay to Radon nuclide 222.
Here, the 226 and 222 are the numbers of (protons + neutrons) in the atoms. In most decay chains from isotopes of high atomic number atoms, many steps occur by emission of γ-rays which can be dangerous and must be treated with care.

Radioactive Minerals
By definition, a radioactive mineral is one that emits α-rays, β-rays or γ-rays. But, as α-rays and β-rays are always weak, it is only minerals that emit γ-rays that are regarded as being radioactive. Further, a radioisotope having a short half-life will decay to a stable end-product in a quite short time and will not be detectable in present day minerals. Only radioisotopes with very long half-lives will survive to the present day and so, the mineral will continue to be radioactive. The main elements with such radioisotopes are Ra, Th and U. Minerals based on these elements will be highly radioactive and minerals that contain them as impurities will be weakly radioactive. Here are some minerals that are strongly radioactive:

Autunite $Ca(UO_2)_2(PO_4)_2.11H_2O$
C*arnotite* $K_2(UO_2)_2(VO_4)_2.3H_2O$
Uraninite UO_2
Davidite $RE(FeMg)_2(Ti\ FeCrV)_{18}(O,OH,F)_{38}$,
Uranophane $Ca(UO_2)_2[SiO_3(OH)]_2.5H_2O$
Thorianite (ThO_2) and
Brannerite $(UCaYCe)(TiFe)_2O_6$. There are many others.

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