In hand specimen as an accessory mineral, it is usually seen as small wedge-shaped crystals with a resinous to adamantine luster and brown to yellow brown color. In thin section, Sphene, has a relief similar to that of zircon, and is usually found in small crystals with an elongated diamond shape. It is generally brownish in color, shows a well developed {110} cleavage, and high order interference colors.

Sorosilicates

Sorosilicates are the double island silicates. Only one important mineral group, the epidote group, has this structure.

Epidote, Clinozoisite, Zoisite

The important minerals in the epidote group are epidote, clinozoisite, and zoisite. Since the sorosilicates are based on the $Si_2O_7^{-6}$ group, the structural formula can be written as:

$$Ca_2(Al,Fe^{+3})Al_2O(SiO_4)(Si_2O_7)(OH)$$

Thus, the epidote group contains both the double tetrahedra and the single tetrahedron, separated by groups of AlO_6 octahedra and Ca in nine to 10 fold coordination with Oxygen or OH.

The formula can be rewritten as:

$$Ca_2(Al,Fe^{+3})Al_2Si_3O_{12}(OH)$$

Epidote is the Fe-rich variety and has the above general formula. Clinozoisite is the Fe-free variety with the chemical formula:

$$Ca_2Al_3Si_3O_{12}(OH)$$

Both clinozoisite and epidote are monoclinic (2/m). Zoisite has the same chemical formula as clinozoisite, but is orthorhombic.

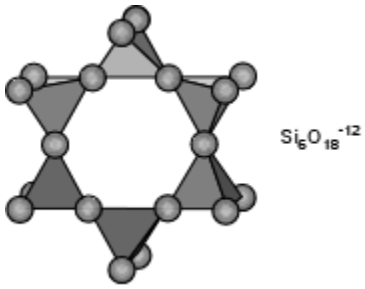
Epidote is usually pistachio green in color with perfect {001} cleavage and imperfect {100} cleavage. It is optically negative with a 2V of 64 - 90^o. It usually shows pleochroism with α - colorless to pale yellow, β - greenish yellow, and γ - yellowish green, and shows high relief relative to feldspars and quartz. It's birefringence is high enough to show 3rd order interference colors. It usually shows an anomalous blue extinction.

Clinozoisite shows similar relief and cleavage to epidote, but it is optically negative with a 2V of 14 to 90^o, shows no pleochroism, and lower birefringence (1st to 2nd order interference colors). Zoisite is similar to clinozoisite, except it will show parallel extinction relative to faces parallel to the crystallographic axes.

Epidote is a common mineral in low grade metamorphic rocks, particularly metamorphosed volcanic rocks and Fe-Al rich meta shales. Both Clinozoisite and epidote occur as alteration products of plagioclase and as veins in granitic rocks.

Cyclosilicates

The cyclosilicates are based on rings of SiO_4 tetrahedra, with a Si:O ratio of 1:3 The most common minerals based on this structure are Beryl, Cordierite, and Tourmaline.



Beryl

$Be_3Al_2Si_6O_{18}$ is hexagonal (6/m2/m2/m) with a strong prismatic habit with the form $\{10\bar{1}0\}$ usually the only form present. It is usually deep green to yellowish green in color. Beryl forms different gemstones depending on color - Aquamarine when it is pale greenish-blue, Morganite if pink, and emerald if deep green and transparent. Beryl is a common constituent of coarse grained granitic rocks and pegmatites and is found in aluminous mica schists.

In thin section, Beryl shows higher relief than quartz, and is distinguished from quartz by its negative optic sign and length-fast character. The only other mineral that it can be confused with is apatite, but apatite shows even higher relief than Beryl.

Cordierite

Cordierite is $(Mg,Fe)_2Al_4Si_5O_{18}\cdot nH_2O$. It is orthorhombic (2/m2/m2/m), but shows a pseudohexagonal character due to its common cyclical twinning on {110}. In thin section it may show a twinning that looks like albite twinning, which makes it hard to distinguish from plagioclase. But, cordierite is usually dusted with tiny opaque inclusions. In thick sections it shows α pale -yellow, violet, pale blue pleochroism. It can be distinguished from quartz by its biaxial character.

Cordierite is a common constituent of aluminous metamorphic rocks. It is common in contact metamorphic rocks where it is commonly associated with sillimanite or andalusite, feldspars and micas.

Tourmaline

Tourmaline - $Na(Mg,Fe,Mn,Li,Al)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4$ is hexagonal (3m) and is commonly found as well-formed prismatic crystals, with a rounded triangular cross section perpendicular to the c crystallographic axis.

Tourmaline is a common mineral in pegmatites (SiO_2 - rich igneous rocks with large grain size), where it is associated with quartz and alkali feldspar. It is also found in metasomatized rocks of all types, where it is precipitated from a Boron and Silica - rich fluid phase.

It's most distinguishing properties are its uniaxial negative optical character and its pleochroism with ω = dark green or dark blue and ε = yellow or violet. Tourmaline usually forms in

euhedral crystals with well developed prism faces and extinction parallel to the prism faces.

Examples of questions on this material that could be asked on an exam
(note that properties that distinguish different minerals will be included in the laboratory exam)

1. Why are the silicate minerals the most common minerals in the earth's crust?

2. Give an alternative name for each of the following groups of silicates (a) nesosilicates, (b) double island silicates, (c) cyclo-silicates, (d) inosilicates, (e) sheet silicates.

3. What would be the normal zoning pattern in a zoned crystal of olivine? Explain why this is the case.

4. What is the difference between the pyralspite garnets and the ugrandite garnets?

5. Draw a pressure - temperature diagram for the Al_2SiO_5 Minerals.

6. State whether each of the following minerals would be most commonly found in igneous rocks, metamorphic rocks, or both igneous and metamorphic rocks: (a) kyanite, (b) olivine, (c) epidote, (d) sillimanite, (e) andalusite (f) tourmaline (g) cordierite (h) garnet.

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