

Amphiboles

$$\text{W}_{0-1}\text{X}_2\text{Y}_5\text{Z}_8\text{O}_{22}(\text{OH})_2$$

The amphiboles show considerable similarity to the pyroxenes in both structure and composition. In terms of the general formula, W represents Na and K, X can be Ca, Na, Mn, Fe^{2+} , Mg, and Li. Y represents Mn, Fe^{2+} , Mg, Fe^{3+} , Al, and Ti, and Z denotes Si and/or Al (see the diagram below for a partial listing of the amphiboles).

Image removed for copyright considerations.

For more information, see the lecture notes section.

The amphibole structure consists of double chains of tetrahedra parallel to the c-axis. The chains are arranged such that the characteristic amphibole cleavage is $56^\circ - 124^\circ$ (see your lecture notes).

Image removed for copyright considerations.

For more information, see the lecture notes section.

Identification:

Hornblende – $(\text{Na}, \text{K})_{0-1}\text{Ca}_2(\text{Mg}, \text{Fe}^{2+}, \text{Fe}^{3+}, \text{Al})_5(\text{Si}, \text{Al})_8\text{O}_{22}(\text{OH})_2$ –

Hand Sample: Black in color with a vitreous luster. Crystals are generally slender and prismatic. Cleavage is perfect and is diagnostic with angles of 56° and 124° . Hornblende is differentiated other amphiboles by the darker color and from dark pyroxenes by the cleavage angles.

Thin section: Plane light: Moderate to high positive relief. Displays a distinct coloration and pleochroism – green, yellow-green, blue-green, and brown. Crossed Polars: Biaxial (-), $2V - 35-130^\circ$. The highest interference colors are upper first to lower second order

colors. (!These may be masked by the mineral color!). Basal sections will display symmetric extinction, with elongate sections displaying inclined extinction (12-34°) and length slow. Hornblende is distinguished from the dark colored pyroxenes by cleavage and crystal habit.

Occurrence: Hornblende can be found in almost any igneous rock but is typical of plutonic and extrusive rocks of intermediate composition, i.e. diorites, granodiorites, and andesites. Hornblende is a common mineral in medium- to high-grade regional metamorphic terranes in rocks such as amphibolite, hornblende gneisses, and other schists. Hornblende may alter to biotite, chlorite, or other Fe-Mg silicates.

Anthophyllite – $(\text{Mg, Fe})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$ –

Hand Sample: Anthophyllite is typically clove brown in color and lamellar or fibrous in habit. It has perfect cleavage but is not always evident.

Thin section: Plane light: Moderate to high positive relief in thin section. Colorless to pale brown in thin section. Weak pleochroism – colorless to pale yellow. Crossed polars: Biaxial, (+) or (-), 2V 65-90°(-) and 90-58°(+). Maximum interference colors are first order red or second order blue, with decreasing order correlating to decreasing Fe content. Basal sections will show symmetric extinction, with elongate sections displaying parallel extinction and length slow. Anthophyllite is distinguished from hornblende by the parallel extinction.

Occurrence: Anthophyllite is found in medium- to high-grade metamorphic rocks. It is commonly associated with cordierite, hornblende, garnet, talc, and sillimanite.

Anthophyllite alters to fine-grained serpentine, talc, or other phyllosilicates.

Tremolite-Actinolite - $\text{Ca}_2(\text{Mg, Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ –

Hand Sample: Tremolite is white in color; Actinolite is green. It displays the typical amphibole cleavage. Crystals are slender and prismatic. It is differentiated from pyroxenes by cleavage and from other amphiboles by color.

Thin Section: Plane light: Moderate to high positive relief. Colorless to pale green to deep green in thin section with varying degrees of pleochroism. Stronger pleochroism correlates to higher iron contents. Crossed Polars: Biaxial (-) 2V 75-88°. Maximum interference colors are upper first order. Basal sections will show symmetrical extinction, with elongate sections showing parallel extinction along (100) and inclined extinction (10-21°) along (010) and length slow. Tremolite is distinguished from anthophyllite by the inclined extinction and from hornblende by the greater 2V and larger degree of inclined extinction.

Occurrence: Tremolite is found in contact and regionally metamorphosed carbonate rocks. It is usually associated with calcite, wollastonite, diopside, talc, and epidote.

Tremolite commonly alters to talc, chlorite, and carbonates.

Glaucophanite-Riebeckite - $\text{Na}_2(\text{Mg, Fe}^{2+})_3(\text{Al, Fe}^{3+})_2\text{Si}_8\text{O}_{22}(\text{OH})_2$ –

Hand Sample: Glaucophanite is blue to lavender-blue in color while Riebeckite is a darker blue. Crystals are generally acicular or fibrous.

Thin section: Plane light: Moderate to moderately high positive relief. Colorless to medium blue in thin section for Glaucophanite to dark blue for Riebeckite. Both are distinctly pleochroic.

Other amphiboles to watch out for: (see Nesse for the properties of each).

Gedrite-

Kaersutite

Cummingtonite-Greunerite

Arfvedsonite

Richterite

Oxyhornblende