

Staurolite – $\text{Fe}_2^{2+}\text{Al}_9\text{Si}_4\text{O}_{23}(\text{OH})$ – monoclinic

Named from the Greek word *Stauros*.

Staurolite is one of the best examples of mineral *twins*.

A twin is a symmetrical intergrowth of two (or more) crystal of the same substance.

The twinned crystals are related by a symmetry element.

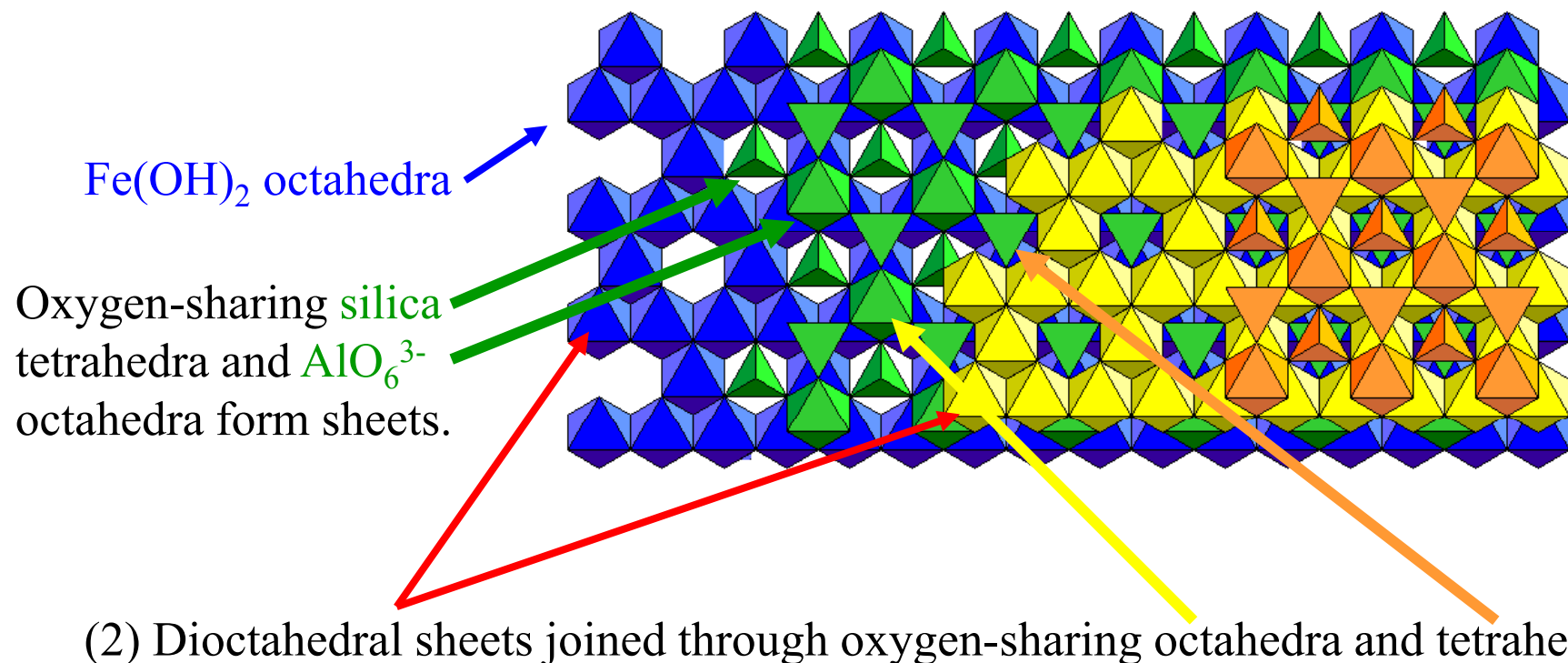
Twinning may occur on almost any range of size – Angstroms of the unit cell, to the mm-scale of minerals seen in hand specimen.



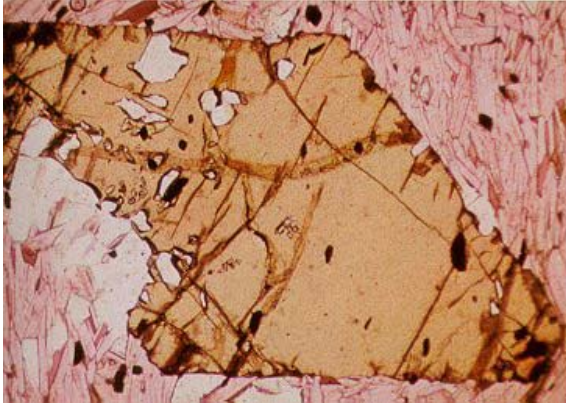
Composition and Structure

$\text{Fe}_2^{2+}\text{Al}_9\text{Si}_4\text{O}_{23}(\text{OH})$ is its end-member composition, but the A-site will accommodate Mg, and often significant quantities of Zn are found.

The B-site will accommodate Fe^{3+} and occasionally Ti.



Staurolite is a characteristic mineral in medium- to high-grade regionally metamorphosed pelitic schists – high Al-content.



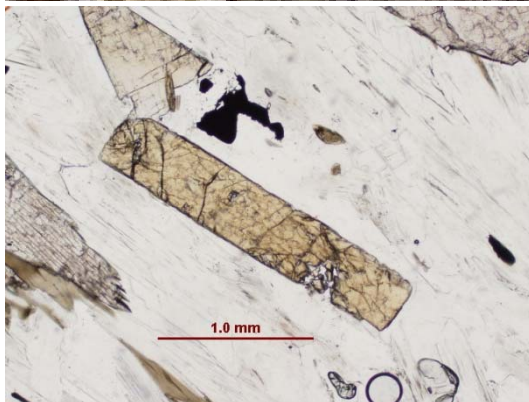
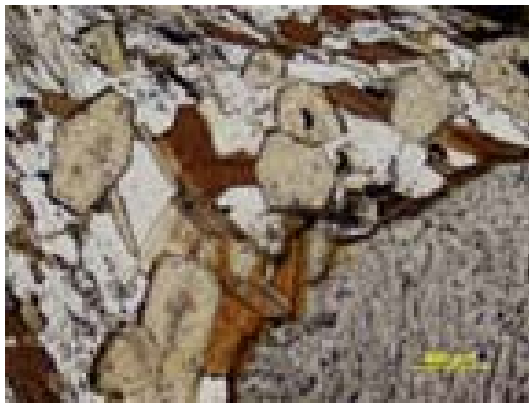
Staurolite displays medium relief with a yellow to golden colour.

This is often accompanied with pleochroism to clear.

The mineral is biaxial positive with a very high $2V$ (80-90°).

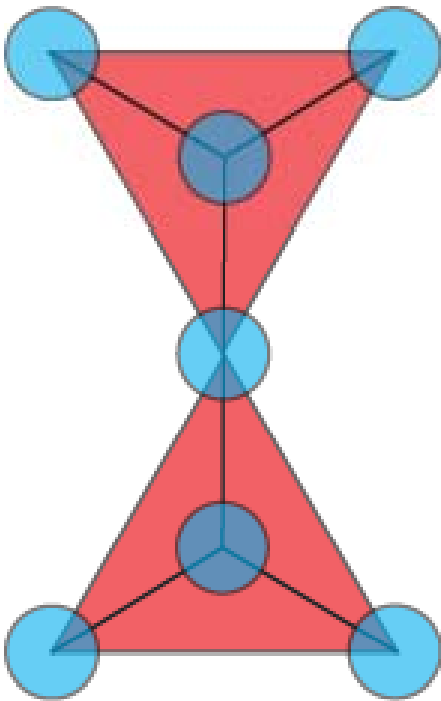
It has low second order birefringence colours that increase with increasing Fe content.

Staurolite has little economic value.



Epidote Group Minerals

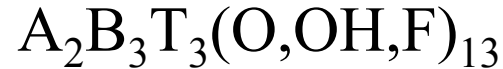
The epidote group minerals are examples of *Sorosilicates*, which are characterised by isolated double tetrahedral groups formed by two SiO_4 tetrahedra sharing an apical oxygen.



There are not many commonly occurring sorosilicates – Lawsonite, vesuvianite and the five Epidote-Group Minerals:

- zoisite
- clinozoisite
- epidote
- allanite
- piedmontite

The general formula of the epidote group minerals may be expressed by the structural formula:



Where A = Ca, LREE, Y, Th, Fe²⁺, Mn²⁺, Mn³⁺

B = Al, Fe³⁺, Mn³⁺, Mn²⁺, Fe²⁺, Ti

T = Si

The end-members have compositions as follows:

Zoisite (clinozoisite) – Ca₂(Al,Fe³⁺)Al₂O.OH.Si₂O₇.SiO₄

Epidote – Ca₂(Fe³⁺Al)Al₂O.OH.Si₂O₇.SiO₄

Allanite – (Ca,Mn,LREE,Y,Th)₂(Fe²⁺,Fe³⁺Al)₃O.OH.Si₂O₇.SiO₄

Piemontite – Ca₂(Mn³⁺Fe³⁺Al)₃O.OH.Si₂O₇.SiO₄

Coupled Substitution

The epidote-group minerals display more complex compositional substitutions than previously encountered.

In olivine and staurolite we saw that Fe^{2+} and Mg^{2+} could substitute with one another on one site.

In garnet, we saw a 4-way substitution (Ca-Fe-Mg-Mn). However, this is still “simple” substitution.

In the A-site of Allanite it is possible to substitute Ca^{2+} for LREE (3+ ions), Y^{3+} or Th^{4+} . This creates a partial +ve charge imbalance because the number of anions (O, OH and F) remains constant.

Coupled Substitutions

The generation of partial charge at one structural site must be balanced by an equal and opposite change in partial charge at a second structural site.

The substitution of LREE^{3+} for Ca^{2+} at the A-site of allanite is balanced by replacing one Al^{3+} for Fe^{2+} in the B-site.

This may be expressed by an *exchange vector*:



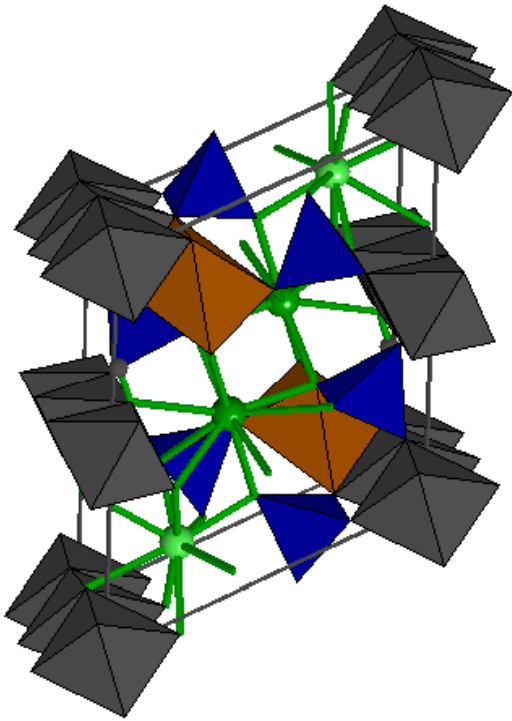
What is the exchange vector for Th^{4+} substitution on the A-site?

Why do the Epidote group minerals display this increasingly complex chemistry?

Zoisite – orthorhombic

Czo & Ep – isostructural monoclinic

Key differential – straight vs oblique extinction. Usually have high relief.



Epidote (Fe^{3+}) is yellow-green in thin section. Zo-Czo – colourless.

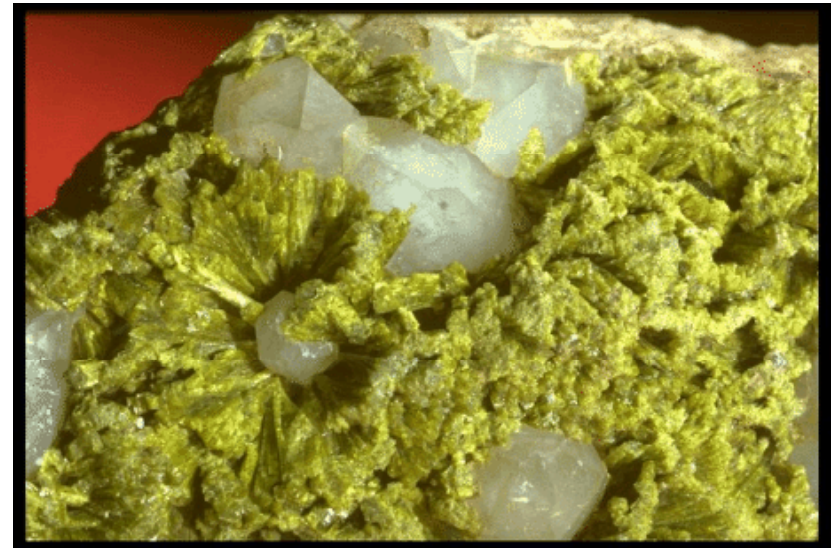
Epidote may also show pale-yellow to green pleochroism.

Interference colours are normally low to mid-1st order. In zoisite anomalous blue colours are not uncommon.

Zo-Czo are optically positive, Ep, negative.
 $2V\gamma$ numbers are 0-69, 14-90, and 90-116°.

Epidote, in hand specimen, often has a very distinctive pistachio green colour.

Zo-Czo are more difficult to identify. Green colour – often mistaken for Ep. White-to-colourless, often overlooked.



Of course, it might also be red....



Epidote group minerals are common in calcareous schists and gneisses.