



# Optical Mineralogy in a Nutshell

Use of the petrographic microscope in  
three easy lessons

**Part III**

A few new properties, and then some review...

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**Cleavage** - number and orientation of cleavage planes

**Twinning** - type of twinning, orientation

**Extinction angle** - parallel or inclined? Angle?

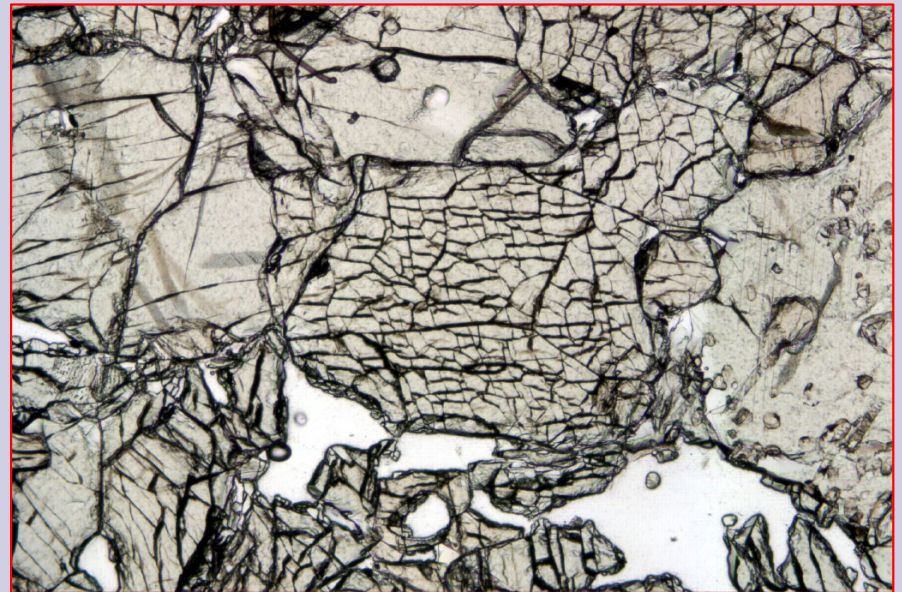
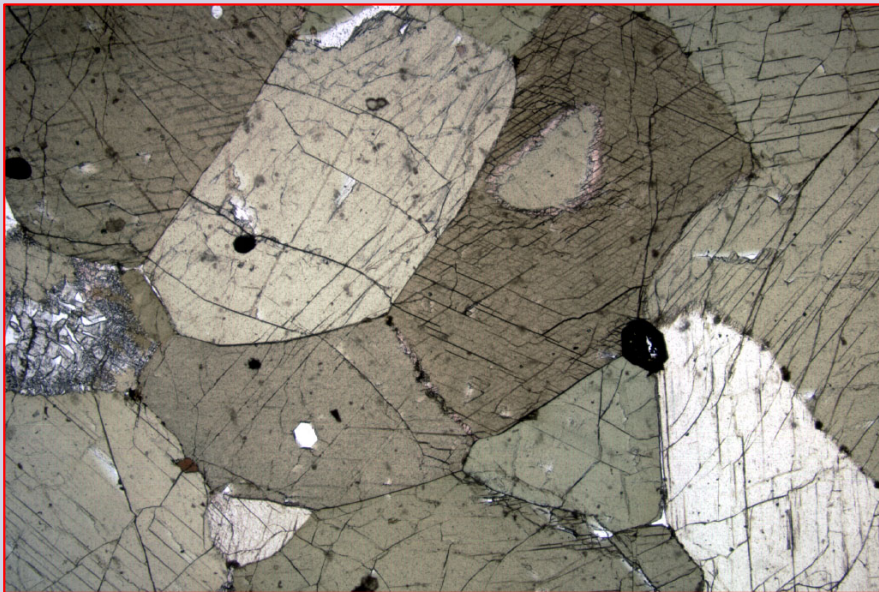
**Habit** - characteristic form of mineral

# Cleavage

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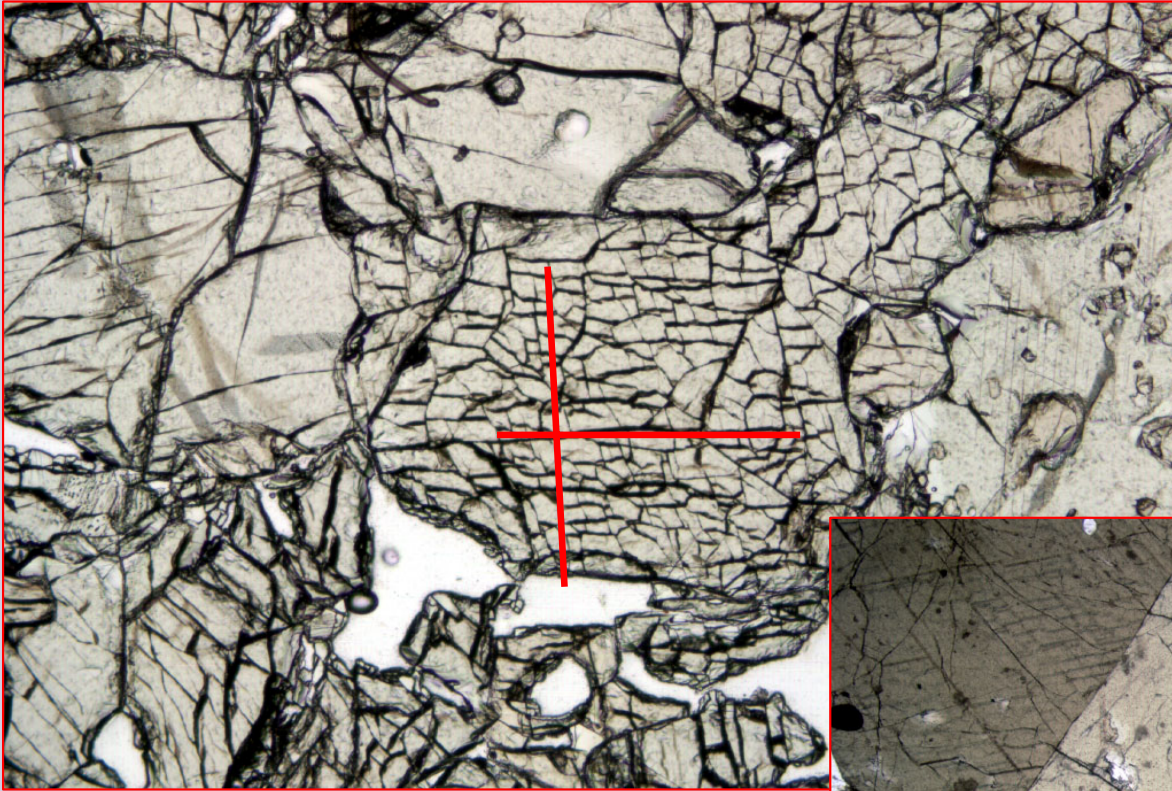
Most easily observed in PPL (upper polarizer out), but visible in XN as well

- No cleavages: **quartz, olivine**
- 1 good cleavage: **micas**
- 2 good cleavages: **pyroxenes, amphiboles**



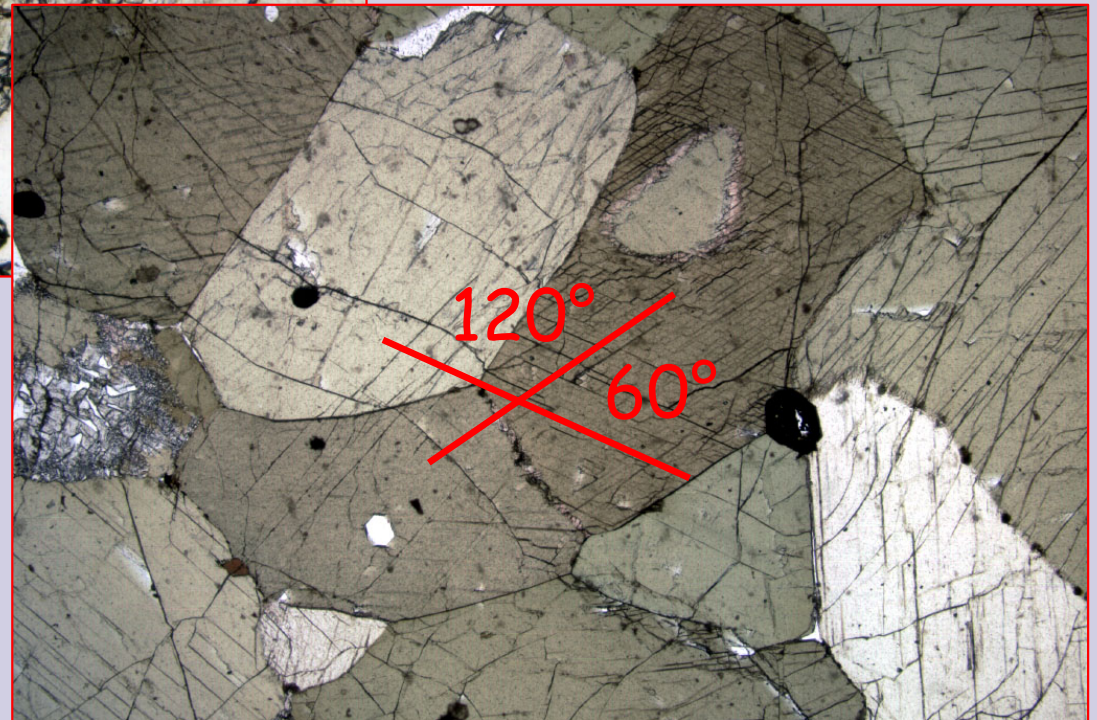
# Cleavage

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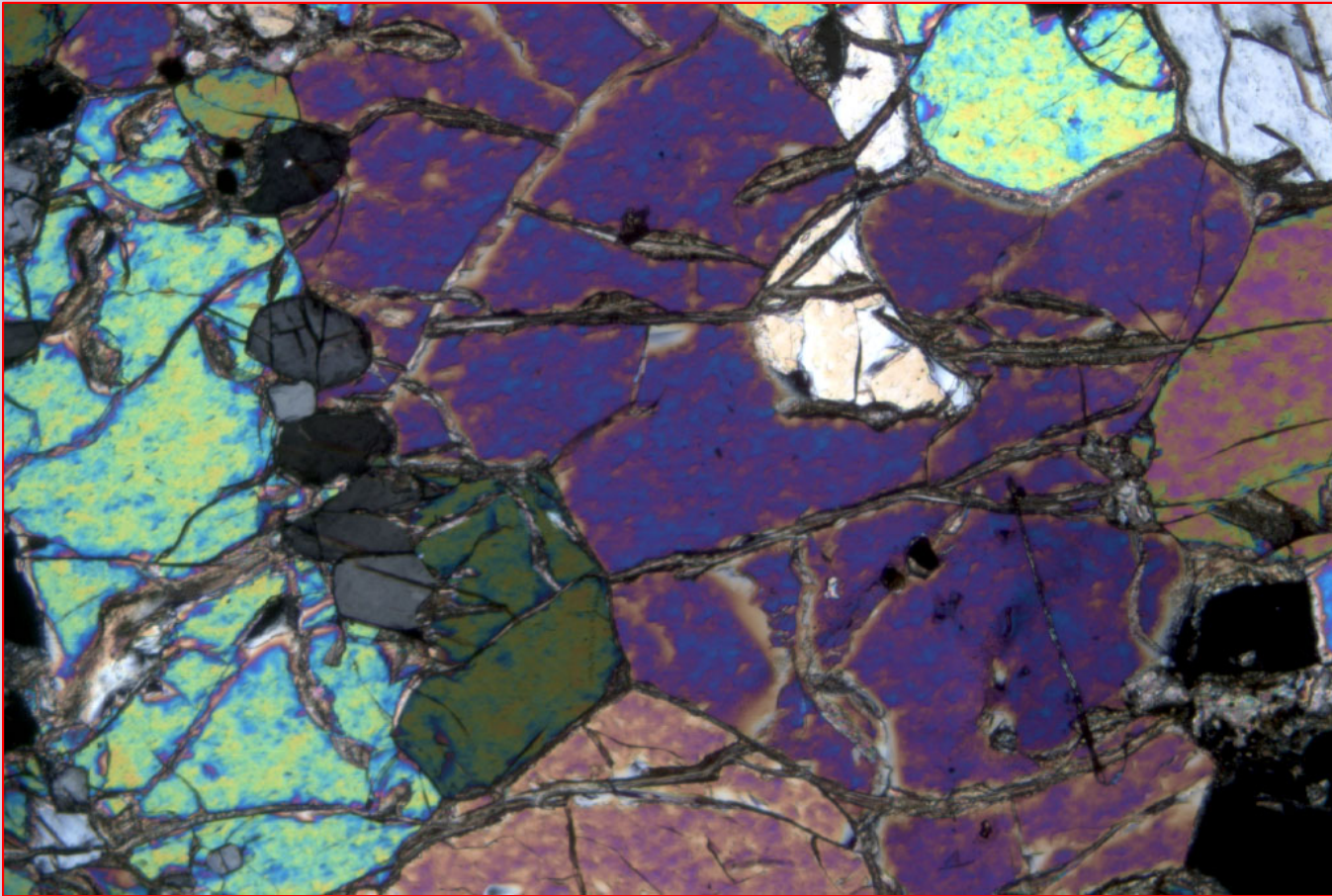
2 cleavages  
intersecting  
at  $\sim 90^\circ$   
pyroxene

2 cleavages  
intersecting  
at  $60^\circ/120^\circ$ :  
amphibole



# Cleavage

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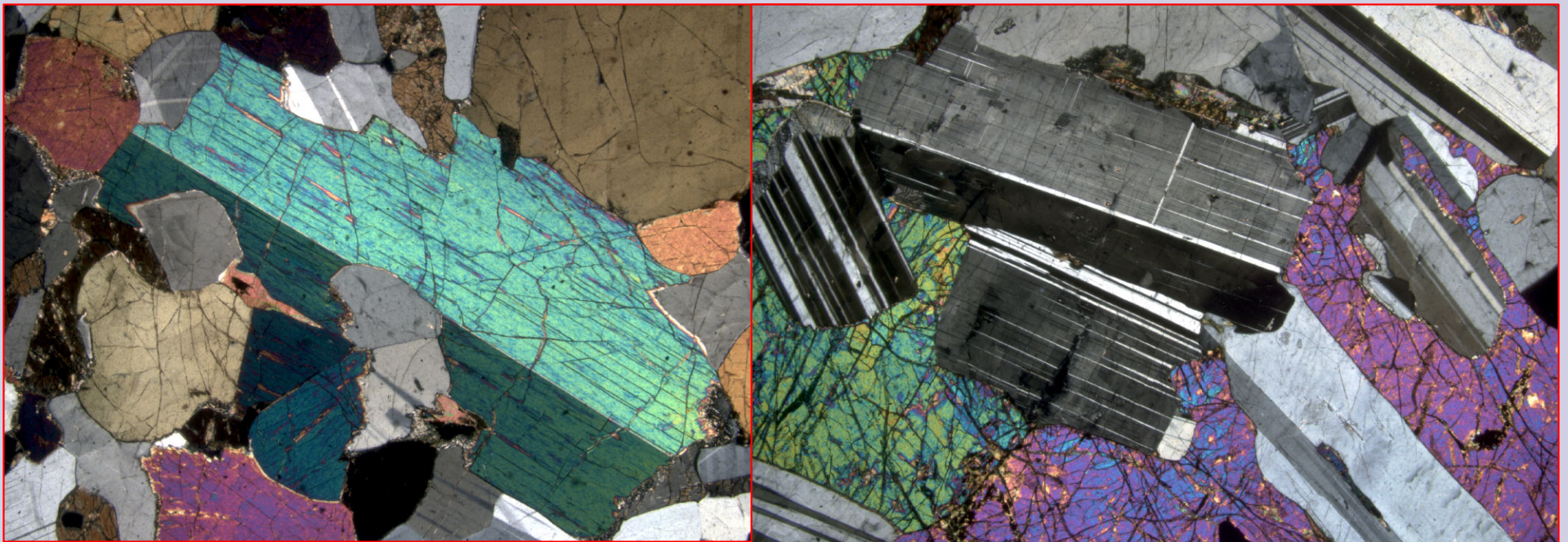


random fractures,  
no cleavage:  
**olivine**

# Twinning

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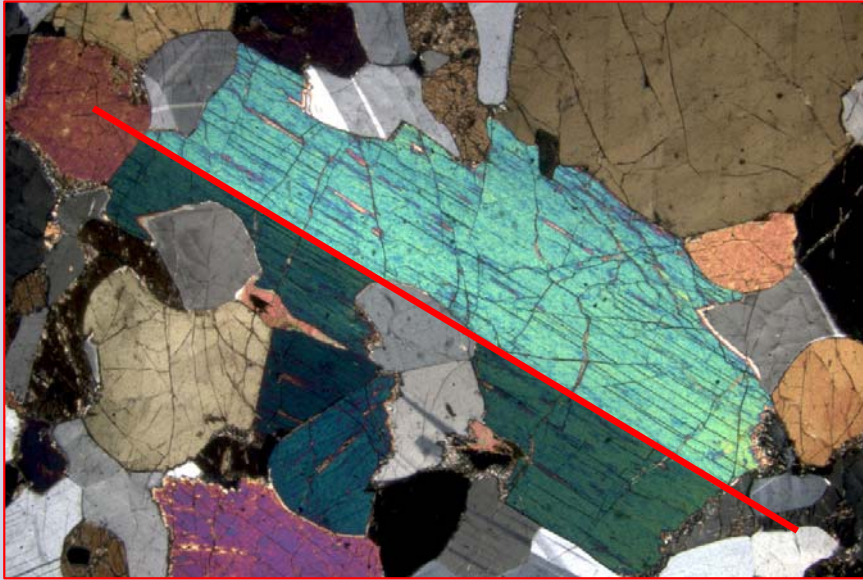
Presence and style of twinning can be diagnostic



*Twins are usually most obvious in XN (upper polarizer in)*

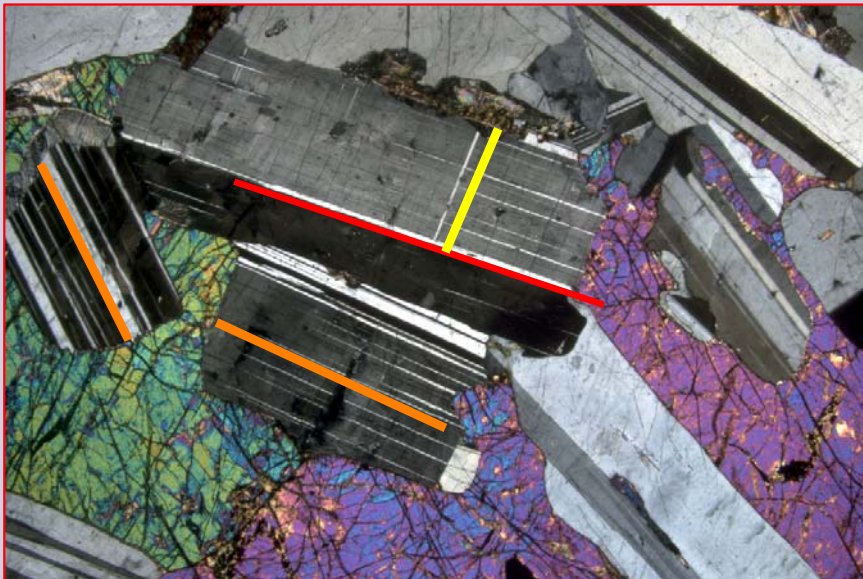
# Twinning - some examples

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## Clinopyroxene (augite)

- Simple twin on  $\{100\}$

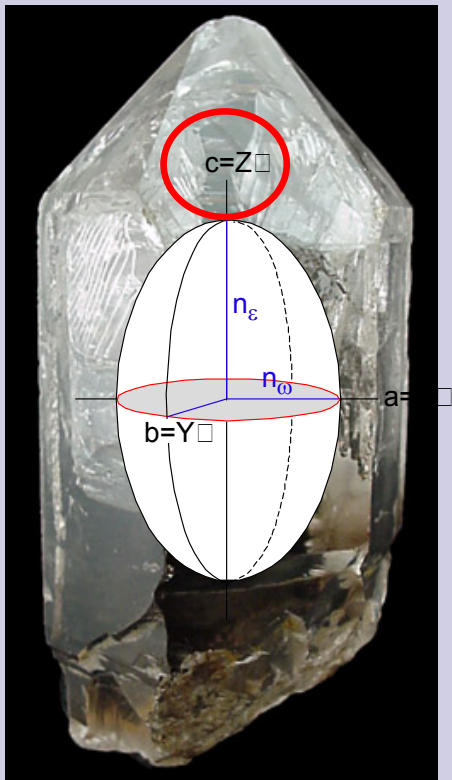


## Plagioclase

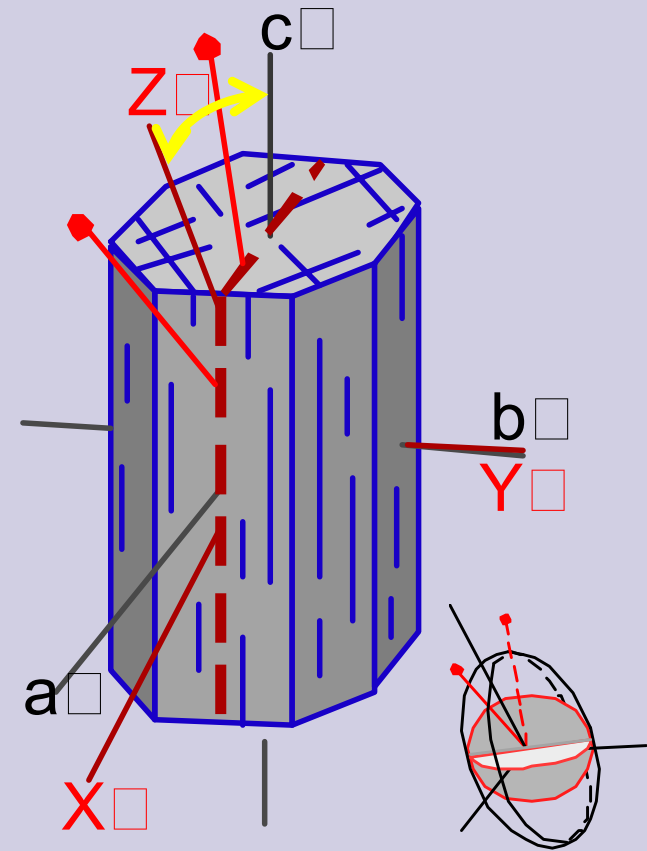
- Simple (Carlsbad) twin on  $(010)$
- Polysynthetic albite twins on  $(010)$
- Pericline twin on  $(h01)$

# Extinction angle

Extinction behavior is a function of the relationship between indicatrix orientation and crystallographic orientation



parallel extinction



inclined extinction



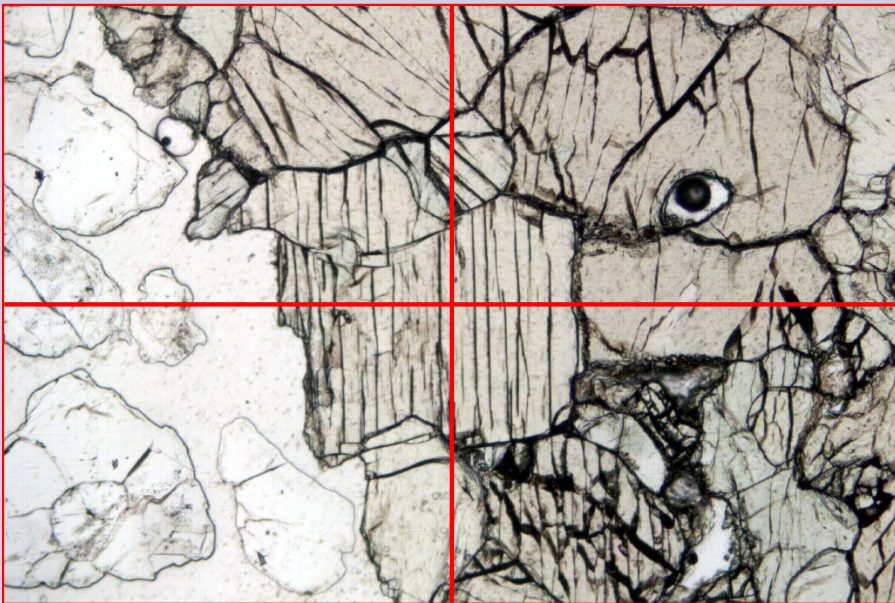
## Extinction angle - parallel extinction

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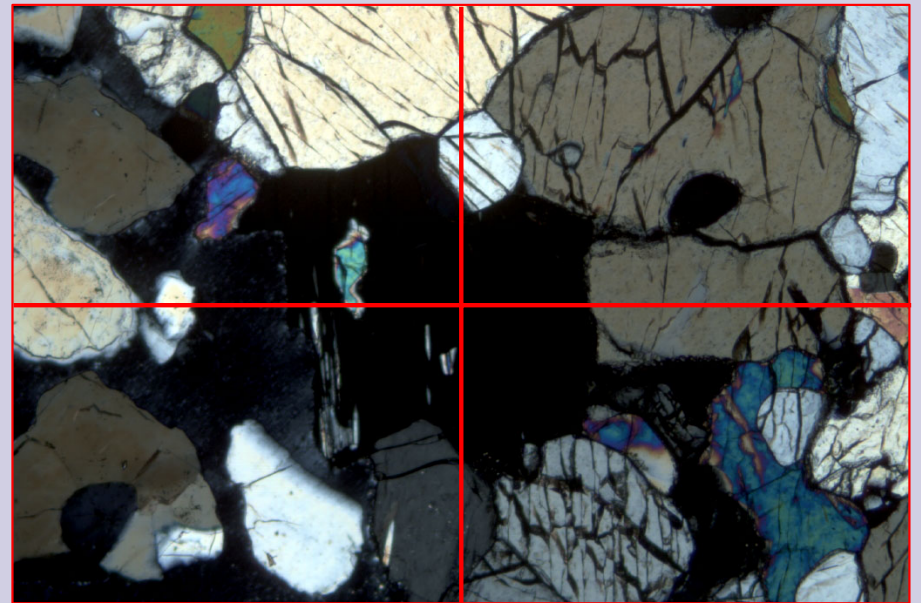
- All **uniaxial** minerals show **parallel extinction**
- **Orthorhombic** minerals show **parallel extinction**

*(this is because the crystal axes and indicatrix axes coincide)*

orthopyroxene



PPL



XN

# Extinction angle - inclined extinction

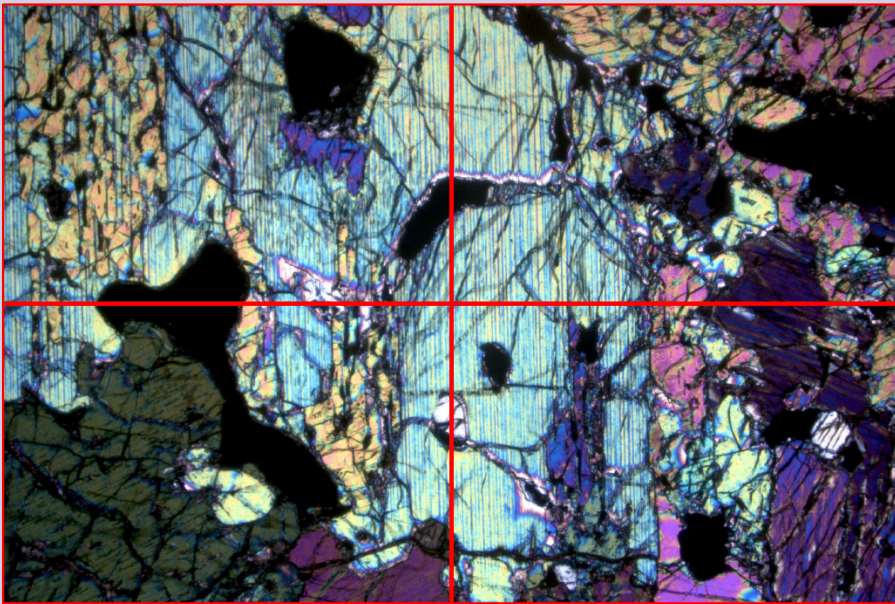
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**Monoclinic** and **triclinic** minerals:

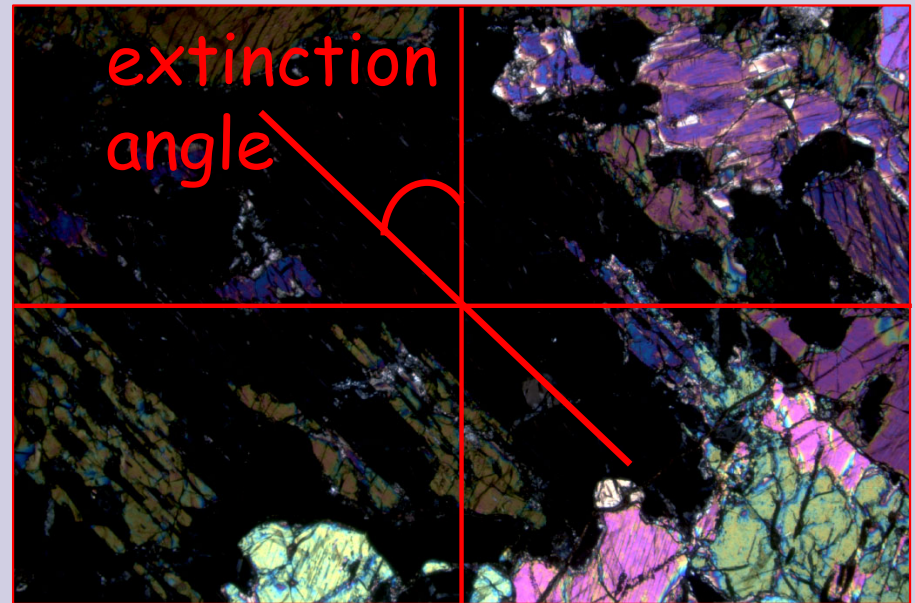
indicatrix axes do not coincide with crystallographic axes

*These minerals have **inclined extinction***

*(and extinction angle helps to identify them)*



clinopyroxene



# Habit or form

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acicular

anhedral/irregular

bladed

blocky

elongate

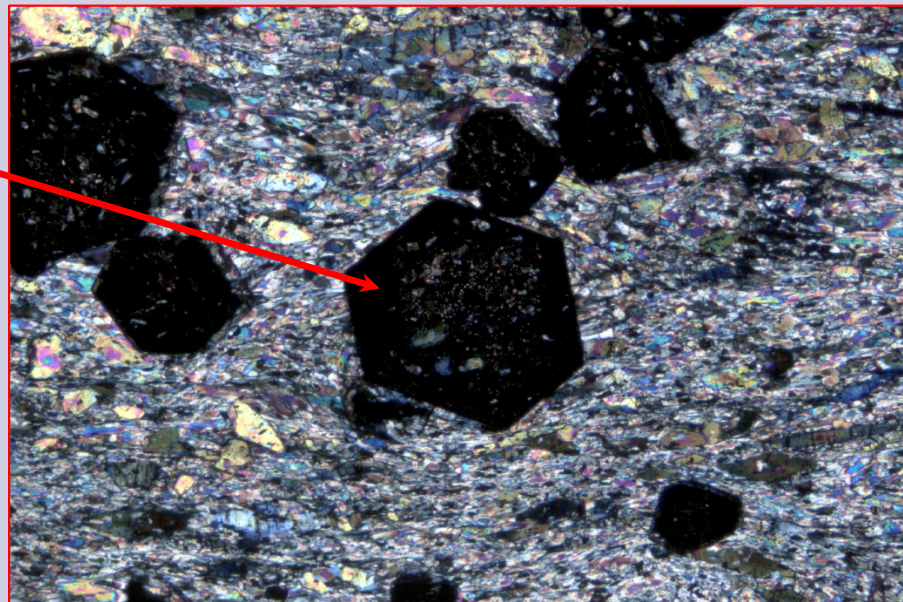
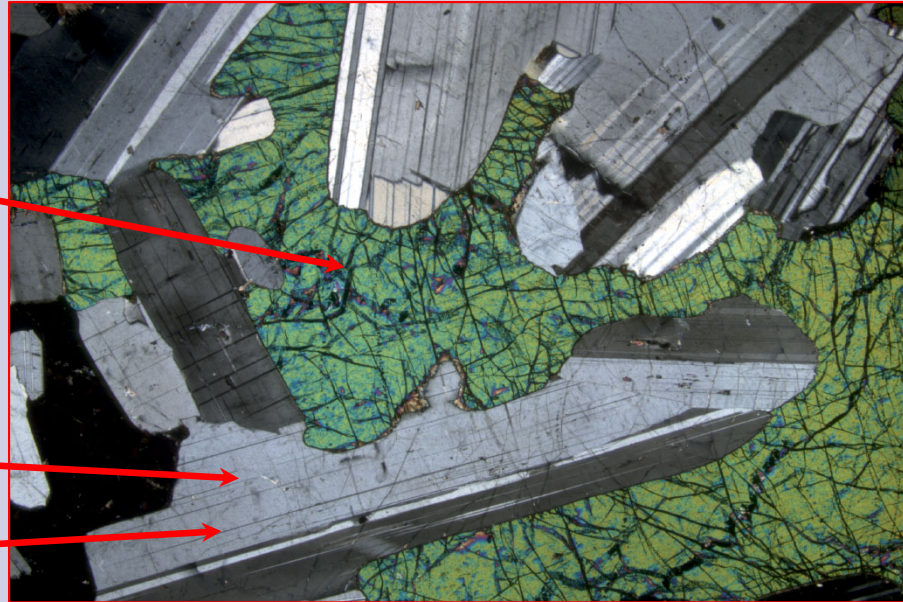
euhedral

fibrous

prismatic

rounded

tabular



# Habit or form

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acicular

anhedral/irregular

bladed

blocky

elongate

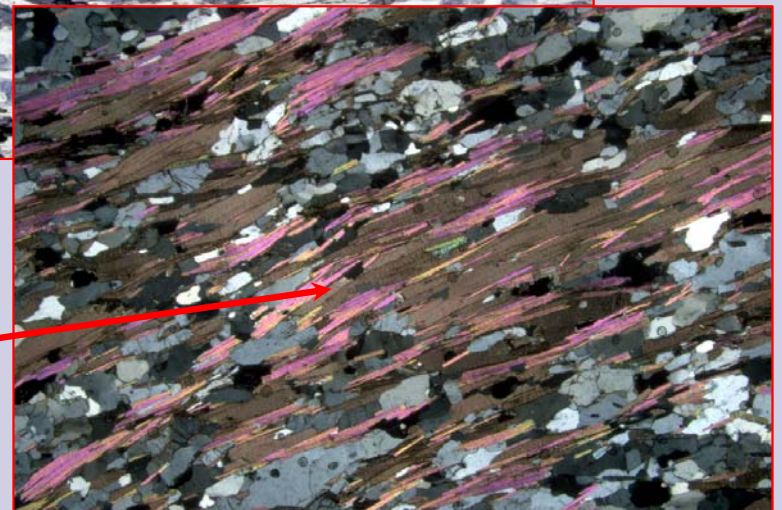
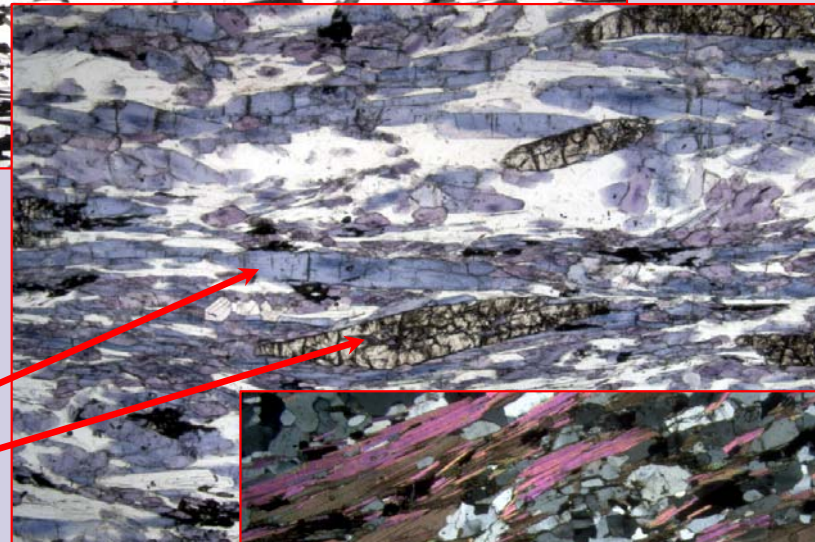
euhedral

fibrous

prismatic

rounded

tabular

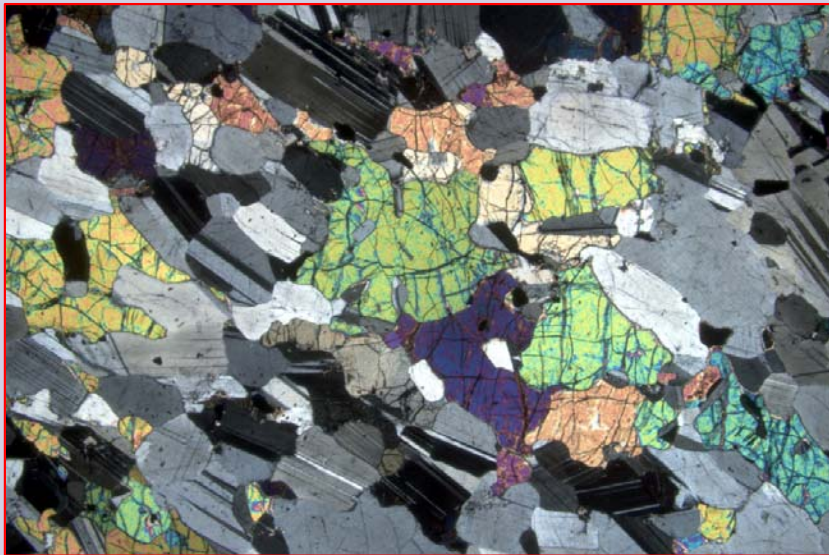


# Review - techniques for identifying unknown minerals

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Start in PPL:

- Color/pleochroism
- Relief
- Cleavages
- Habit



Then go to XPL:

- Birefringence
- Twinning
- Extinction angle
- Uniaxial or biaxial?
- $2V$  if biaxial
- Positive or negative?

Go to Nesse or similar book...

**Orthopyroxene  
(Enstatite–Orthoferrosilite)**

$(\text{Mg,Fe})_2\text{Si}_2\text{O}_6$

Orthorhombic

Biaxial (+) or (-)

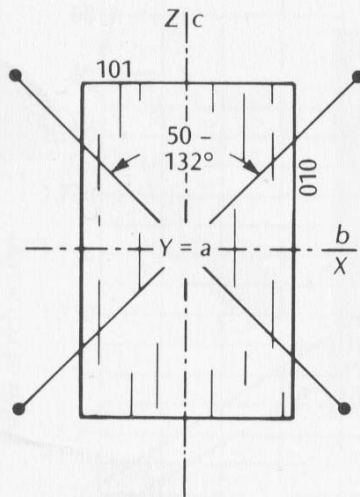
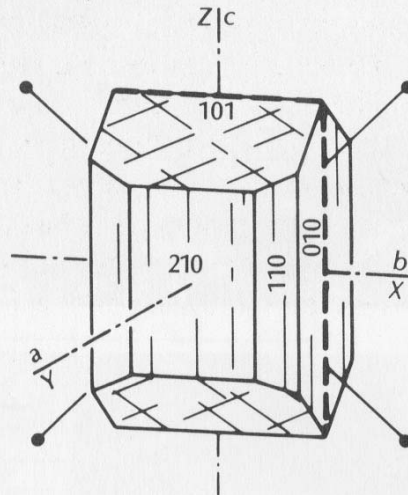
$n_\alpha = 1.649\text{--}1.768$

$n_\beta = 1.653\text{--}1.770$

$n_\gamma = 1.657\text{--}1.788$

$\delta = 0.007\text{--}0.020$

$2V_z = 50\text{--}132^\circ$



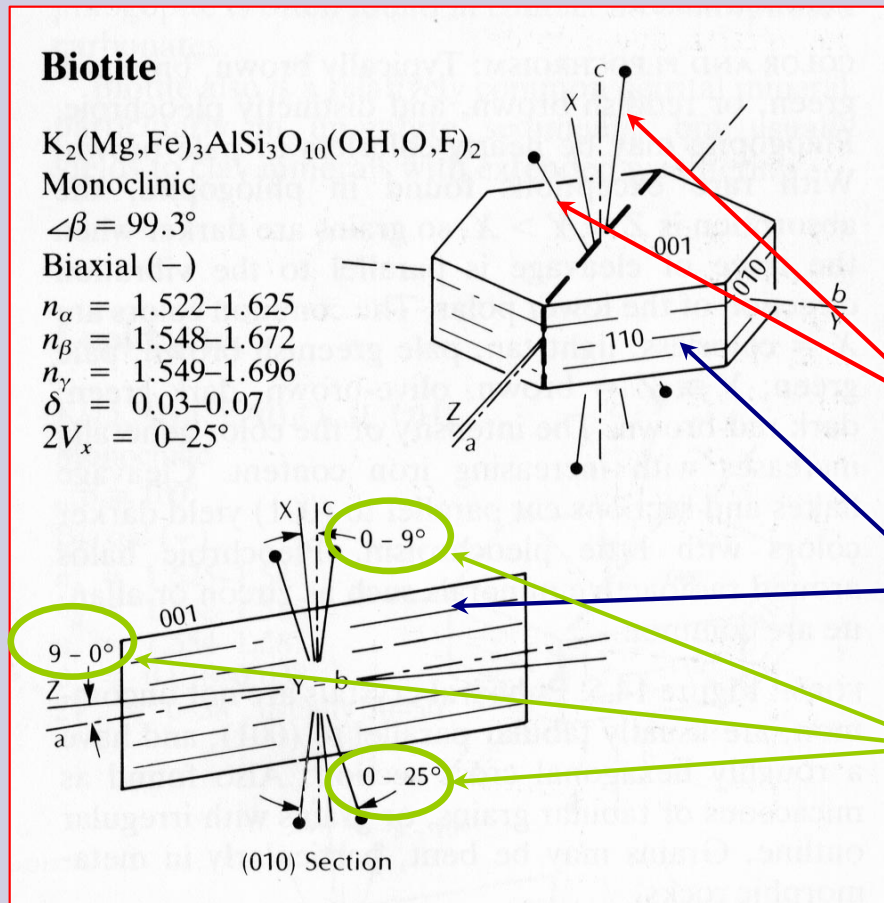
(100) Section

- Chemical formula
- Symmetry
- Uniaxial or biaxial, (+) or (-)
- RIs: lengths of indicatrix axes
- Birefringence ( $\delta$ ) = N-n
- $2V$  if biaxial

**Diagrams:**

- \* Crystallographic axes
- \* Indicatrix axes
- \* Optic axes
- \* Cleavages
- \* Extinction angles

# Another example



Crystallographic axes: **a, b, c**

Indicatrix axes: **X, Y, Z** or  $\epsilon, \omega$

Optic axes

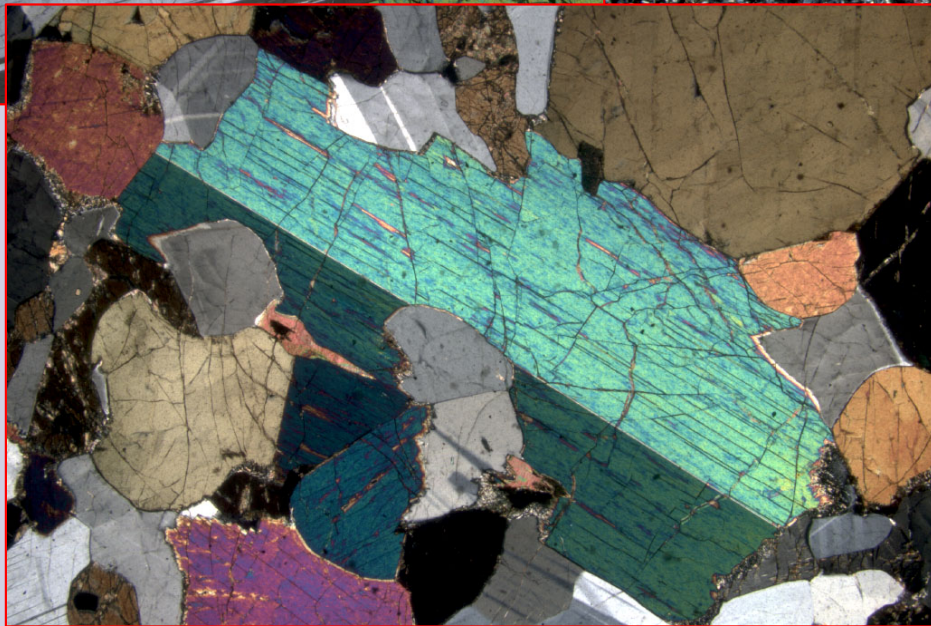
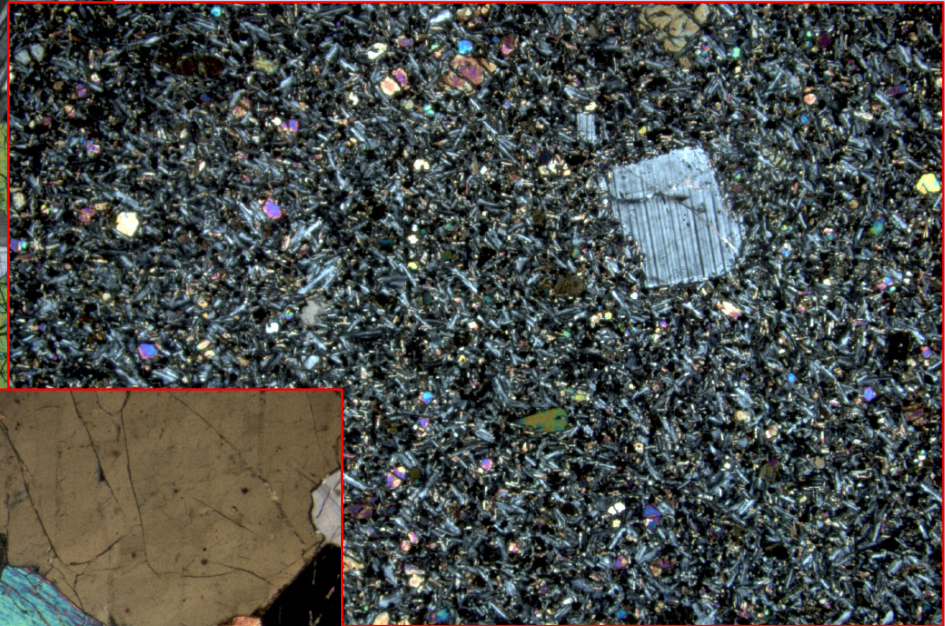
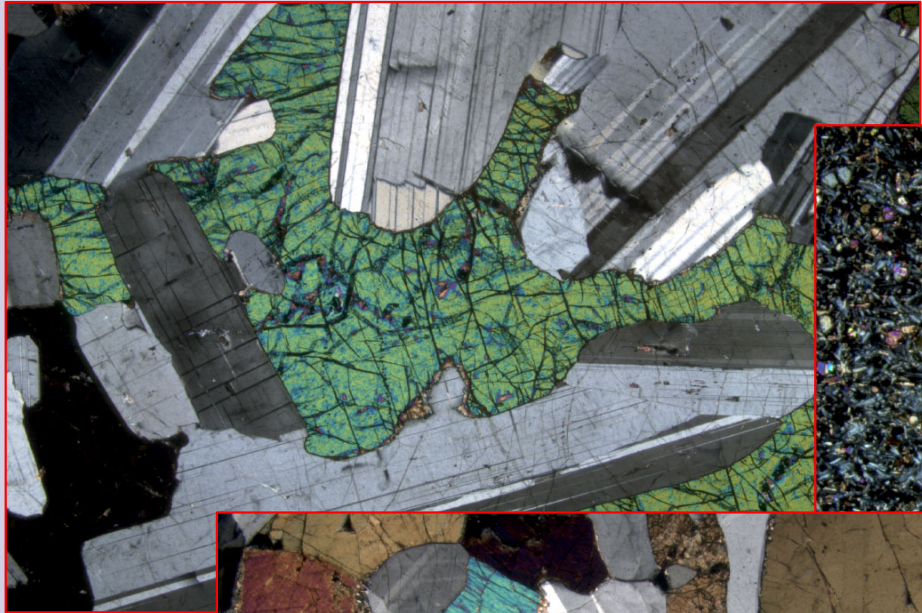
Cleavages

Extinction angles

Then read text re: **color, pleochroism, habit, cleavage, twinning, distinguishing features, occurrence** - make sure properties match your observations. If not, check another mineral...

On to real rocks...

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...good luck and have fun!