Optical Mineralogy in a Nutshell

Use of the petrographic microscope in three easy lessons

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Part III

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

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

**Twinning** - type of twinning, orientation

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

**Habit** - characteristic form of mineral
Cleavage

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

2 cleavages intersecting at ~90°: pyroxene

2 cleavages intersecting at 60°/120°: amphibole
Cleavage

random fractures, no cleavage: olivine
Twinning

Presence and style of twinning can be diagnostic

Twins are usually most obvious in XN (upper polarizer in)
Twinning - some examples

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

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

*(this is because xtl axes and indicatrix axes coincide)*

orthopyroxene

PPL  XN
Extinction angle - inclined extinction

Monoclinic and triclinic minerals:
indicatrix axes do not coincide with crystallographic axes

These minerals have inclined extinction
(and extinction angle helps to identify them)
Habit or form

- acicular
- anhedral/irregular
- bladed
- blocky
- elongate
- euhedral
- fibrous
- prismatic
- rounded
- tabular
Habit or form

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Review – techniques for identifying unknown minerals

Start in PPL:
- Color/pleochroism
- Relief
- Cleavages
- Habit

Then go to XN:
- Birefringence
- Twinning
- Extinction angle
- Uniaxial or biaxial?
- 2V if biaxial
- Positive or negative?
Go to Nesse or similar book...

Orthopyroxene
(Enstatite–Orthoferrisilite)

\[(\text{Mg},\text{Fe})_2\text{Si}_2\text{O}_6\]
Orthorhombic
Biaxial (+) or (−)

\[
\begin{align*}
n_a &= 1.649–1.768 \\
n_β &= 1.653–1.770 \\
n_γ &= 1.657–1.788 \\
δ &= 0.007–0.020 \\
2V_e &= 50–132°
\end{align*}
\]

- Chemical formula
- Symmetry
- Uni or biaxial, (+) or (−)
- RIs: lengths of indicatrix axes
- Birefringence
- 2V if biaxial

Diagrams:
* Crystallographic axes
* Indicatrix axes
* Optic axes
* Cleavages
* Extinction angles
Another example

**Biotite**

\[
\text{K}_2(\text{Mg,Fe})_3\text{AlSi}_3\text{O}_{10}(\text{OH, O,F})_2
\]

- Monoclinic
- \( \angle \beta = 99.3^\circ \)
- Biaxial (–)
  - \( n_g = 1.522–1.625 \)
  - \( n_b = 1.548–1.672 \)
  - \( n_c = 1.549–1.696 \)
  - \( \delta = 0.03–0.07 \)
  - \( 2V_x = 0–25^\circ \)

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

**Indicatrix axes:** X, Y, Z or \( \varepsilon, \omega \)

**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...

...good luck and have fun!