Magnetite

chalcopyrite

# Chapter 7 Reflected light optic SARAH LAMBART

http://www.pandageoscience.co.nz/ photomicrographs/

Hematite

http://www.geo.arizona.edu/

### Content chapter 7

why reflected light and reflected light microscopes

optical properties in reflected light

other features in reflected light

### MINERAL IN REFLECTED LIGHT

### Why reflected light?

Opaque = large group of (accessory) minerals that do not transmit significant light. But they do reflect the light back.

#### ► No choice:

electronic microprobe, SEM

experimental charges (in a metal capsule)

#### What minerals are opaque in thin section?

- significant metal bounding (native element, sulfides, oxides)
- Many are metals: economic importance

Give clue to the petology of the rocks. Ex.: Fe-Ti oxides, Fe sulfides, graphite.

### MINERAL IN REFLECTED LIGHT

### Reflected light microscope



Incident light inserted from above (rather than below in petrographic microscope) ▶ Most of the time, we used the same microscope: reflected light introduced by inserting a half-silvered mirror

### MINERAL IN REFLECTED LIGHT

#### Reflected light microscope



Use of polished thin section ONLY (no "covered" thin section)

Reflectivity and color: amount and color of the reflected light from the mineral surface

Non-isometric mineral: reflection pleochroism, bireflectance, anisotropism

### ► Color:

- part of the visible spectrum absorbed instead of being reflected => color
- Useful but <u>subtle</u>: should be used in conjunction with other observations
- Example:
  - Most Fe-oxides: grey
  - Many sulfides: yellow (except sphalerite: grey, and galena: white)



Magnetite  $Fe_3O_4$ 

Chalcopyrite CuFeS<sub>2</sub>

http://www.pandageoscience.co.nz/photomicrographs/

- Reflectance or reflectivity: measure of the ratio of the intensity of reflected light from a mineral's surface to the intensity of incident plane-polarized light (λ = 546 nm).
  Amount of light reflected
- Most opaques: intermittent reflectivities; reflectivity drop when the light is transmitted (most silicates) or absorbed (graphite)
- sphalerite (17%) < magnetite (21%) < galena (43%) < pyrite (54%) < gold (74%)</li>



#### Other diagnostic properties:

Bireflectance and reflection pleochroism: changes in reflectivity (bireflectance) and/or colour (pleochroism) upon rotation of the microscope's stage.

Ex.: pyrrhotite, hematite and ilmenite

Anisotropy: under cross-polars: variation in color or brightness upon rotation of the stage with 4 positions of extinction. BUT: these effects are much harder to see than with transmitted light

- cleavage: seen as dark lines and straight sided pits
- Ex.: galena: distinctive triangular pits
- Internal reflection: Minerals that are not totally opaque can display colored internal reflections under crossed polars when using bright illumination.
- Ex.: sphalerite, cassierite



**Cassierite PRL** 

**Cassierite XRL** 

- Hardness: Polishing hardness can be judged by the quality of the polished surface (the hardest surfaces have the most mirror-like finishes) and can be tested using the "Kalb line" test. (equivalent to the Becke line):
- When using the high power objective, and a partly closed diaphragm, lowering the stage will cause the "Kalb line" to move from the grain boundary towards the softer of two adjacent mineral grains.

Ex.: Pyrite (yellow white) in an overly polished block stands out in relief against softer chalcopyrite (yellow) and bornite (pinkish brown).



### COMMON OPAQUES

Mineral	Formula	Reflect ance	Color	Anisotropy	Hardness	Comments
Gold	Au	75	bright yellow	isotropic	2.5 - 3.0	very bright & soft
Pyrite	FeS <sub>2</sub>	55	Pale_yellow	isotropic	6.0 - 6.5	Hard,_euhedral cubes & triangles
Chalcopyrite	$CuFeS_2$	44	Strong yellow	weak	3.5 - 4.0	soft, yellow
Pentlandite	(Fe,Ni) <sub>9</sub> S <sub>8</sub>	47	light, yellow	isotropic	3.5 - 4.0	exsolutions in pyrrhotite
Galena	PbS	43	grey, white	isotropic	2.5	bright white, cleavage, triangular pits
Chalcocite	$Cu_2S$	32	Light grey	weak	2.5 - 3.0	ductile
Hematite	$Fe_2O_3$	25-30	Bluish grey	strong	5.0 - 6.0	Internal reflections
Bornite	$Cu_5FeS_4$	22	pinkish brown	isotropic	3.0	Tarnishes violet/purple
Magnetite	Fe <sub>3</sub> O <sub>4</sub>	21	brownish grey	isotropic	5.5	lamellae of anisotropic ilmenite or hematite
Ilmenite	FeTiO <sub>3</sub>	17-20	Pinkish grey	strong	5.0 - 6.0	lamellae of isotropic magnetite
Sphalerite	(Zn,Fe)S	17	brownish grey	isotropic	3.5 - 4.0	Internal reflections
Chromite	FeCr <sub>2</sub> O <sub>4</sub>	12	Dark grey	isotropic	5.5	Internal reflections

### **IDENTIFICATION PROCEDURE**

- ► 1) Look at the hand sample: you can often identify major minerals based on their physical properties (color, luster, streak, cleavages, ect...) ⇒ guess on what other minerals can be present
- 2) look at the thin section in transmitted light to easily recognize the opaques (black)
- ► 3) Look at the thins section with reflected light:
  - ▶ 3.1.) in plane light
  - ▶ 3.2.) in crossed polarized light
- For each: take some notes of all your observations

### **IDENTIFICATION PROCEDURE**

#### Plane light:

- Reflectance: low, moderate or high; bireflectance: no, weak, strong
- Color and pleochroism: paying attention to subtle shades
- Polishing hardness: Use Kalb line

#### Crossed polarized light:

- Polarization colors: record color and amount of variation (isotropic/ anisotropic)
- Internal reflection: highlight the color along cracs or imperfections.

#### **Opaque Mineral Identification Flow Chart**



### COLOR

#### Quartz gangue

Pyrite

chalcopyrite

galena

sphalerite

http://www.turnstone.ca/

# COLOR

Quartz gangue

galena

Gold

chalcopyrite

sphalerite

http://www.turnstone.ca/

### POLISHING HARDNESS





# ANISOTROPY



# SURFACE OXIDATION

Thin sections need to be regularly repolished to avoid the effect of the surface oxidation



# OTHER PROPERTIES (not discussed in class)

Magnetite

Exsolution lamellae

Ilmenite lamellae

http://www-odp.tamu.edu/

# OTHER PROPERTIES (not discussed in class) Exsolution lamellae



# OTHER PROPERTIES (not discussed in class) Alteration



# FOR FUN!

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Happy sulfide

Happy sulfide 2

0

8

Ghost sulfide