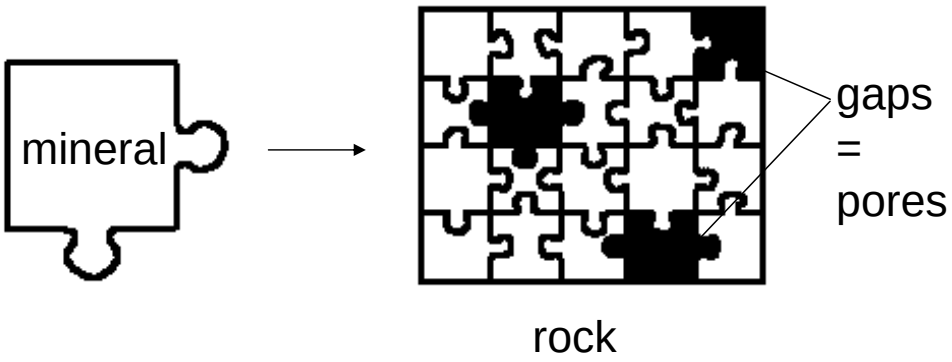
NATURAL STONE

1 - MINERALOGY

Some definitions

Natural Stone = Rock = natural material constituting the crust and mantle. Generally, it is solid (≠ unconsolidated sediments like sand) and made of aggregate of **minerals** more or less closely knitted together (gaps = **pores**)



Some definitions

Mineral = **inorganic** natural compound (although some of them may be bioproducts like apatite, calcite, oxalates...) with a **definite chemical composition**, an **atomic structure** and **physical properties** of its own.
Generally, it is **solid** (≠ mercury)

Cristal = **homogeneous solid** composed of atoms, ions or molecules with an **organized arrangement** that is **repeated periodically** in three dimensions of space
(cristal ≠ amorphous compounds)

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Classification of minerals

Minerals may be classified according to chemical composition.
We can define 8 major classes (≈ in order of abundance):

1. **Silicates** ($(Si,Al)_xO_{2x}$+/-alk. and alk. earth met.)
2. **Carbonates** (CO_3^{2-})
3. **Sulfates** (SO_4^{2-})
4. **Halides** (Cl^-, F^-,…)
5. **Oxides** (O^{2-}), **hydroxides** (OH-)
6. **Sulfides** (S^{2-})
7. **Phosphates** (PO_4^{3-})
8. **Native elements** (C, S, Au,…)

*+ 2 minor classes : **borates** (borax,...)*
*and **organic minerals** (amber, oxalates, ...)*

The identification criteria of minerals

- **Colour:** not a differential criteria

- **Streak** *(trait)*: colour of the powder, more reliable than the colour of the mineral itself (Scratch unglazed porcelain)

- **Luster** *(éclat)*: aspect of the surface mineral when it reflects light

- **Flam test**: the color of flames depends on the chemical composition (Ca: red, Na: yellow, Cu: blue or green, K: violet…)

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The identification criteria of minerals

- **Hardness:** Mohs scale of relative mineral hardness

The identification criteria of minerals

- **Density:** physical constant (2.7 g/cm^3 for silicates)

- **Reaction with dilute HCl (10%)**: carbonates + HCl 10% => emission of CO_2 = effervescence (calcite ($CaCO_3$) fizzes readily in either massive or powdered form, but dolomite ($Ca,Mg(CO_3)_2$) reacts best as a powder or with heated acid)

- **Touch, flavour, radioactivity, magnetism,...**

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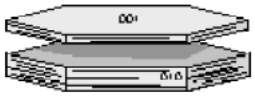
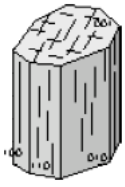
The identification criteria of minerals

- **Cleavage / fracture:** in some minerals, bonds between layers of atoms aligned in certain directions are weaker than bonds between different layers. In these cases, breakage occurs along smooth, flat surfaces parallel to those zones of weakness



micas



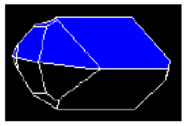
pyroxène

≠

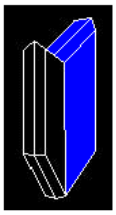
conchoidal fracture

The identification criteria of minerals

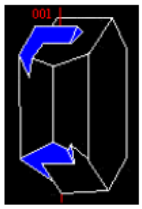
- **Twinning** *(macle)*: Crystal twinning occurs when two separate crystals share some of the same crystal lattice points in a symmetrical manner. The result is an intergrowth of two separate crystals in a variety of specific configurations.



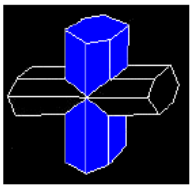
microcline



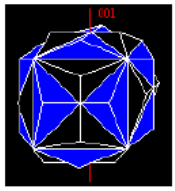
gypse



orthose



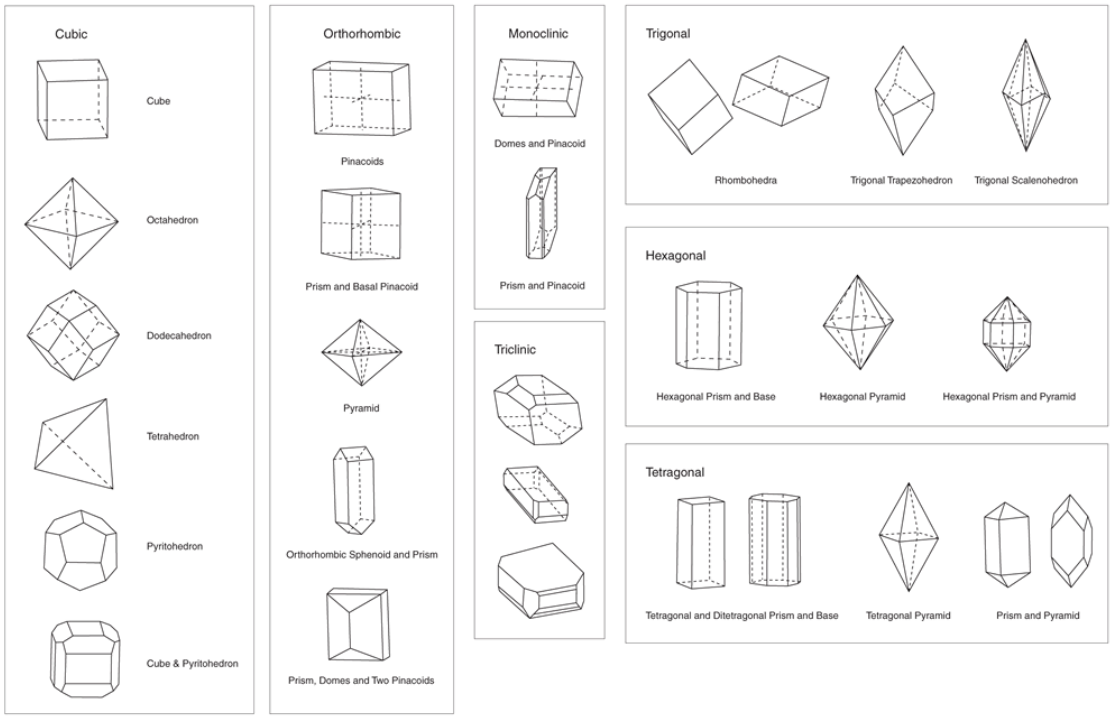
staurotide



pyrite

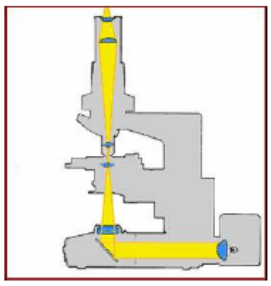
The identification criteria of minerals

Crystal shape: the 7 crystal systems



The identification criteria of minerals

- Optical properties:



Polarizing microscope

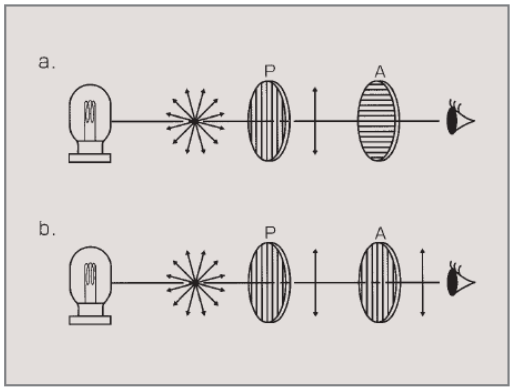
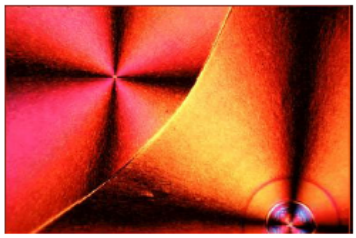


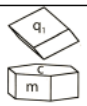
Fig. 1.3 a) crossed nicols and b) parallel nicols
P: polarizer A: analyzer



Interference colors

For more details, see for ex.:
http://www.olympusamerica.com/files/seg_polar_basic_theory.pdf (english)
http://www.kasuku.ch/pdf1.php#a_microscope (french)

Mineral Category	Mineral name Chem. formula	Colour *Streak*	Hardness	Lustre *Transparency*	Cleavage *Fracture*	Habit *Cryst. Syst.*	Remarks
Elements	Graphite C	steel grey, black *grey to black*	1	metallic, dull *opaque*	5 (excellent) *elastic flexible*	hexagonal	colours paper, greasy touch
Sulfides	Galena PbS	lead grey *grey to black*	2,5-3	metallic *opaque*	5 (excellent) *conchoidal*	*cubic*	sometimes iridescence
	Chalcopyrite $CuFeS_2$	brass yellow *Greenish black to black*	3,5-4	metallic *opaque*	1 (indistinct) *uneven*	*tetragonal*	often Iridescence: brownish, blackish, colourful
	Pyrite FeS_2	bright to bright brass yellow *greenish and brownish black*	6-6,5	metallic *opaque*	1 (indistinct) *conchoidal*	cubic	often iridescence: golden yellow, brownish, colourful
	Orpiment As_2S_3	lemon yellow, brownish yellow, orange yellow *pale lemon-yellow*	1.5 – 2	resinous, pearly on cleavage surface *translucent*	2-4 (fair to perfect) *uneven*	*monoclinic*	pigment found in wall paintings in Ladakh
Halides	Fluorite CaF_2	usually coloured, rarely colourless, *white*	4	glassy *transparent to opaque*	4 (perfect) *uneven*	*cubic*	often fluorescent, during crushing typical unpleasant odour
	Halite = Salt NaCl	colourless to white, often coloured *white*	2	vitreous, greasy *transparent to opaque*	5 (excellent) *conchoidal, uneven*	*cubic*	easily soluble in water, salty taste; cooking salt
Oxides, Hydroxides (cont. next page)	Corundum Al_2O_3	rarely colourless, often grey, blue, red *white*	9	vitreous *Transparent to opaque*	0 (none), *conchoidal*	*trigonal*	varieties: Sapphire (blue), Ruby (red) etc.
	Hematite Fe_2O_3	greyish black *bright red to reddish brown*	5,5-6,5	metallic, dull *opaque*	0 (none) *uneven, conchoidal,*	*trigonal - hexagonal*	pigment found in wall paintings in Ladakh (red ochre)
	Magnetite Fe_3O_4	Ferrous black *black*	5,5-6	metallic, dull *opaque*	1 (indistinct) *conchoidal,*	*cubic*	magnetic

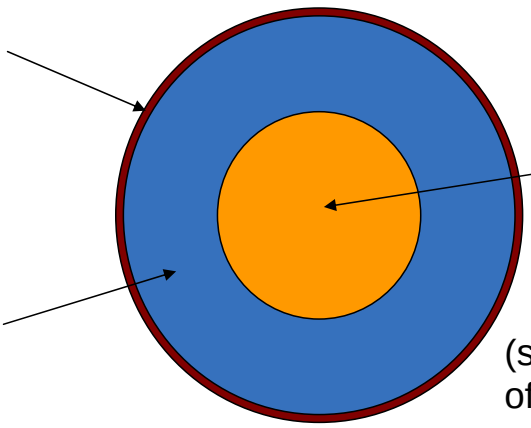
Mineral Category	Mineral name Chem. formula	Colour *Streak*	Hardness	Lustre *Transparency*	Cleavage *Fracture*	Habit *Cryst. Syst.*	Remarks
Oxides, Hydroxides (cont.)	**Limonite** $FeOOH \cdot nH_2O$	brown to yellow, brownish black *braun bis gelb*	5-5,5	silky, often dull *transparent, mostly opaque*	4 (perfect) – difficultly detectable *uneven*	 *orthorhombic*	amorphous and cryptocrystalline mixture of Goethite and Lepidocrocite; pigment found in wall paintings in Ladakh (yellow ochre)
Carbonates	**Calcite** $CaCO_3$	colourless, often white, grey or coloured *white*	3	vitreous, silky, pearly *transparent to opaque*	5 (excellent) *conchoidal*	 *trigonal*	strong reaction in cold HCl (10%)
	Dolomite $CaMg[CO_3]_2$	colourless, white, often yellowish *white*	3,5-4	vitreous *transparent to translucent*	4 (perfect) *conchoidal*	 *trigonal*	hardly any reaction in cold HCl (10%)
	Malachite $Cu_2CO_3(OH)_2$	green, dark green, blackish green *light green*	3.5-4	vitreous - silky *Translucent to opaque*	2 – 4 (fair to perfect) *uneven*	*monoclinic*	pigment found in wall paintings in Ladakh
	Azurite $Cu_3[CO_3]_2(OH)_2$	azure blue, blue, light blue, dark blue *light blue*	3.5-4	vitreous *transparent to subtranslucent*	2 – 4 (fair to perfect) *Brittle - conchoidal*	*monoclinic*	pigment found in wall paintings in Ladakh
Sulfates	**Baryte** $BaSO_4$	Colourless, white, often pale pink *white*	3-3,5	vitreous, greasy looking *often translucent to opaque*	3 (good) *uneven, conchoidal*	 *orthorhombic*	high density, platelike habitus
	Anhydrite $CaSO_4$	colourless, white to grey *white to greyish white*	3-3,5	vitreous *transparent to translucent*	3 - 4 (good to perfect) *conchoidal*	 *orthorhombic*	Fractures into nearly dice shaped grains
	Gypsum $CaSO_4 \cdot 2H_2O$	colourless, whitish grey, yellow *white*	1,5-2	Vitreous *Transparent, translucent, opaque*	5 (excellent) *conchoidal, fibrous*	 *monoclinic*	Varieties: Selenite (glasslike), Alabaster (fine grained); efflorescence
	Mirabilite $Na_2SO_4 \cdot 10H_2O$	colourless, white *white*	1,5-2	Vitreous *Transparent, translucent, opaque*	4 (perfect) *conchoidal*	*monoclinic*	easily soluble in water; efflorescence
	Thenardite Na_2SO_4	White *white*	2.5	vitreous, greasy *transparent*	4 (perfect) *Splintery*	*orthorhombic*	easily soluble in water; efflorescence
	Epsomite $MgSO_4 \cdot 7H_2O$	colourless, white *white*	2-2.5	vitreous *Transparent to translucent*	4 (perfect) *Acicular*	*orthorhombic*	easily soluble in water; efflorescence, bitter taste

Mineral Category	Mineral name Chem. formula	Colour *Streak*	Hardness	Lustre *Transparency*	Cleavage *Fracture*	Habit *Cryst. Syst.*	Remarks
Silicates and Quartz	**Olivine** $(Mg,Fe)_2[SiO_4]$	pale green, oliv *white*	6,5-7	prism surfaces vitreous, fractured surfaces waxy *transparent to translucent*	2-3 (fair to good) *conchoidal*	 *orthorhombic*	"saccharoidal" apparence
	Chrysotile = Asbestos $Mg_3(Si_2O_5)(OH)_4$	green *white*	2.5	silky *translucent*	0 (none) *fibrous*	*monoclinic*	
	Lizardite $Mg_3(Si_2O_5)(OH)_4$	green, green blue, yellow, white *white*	2.5	silky *translucent*	4 (perfect)	*triclinic*	found in "Karsi"
	Garnet $X_3Y_2[SiO_4]_3$ X = Mg, Fe^{2+}, Mn^{2+}, Ca Y = Al, Fe^{3+}, Cr^{3+}, V^{3+}	very variable dependent on composition *white*	6,5-7,5	vitreous to resinous *translucent to opaque*	1 (indistinct) *conchoidal, splintery*	 *cubic*	varieties: Pyrope (MgAl; dark red), Almandine (Fe Al; brown red), Spessartine (Mn Al; brown), Grossular (Ca Al; pale green), Uwarowite (Ca Cr; green) etc.
	Kyanite (Disthen) $Al_2[O/SiO_4]$	clear blue, whitish *white*	4-4,5 and 6-7	vitreous *transparent to translucent*	2 und 4 (fair to perfect) *uneven*	 *triclinic*	anisotropic hardness
	Topaz $Al_2[F_2/SiO_4]$	clear (if no impurities), blue, brown, orange, gray, yellow, pink, reddish pink and green *white*	8	vitreous *transparent to translucent*	4 (perfect) *conchoidal*	 *orthorhombic*	
	Tourmaline $XY_3Z_6[(OH)_4/(BO_3)_3/Si_6O_{18}]$ X = Na, Ca Y = Al, Fe^{2+}, Fe^{3+}, Mg, Ti^{4+}, Cr^{3+} Z = Al, Fe^{3+}, Mn	very variable according to composition *white*	7	vitreous *transparent to translucent*	0 (none), *conchoidal, uneven, splintery*	 *trigonal*	varieties: Schorl (black), Dravite (brown), Elbaite (green) etc.
	Pyroxene $XY[Z_2O_6]$ X = Li, Na^+, Ca^+, Fe^{2+}, Mg Y = Fe2+, Fe3+, Mg, Mn, Ti, Al, Cr^{3+} Z = Si^{4+}, Al^{3+}	often black, greenish and brownish black *Not very characteristic: greyish green or brown, white*	5,5-7	vitreous *Opaque, rarely translucent*	2-3 (fair - good), angle of cleavage planes +/- 90°  *conchoidal, uneven*	 *monoclinic*	often more stocky habit and more dull fracture plains than Amphiboles

Mineral Category	Mineral name Chem. formula	Colour *Streak*	Hardness	Lustre *Transparency*	Cleavage *Fracture*	Habit *Cryst. Syst.*	Remarks
	Amphibole $A_{0-1}B_2C_5[(OH, F)_2/T_8O_{22}]$ A = Na^+, K^+ B = Ca^{2+}, Na^+, Mg^{2+}, Fe^{2+}, Mn^{2+} C = Mg^{2+}, Fe^{2+}, Mn^{2+}, Al^{3+}, Fe^{3+}, Ti^{4+}, T = Si^{4+}, Al^{3+}	often black, greenish and brownish black *Not very characteristic: greyish green, yellow or brown, white*	5-6	vitreous *opaque*	4 (perfect) angle of cleavage planes +/- 120° *uneven*	*monoclinic*	often more columnar habit than Pyroxenes
	Talc $Mg_3[(OH)_2/Si4O_{10}]$	Bright green, white, grey, yellowish *white*	1	waxy, pearly, dull *translucent*	5 (excellent) *uneven*	*monoclinic*	greasy touch
	Muscovite = white mica $KAl_2(OH)_2AlSi_3O_{10}$	colourless, silvery, yellowish, greenish *white*	2-2,5		5 (excellent) *micaceous*	*monoclinic*	easily delaminated
	Biotite = dark mica $K(Mg,Fe)_3(OH)_2(Al,Fe)Si_3O_{10}$	black, dark brown, dark green *white*	2,5-3	pearly *translucent to opaque*	5 (excellent) *micaceous*	*monoclinic*	easily delaminated; golden weathering colour
	Quarz SiO_2	colourless, often white to grey, various colours *white*	7	prism surfaces vitreous, fractured surfaces waxy to dull *transparent, to opaque*	0 (none) *conchoidal, also granular, splintery fibrous*	*trigonal*	many varieties: rock cryst., Citrine, Onyx, Agate, Amethyste, smoky quartz, rose quartz, Chalcedony, Carnelian, Jasper, Chrysoprase etc.
	Opal SiO_2-nH_2O	colourless, diverse colourations *white*	5,5-6,5	vitreous, dull waxy, *opaque to transparent*	0 (none) *conchoidal*	*amorphous no crystals*	amorphous, glasslike and dense material, opalescent!
	Orthoclase = alkali feldspar $K[AlSi_3O_8]$	reddish, yellow, white *white*	6	vitreous *opaque*	3-4 (good – perfect) cleav. planes angle 90° *conchoidal*	*monoclinic*	typically displays carlsbad twinning, fractures in right angles
	Plagioclase Albite (Ab): $Na[AlSi_3O_8]$ Anorthite (An): $Ca[Al_2Si_2O_8]$	white, grey, greenish, yellowish *white*	6-6,5	vitreous *translucent*	4 (perfect) angle of cleav. planes 86°-88° *conchoidal*	triclinic	often polysynthetic twinning
	Leucite $K[AlSi_2O_6]$	white, grey, colourless *white*	5,5-6	glassy waxy *translucent to opaque*	0 (none) *conchoidal, uneven*	*tetragonal*	does not occur together with quartz
	Nepheline = nephelite $Na[AlSiO_4]$	colourless, white *white*	5,5-6	vitreous on prism surfaces, waxy on fract. *translucent to opaque*	0-1 (none to indistinct) *conchoidal*	*hexagonal*	does not occur together with quartz
	Lazurite = Lapis Lazuli $Na_3CaAl_3Si_3O_{12}S$	blue *light blue*	5.5	vitreous -d ull *translucent*	1 (indistinct) *conchoidal*	*cubic*	does not occur together with quartz

Distribution of elements within the earth

crust:
Si, O, Al



core:
Fe, Ni

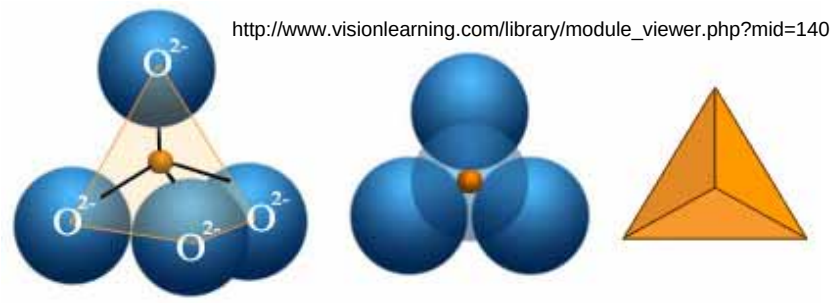
mantel:
Si, O, Mg

(simplified structure of the Earth!)

➔ **silicates (& other light minerals) are the most abundant minerals in the earth's surface**

The silicate class

The silicates are the largest, the most interesting and the most complicated class of minerals. ≈ 30% of all minerals are silicates and 90% of the Earth's crust is made up of silicates.

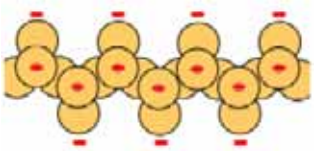


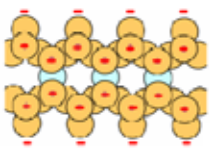
The basic chemical unit of silicates is the (SiO_4) tetrahedron shaped anionic group **with a negative four charge (-4). But a mineral must be neutral !!!**

The silicate class - Neutralization of charges…

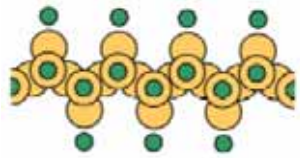
- with cations :

- polymerization with sharing the O^{2-} anions :

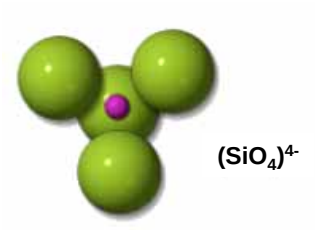
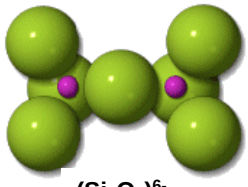
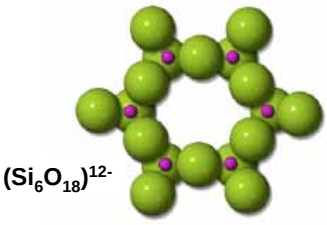
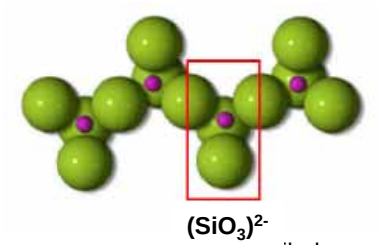
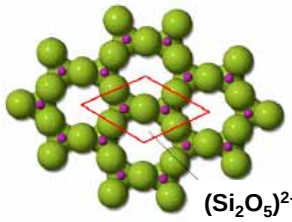




- combining the two previous solutions :



The silicate class - The 6 groups of silicate minerals

Nesosilicates  $(SiO_4)^{4-}$ ex.: olivine, garnet, zircon,…	**Sorosilicates**  $(Si_2O_7)^{6-}$ ex.: epidote,…	**Cyclosilicates**  $(Si_6O_{18})^{12-}$ ex.: beryl, tourmaline,…
Inosilicates  $(SiO_3)^{2-}$ ex.: pyroxene, ampnibole,…	**Phyllosilicates**  $(Si_2O_5)^{2-}$ ex.: mica, clay,…	**Tectosilicates** $(SiO_2)^0$  ex.: quartz, feldspar,…

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Minerals and rocks

Cardinal minerals:

60 to 70% of the rock (usually white or slightly colored)
quartz, feldspars, feldspathoids, calcite

Essential minerals:

20 to 25% of the rock (often dark)
micas, amphiboles, pyroxenes, olivine,...

Accessory minerals:

5 to 10% of the rock
oxides, sulfides,...

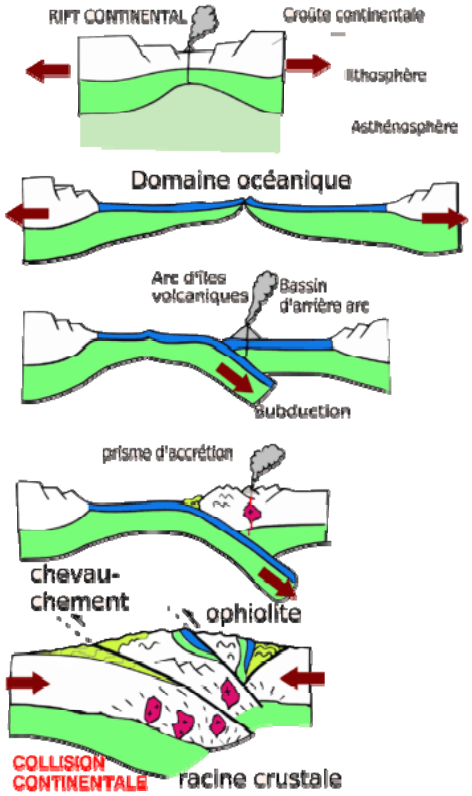
Genesis of minerals and rocks

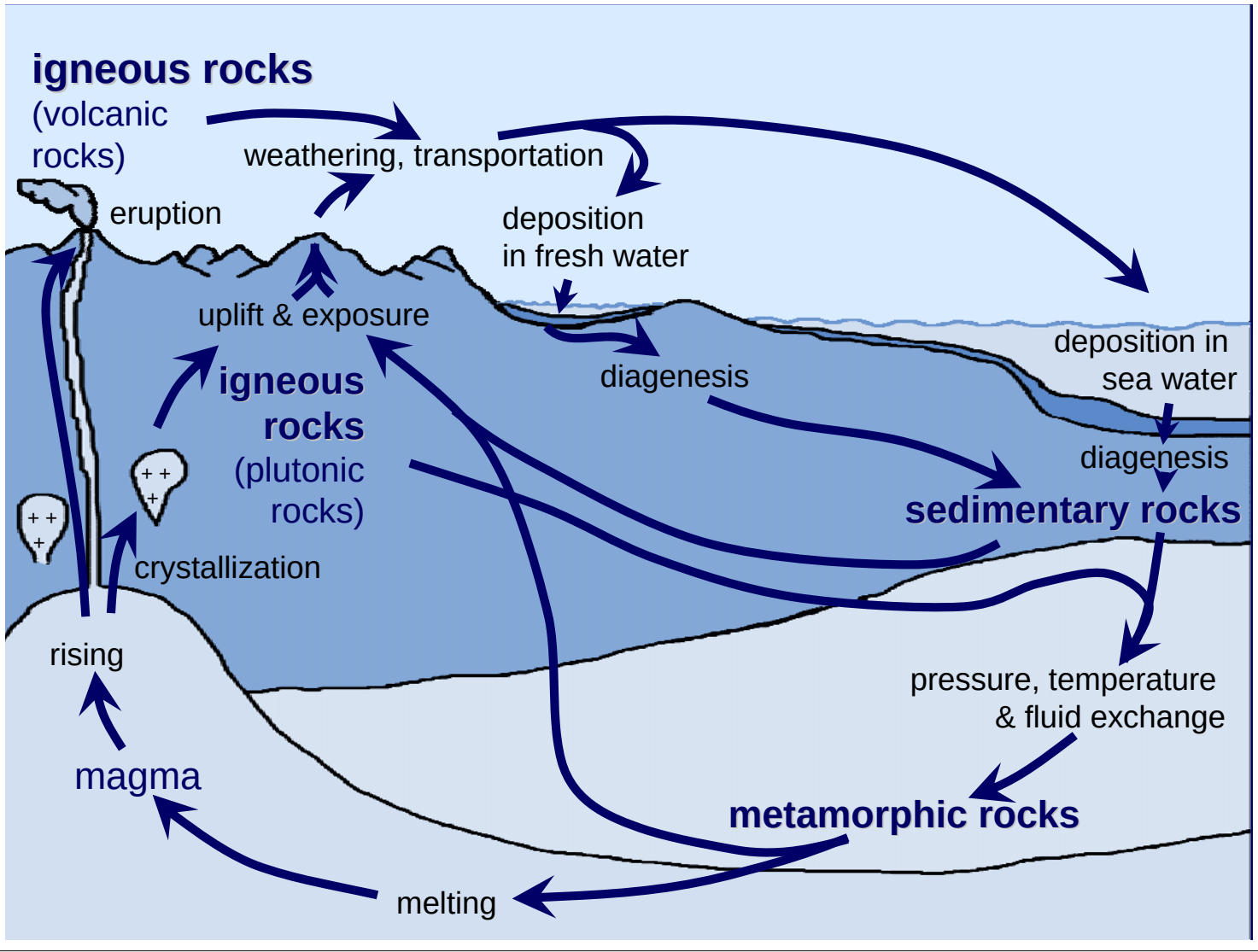
Endogenous genesis (in depth)

- **magmatic process:** coming from a magma
- **metamorphic process:** transformation of pre-existent mineral materials

Exogenic genesis (at the surface)

- **sedimentary process:** pre-existent mineral materials transformation and/or neo-formation





A few silicate minerals

Nesosilicates / Garnets $(X_3^{2+}Y_2^{3+}[SiO_4]_3)$

Use: gemstone, abrasive

Inosilicates / Amphiboles

Bleu asbestos: Crocidolite $(Na_2(Fe,Mg)_5Si_8O_{22}(OH)_2)$

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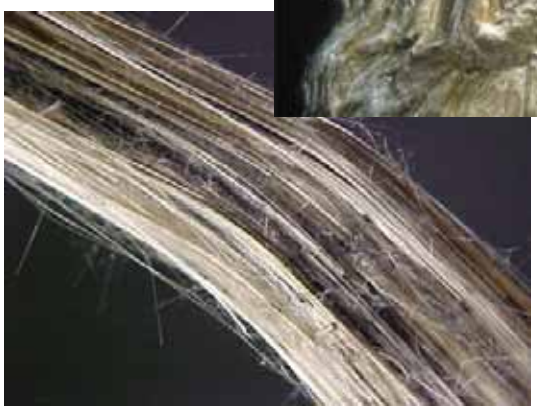
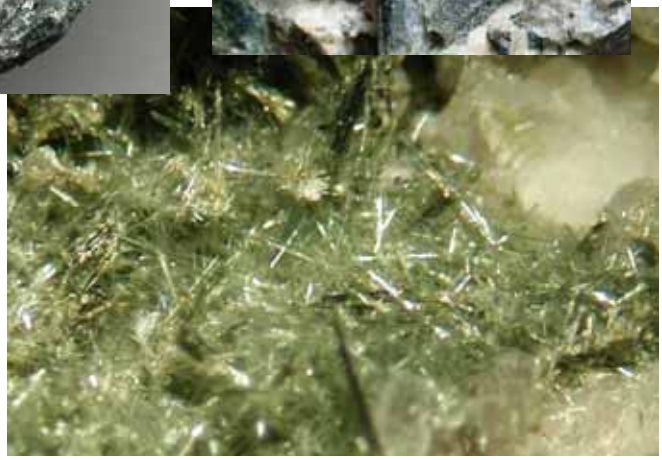
Inosilicates / Amphiboles

Brown asbestos: Amosite $(Fe_7Si_8O_{22}(OH)_2)$



Inosilicates / Amphiboles

Green asbestos. ex. : Actinolite $(Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2)$

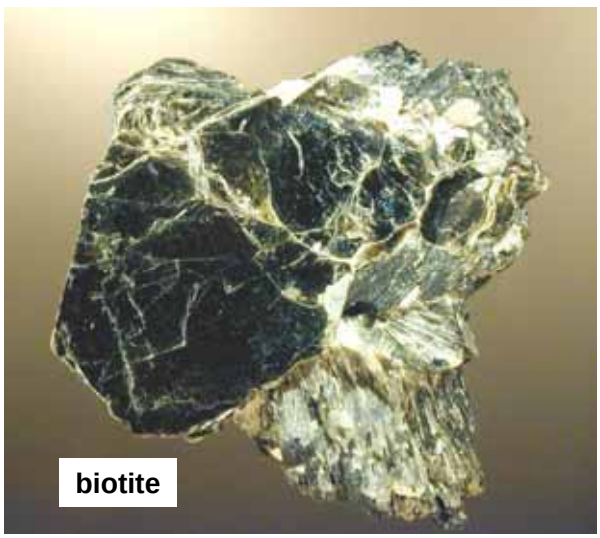


Phyllosilicates / Micas

Muscovite $(KAl_2[(OH,F)_2|AlSi_3O_{10}])$ white mica,

Biotite $(K(Mg,Fe^{2+},Mn^{2+})_3[(OH,F)_2(Al,Fe^{3+},Ti^{3+})Si_3O_{10}])$ black/brown mica

Use: Heat, acoustic and electric insulator, paints



Phyllosilicates / Clay minerals

Kaolinite ($Al_2Si_2O_5(OH)_4$)

Use: porcelain manufacture, filler in papers

Phyllosilicates / Clay minerals

Montmorillonite ($((Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2.nH_2O$)

Swelling clay mineral exchanger of ions

Use: gastric plaster, cleaner of greases (Terre de Sommières), bentonite, container for the nuclear waste

Phyllosilicates / Clay minerals

Talc ($Mg_3Si_4O_{10}(OH)_2$)

Use of talc: cosmetic, lubricant, manufacture of paper, excipient and lubricant in the pharmaceutical industry, tailor's chalk

Phyllosilicates / Chlorites

$((Mg,Fe,Mn,Al)_6((Si,Al)_4O_{10})(OH)_8)$

Use: decorative stone

Phyllosilicates / Serpentinites

White asbestos: Chrysotile ($Mg_3Si_2O_5(OH)_4$)

Use: reinforced cement, machine parts under friction, joints for high temperature machines… because non flammable, imputrescible, flexible, resistant to the majority of chemicals and with a high breaking stress => majority of the world market of asbestos

http://www.ec.gc.ca/nopp/docs/consult/Rotterdam/ca/fr/chrysotileBG.cfm

Tectosilicates / Quartz

(SiO_2)

Use:
Piezoelectric (clock industry, …) and…

citrine

amethsyt

gemstones (amethyst, citrine)…
cryptocristalline varieties: flint, agate, onyx, carnelian, jasper, opal

Tectosilicates / Feldspars

K- feldspars ($KAlSi_3O_8$)

Use:
ceramics, porcelain, glass, bricks, soaps, scouring powders, gemstones

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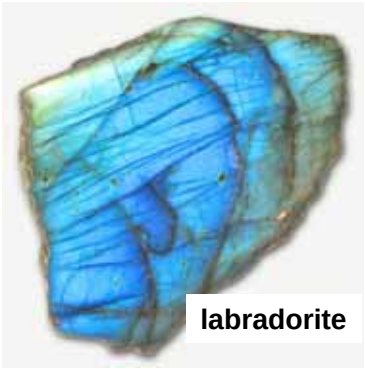
Tectosilicates / Feldspars

Plagioclases ($(AlSi_3O_8)(Ca,Na)$)



Use:
ceramics, porcelain, glass, bricks, soaps, scouring powders, gemstones

Tectosilicates / Feldspathoids

Lazurite ($(Na, Ca)_8(Al, Si)_{12}O_{24}S_2$ FeS- $CaCO_3$)

Use: gemstone, blue pigment

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A few non silicate minerals

Carbonates / Calcite ($CaCO_3$)

Use: white pigment (calcite as chalk used since prehistory), raw material of lime

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Carbonates / Azurite ($2CuCO_3,Cu(OH)_2$)

Use: blue pigment, gemstone

Carbonates / Malachite ($CuCO_3$,$Cu(OH)_3$)

Use: green pigment, gemstone

polished roller

Carbonates / Cerussite ($PbCO_3$)

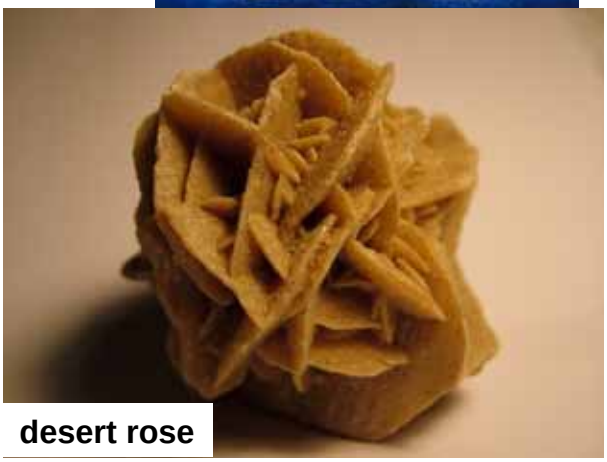
Use: cosmetic (in the past since antiquity); white pigment (= white lead)

Sulfates / Gypsum ($CaSO_4,2H_2O$)


fibrous


swallowtail twinning

Selenite (= pierre de lune)


desert rose

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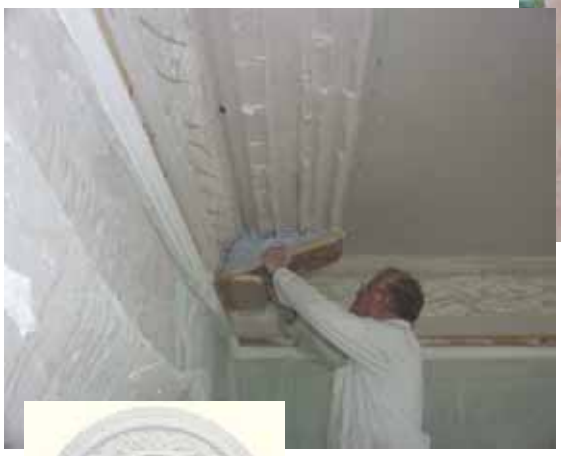
Sulfates / Gypsum ($CaSO_4,2H_2O$)

Use: raw material of plaster; fertilizer and soil conditioner, Tofu coagulant, blackboard chalk



Sulfates / Gypsum alabaster ($CaSO_4,2H_2O$)

Use: decorative stone

Sulfates / Gypsum ($CaSO_4,2H_2O$)

Danger: coming from the air pollution, the stone itself or from cements => degrading stones

Sulfates / Barite ($BaSO_4$)

Use: major source of barium, white pigment (blanc fixe), used in paper or paint manufacturing, radiography, heavy filler

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Halides / Halite (NaCl)

Use: table salt, road salt

Danger for building stones: crystallisation damp patches

Halides / Sylvite (KCl)

Use: fertilizer, substitute for table salt, lethal injection

Danger for building stones: crystallisation, damp patches

Halides / Fluorite (CaF_2)

Use: manufacture of hydrofluoric acid, enamels, glass fibre; used as camera lens; purple pigment; gemstone

Oxides / Hematite (Fe_2O_3)

Use: red pigment; gemstone

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Oxides / Goethite (FeO(OH))

Use: yellow pigment

Oxides / Rutile (TiO_2)

Use: white pigment (artificial); manufacture of paints; +/- in gemstones

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Oxides / Corundum (Al_2O_3)

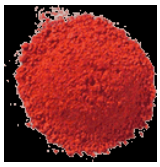
Use:
abrasive;
gemstones

sapphire

ruby

Oxides / Minium (Pb_3O_4)

Use: red pigment, manufacture of glass, protecting paint against the corrosion of metals



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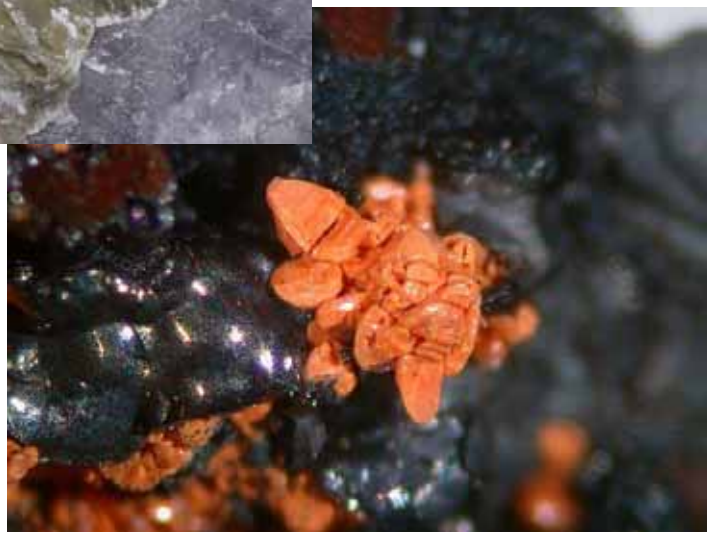
Oxides / Massicot (or litharge) (PbO)

Use: yellow pigment, manufacture of glass, of oils and varnishes (desiccant), production of insecticides



Sulfides / Galena (PbS)

Use: black pigment, cosmetic (khol), semiconductor in old wireless systems

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Sulfides / Pyrite (FeS_2) (= fool's gold)

Use: production of sulfur dioxide for paper industry or manufacturing of sulfuric acid

"Dangers" in building oxidation makes it dangerous in aggregates of concrete; rost patches on stones (marble, sandstones,...)

Sulfides / Realgar (AsS)

Use: red pigment; fireworks

Problems: unstable with light (=> yellow pararealgar)

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Sulfides / Orpiment (As_2S_3)

Use: yellow pigment; production of semiconductors and photoconductors, fireworks

Problems: incompatible with pigments like lead and copper-based; it blackens in contact with the air

Sulfides / Cinnabar (HgS)

Use: red pigment; medicine, drug, food dye

Problems: it blackens in contact with the air

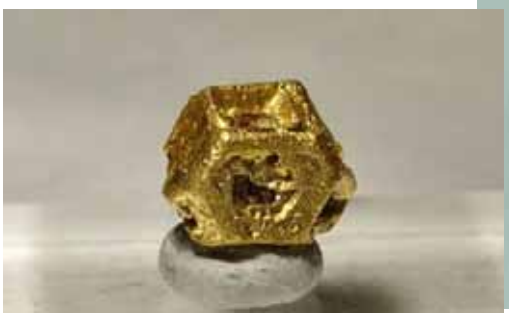
Phosphates / Apatite ($Ca_5(PO_4)_3(OH, F, Cl)$)

Use: fertilizer; gemstone; new stone consolidant

Elements / Gold (Au)

Use: noble metal, decorative metal, gilding; conductive coating, money

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Elements / Silver (Ag)

Use: noble metal; decorative metal; printed circuits; electrical contacts; dental alloys; antibacterial; money





French bibliography

- Schumann W., 1990 - Guide des pierres et minéraux - Ed. Delachaux et Niestlé
- http://www.kasuku.ch/

English bibliography

- http://webmineral.com/