



## 5. OXYDES ET HYDROXYDES

The class of oxides (around 320 minerals) includes compounds of metals or metalloids with oxygen or hydroxide groups.

The oxides present: hardnesses frequently exceeding 8 (only minerals with a hardness > 8 except diamond); great chemical stability, hence low solubility and high melting point. On the other hand, hydroxides often have low hardness, attack easily and frequently show excellent cleavage.

Deposits - There is great diversity in the deposit conditions of these minerals. Most simple oxides and multiple oxides belong in the fields of magmatism, metamorphism and marine sedimentation. There most of the hydroxides are found in the oxidation zone of the deposits metallic.

### SPINEL



### Cubic

$\text{Mg}^{2+}$  and  $\text{Al}^{3+}$  can be substituted by  $\text{Fe}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$  and by  $\text{Cr}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Mn}^{3+}$ , respectively, leading to changes in physical properties. Octahedral crystals. Macle frequents.

D = 3.5 to 4 depending on the composition/ H = 8. Irregular breakage. Transparent to opaque. Glassy shine. Varied colors: most commonly brownish or greenish more or less dark to black (iron-bearing varieties); sometimes colorless, pink, red, blue.

Mineral from contact metamorphism of dolomites and magnesium limestones (in cipolins with phlogopite). Accessory mineral of certain pegmatites. Frequent constituent of ultrabasic rocks (iron and chromium varieties) (spinel herzolites).



**Use:** Transparent varieties are used as gems.

### MAGNETITE



### Cubic

Automorphic crystals are generally octahedrons. Most often, granular or compact masses.

Density: 5.2 / H = 6. Uneven breakage. Opaque, metallic shine or dull. Black. Black dust. Strongly magnetic. Alteration into hematite and limonite.



High temperature primary mineral: disseminated or segregated in especially basic eruptive rocks; in high temperature veins, with varied sulphides; contact metamorphism deposits; in meteorites, in alluvium. Sometimes secondary: sedimentary deposits with hematite, siderite, chlorites.



**Iron ore.**

**CHROMITE**



**Cubic**

Very rare crystals: octahedrons. Usually in rounded grains or in grainy to compact masses.

D = 4.1 to 4.9/ H = 5.5. May contain Mg (up to 20% MgO). Uneven breakage. Black color. Opaque. Metallic shine to matte. Black dust. Sometimes weakly magnetic.

Common in peridotites and serpentines.



**CHRYSOBERYL**



**Orthorhombic**

Generally well crystallized: tabular crystals, with streaks on the flattening side. Frequent twins giving crystals with a hexagonal appearance.

D=3.7/H=8.5. Fragile. Irregular breakage. Fairly easy cleavage. Color: yellow, green, olive green, brownish green. Transparent to opaque. Glassy shine. Colorless dust.



### Varieties:

- **Alexandrite:** gem variety of chrysoberyl, green in daylight, purplish red in artificial light.
- **Cat's eye:** shimmering variety of yellowish green chrysoberyl.

## CORUNDUM



### Rhombohedral

Often in crystals that can reach large dimensions (1 m and more). Prisms in the shape of pseudo-hexagonal barrels. Also in lamellar or grainy masses.

D = 4 / H = 9. Irregular break. Tenacious. Color: gray, bluish, brownish, reddish, rarely colorless or black. Adamantine to vitreous luster. Colorless dust.

### Varieties:

- **Ruby:** red variety
- **Sapphire:** blue variety in particular, but also in various colors.



Sapphires and rubies are gems, they are part of precious stones with diamond and emerald (green beryl).

Deposits: In certain hyperaluminous igneous rocks (syenites); in metamorphosed limestones; in the shales.

## ILMENITE



### Triclinic

Crystals generally tabular, more rarely in rhombohedral crystals, micaceous lamellae. Grainy aggregates. Compact masses.

D = 4.7 / H = 5.5. Conchoidal breakage. Cleavage good. Color: black to black-brown. Opaque. Metallic shine. Black dust, sometimes weakly magnetic.

Accessory constituent of magmatic and metamorphic rocks. Sometimes economical concentration in basic rocks, with magnetite and rutile. In detrital deposits.



## HEMATITE (Oligist)



## Rhombohedral

**Etymology:** from the Greek “hematicos” bleeding (color of dust).

Automorphic crystals generally tabular, in thin or thick lamellae. Often grouped parallel or in rosettes. Triangle-striated flattening face. More rarely in prismatic or rhombohedral crystals. Often micaceous in appearance. Massive, granular, fibrous, fibro-radiated, concretionary. Earthy, mixed with clay and brightly colored red (ochre).

D = 5 / H = 5 to 6. Opaque, transparent in very thin strips. Metallic shine. Iron gray color, dull red in compact varieties. Reddish brown to red dust. Can hydrate in limonite.

**Deposit:** Very widespread oxide, of primary origin or coming from the transformation of siderite, magnetite. Various deposits. The main ones: sedimentary deposits with siderite, limonite, chlorite, substitution deposits of siderite in limestone, transformed in the oxidation zone into hematite, goethite, limonite; high temperature veins



Earthy hematite (Black Hills, South Dakota, USA)



Hematite stone Morocco

## PECHBLEND /Uraninita



## Cubic

Rare, cubic or octahedral crystals (Uraninite). Most often cryptocrystalline varieties (Pechblende) in hilly, compact or earthy masses.

**Density:** 8 to 10 (Uraninite); 6.5 to 8.5 (Pechblende) / H = 5.5. Uneven or conchoidal breakage. Opaque. Resinous or matte shine. Black to brownish black color. Brownish black dust. Very radioactive.



PECHBLEND





## Main ore of uranium.

Deposits: In mesothermal Ni-Co-Bi-Ag or BPGC deposits with fluorite; In powdery varieties in certain sedimentary rocks rich in organic matter with pyrite and marcasite.

## RUTILE (TiO<sub>2</sub>) Quadratic

Almost always in clear crystals, with an octagonal section, prism faces often longitudinally striated and octahedral termination. Also in grainy or compact masses. In fine needles included in quartz. Macle in "knee" frequent.

D = 4.2 / H = 6 to 6.5. Conchoidal breakage. Translucent to opaque, adamantine luster. Color dark brown to black; red to red-brown in acicular facies. Pale brown dust. May contain notable quantities of Fe, Nb, Ta.



Etymologie (du latin "rutilus" = rouge)



Unalterable, it is common in alluvium. Most stable form of  $\text{TiO}_2$ . Frequent accessory constituent of numerous eruptive (granites, syenites, diorites, etc.) and metamorphic (cipolins, gneiss, quartzites, etc.) rocks.

In large crystals in pegmatites and hydrothermal veins. In detrital deposits, sometimes with ilmenite, magnetite and monazite (black sands).

**CASSITERITE**                      ( $\text{SnO}_2$ )                      **Quadratic**

Isomorph of rutile. Often well-formed but small crystals. Stubby prisms, more rarely acicular. Irregularly shaped grains. Sometimes in concretionary masses with a fibrous structure. Macle frequents.

$D = 7 / H = 6$  to 7. Uneven breakage. Translucent to opaque, adamantine shine, bold on the break. Color light pinkish-brown, black-brown to black; white to gray dust.

May contain a few % of iron, Nb, Ta, Ti, mainly in the form of mineral inclusions.

Principal minerai d'étain



Translucent Cassiterite Crystal

Unalterable, it is common in alluvial deposits. High temperature mineral, linked to pegmatitic and pneumatolitic phases in granites, aplites and pegmatites and in quartz veins, with topaz, fluorite, tourmaline, lepidolite, beryl, molybdenum, wolframite, mispickel, etc.

**PYROLUSITE**                      ( $\text{MnO}_2$ )                      **quadratic**

Prismatic crystals, rare and small. Aggregates generally botryoidal, fibro-radiated and with a smooth, hilly surface, also in the form of earthy and oolitic masses. Usually slightly staining.

$D = 5 / H = 2$  to 6, depending on compactness. Opaque, steel gray to dark gray, black line, metallic to matte shine, perfect cleavage.

Mode of deposit: in sedimentary deposits or as accessory ore in hydrothermal deposits.



## PSILOMELANE



monoclinic

Unknown crystals. Finely granular to massive, radiating, also earthy masses.

D = 4.7 / H = 4 to 6. Cleavage none; irregular, fragile breakage. Color: black, black brown, black line, brown, metallic shine, matte,

In the oxidation zone of manganese metal deposits.

## MANGANESE NODULES

Nodules 2 to 5 cm in diameter developed concentrically around a core, found on the seabed at 4000-6000 m depth. These are mineralized nodules containing up to 40% manganese. They also contain copper, nickel, cobalt and zinc at levels of 0.2 to 1%.

## GEOHITE



Orthorhombic

Rarely in prismatic crystals (< 1 cm), vertically streaked; fibrous aggregates, radiated tufts. Generally fibrous to fibro-radiated and concretionary masses, sometimes porous to earthy.



D = 4.3 / H = 5. Uneven breakage. Clear divide. Color: black brown to dark red brown, yellow brown. Opaque. Dull shine. Yellow-brown dust.

Mineral generally originating from the **alteration** of other iron minerals (Pyrite, Magnetite, Siderite, Ankerite, etc.).

## LIMONITE



Amorphous H<sub>2</sub>O

Under this term we designate a mixture of oxidized iron minerals, colloidal silica, clays, dominated by goethite containing adsorbed water (FeOOH. n H<sub>2</sub>O)

Generally compact, fibrous, hilly, concretionary masses, often porous and earthy to powdery (powdery).



D= 2.7 / H= 4 to 5. Variable breakage: conchoidal or earthy. Fragile. Color: black brown to black, brownish yellow, red brown (earthy variety), yellow ocher to orange brown (powdery variety). Opaque. Earthy shine, glazed in the nipped varieties. Dust: yellow brown.



### BRUCITE



### Rhombohedral

Small tabular to micaceous crystals. Generally in flaky masses, rarely grainy.

D = 2.4 / H = 2.5. Micaceous cleavage. Color: white to greenish white. Transparent. Glassy shine. White dust.

In low temperature hydrothermal veins, crossing serpentines or metamorphic limestones. Associated with magnesite, talc.

### BAUXITE: Alumina hydrates



Bauxites are mixtures, in variable proportions, of various cryptocrystalline constituents, among which can dominate gibbsite (or hydrogillite) of formula  $\text{Al}(\text{OH})_3$ , boehmite and diaspore both of formula  $\text{AlO} \cdot (\text{OH})$  and orthorhombic .

Bauxite occurs in compact earthy, clayey masses with a pisolithic structure. D = 2.5/ H = 1 to 3. Color: white, yellowish, pink, brick red. Opaque. Earthy shine.

As a residual product of alterations in tropical climates of aluminous rocks and limestones.

*\*Main and important ore of aluminum.*



**BAUXITE**



**BAUXITE (Guinea)**

