

INTERNAL GEODYNAMICS
(ENDOGENOUS PROCESSES OF THE EARTH)

İÇ JEODİNAMİK
(*DÜNYANIN ENDOJEN OLAYLARI*)

A. M. C. Şengör

İTÜ Avrasya Yerbilimleri Enstitüsü

2005 Kış yarıyılı

Lesson 4:

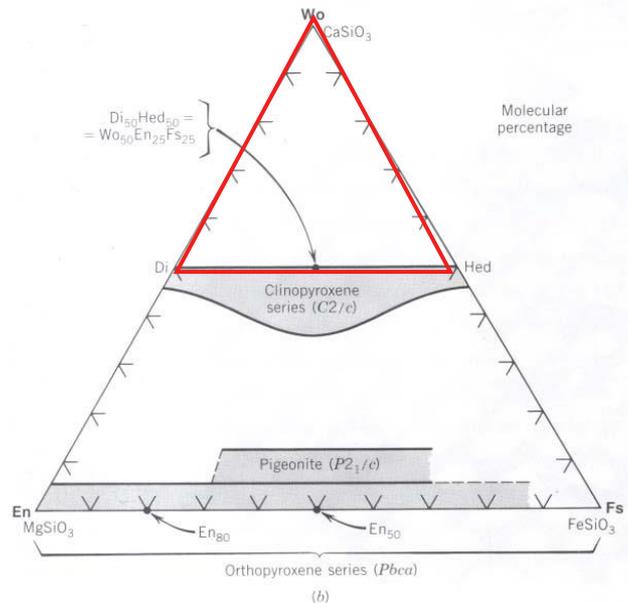
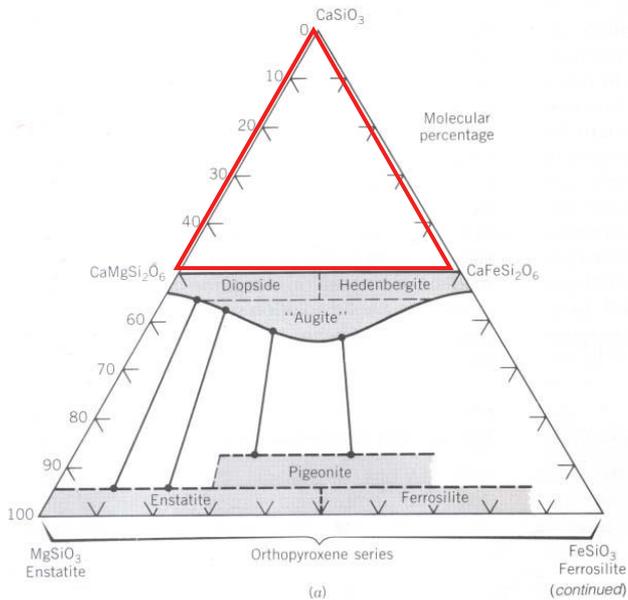
The Minerals and Rocks of the Earth

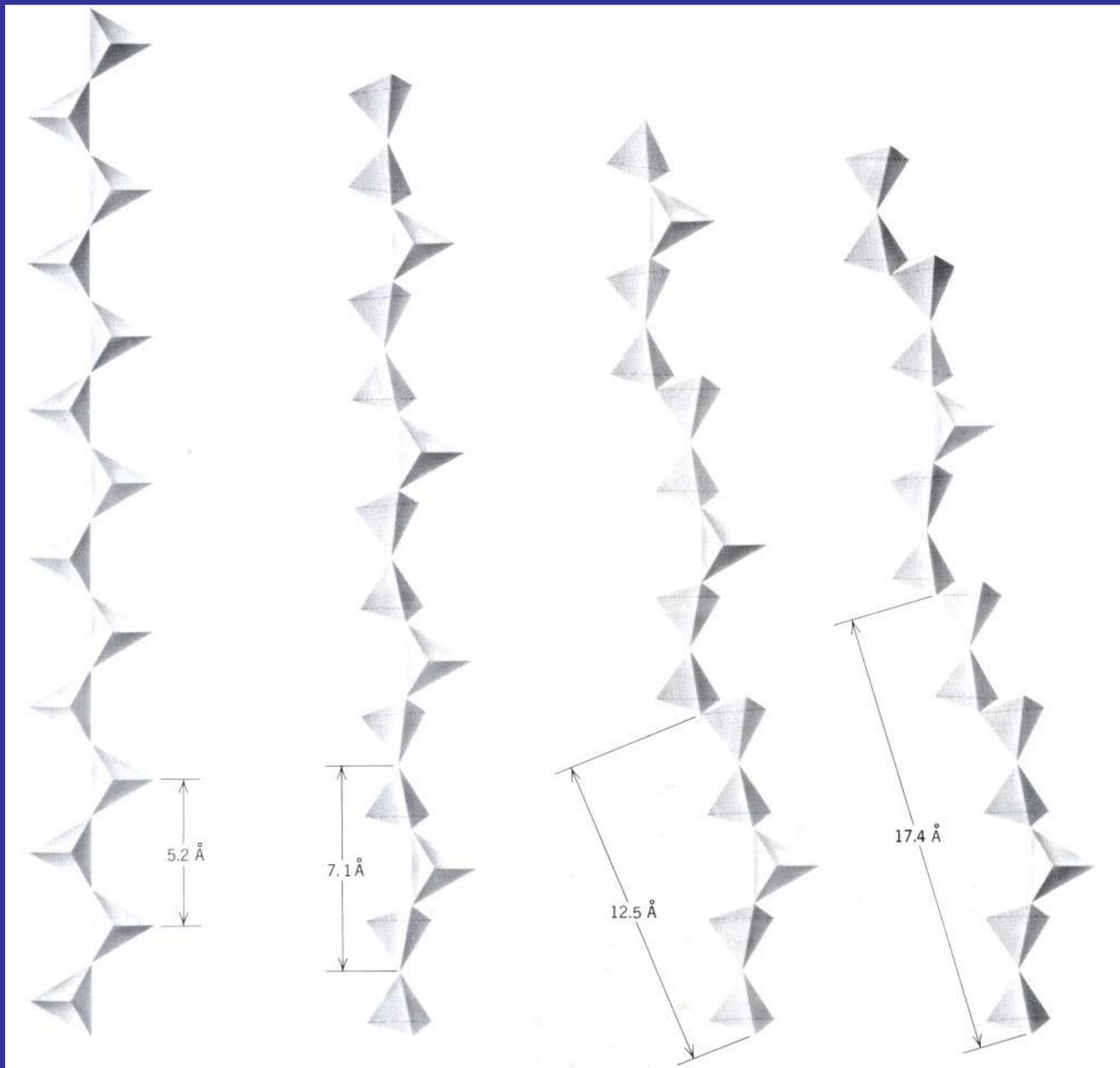
*Part IIIb: The minerals- special
mineralogy*

Pyroxenoids

The pyroxenoids have the same Si : O = 1:3 ratio as the pyroxenes, but their chains are not straight as those of the true pyroxenes. Instead, the chains are curvilinear with varying repeat distances in different species.

The repeat distance of the true pyroxenes is 5.2 Å. In wollastonite, Ca SiO₃, for example, the repeat distance of three twisted tetrahedra is 7.1 Å. In rhodonite, MnSiO₃, the repeat distance of five twisted tetrahedra is 12.5 Å





True pyroxenes Wollastonite Rhodonite Pyroxmangite

Why is the twisting of the SiO tetrahedra? In true pyroxenes the M_1 site must be occupied by a large ion, and the M_2 site by a small ion. Pyroxenoids form in cases where this is not possible, as in wollastonite:

since $\text{CaCaSi}_2\text{O}_6$ is not possible, we get
 CaSiO_3 .



Wollastonite from Svartsång
mine, Filipstad, Sweden



Wollastonite from
Ihalainen, Finland

Wollastonite (Ca SiO_3)

Named after W.H.Wollaston (1766-1828),
English mineralogist and chemist

Crystal system: triclinic

Cleavage: [100] perfect, [102] good, [001]
good

Colour: mostly white, grayish white, grey,
brown, red

Average density: 2.8-2.9

Hardness: 4.5-5

Streak: white

Luster: vitreous-silky or pearly on fresh
cleavage surfaces

Fracture: splintery

The inosilicates, continued

Let us remember that the “chain” silicates are so called, because their structure consists of SiO_4 tetrahedra so connected as to form a continuous chain or two parallel chains.

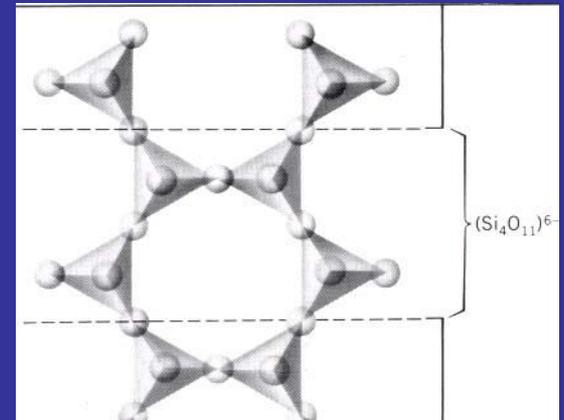
The charge of the Si ion is +4, and the O ion is -2, so, in a single chain of silicate tetrahedra:



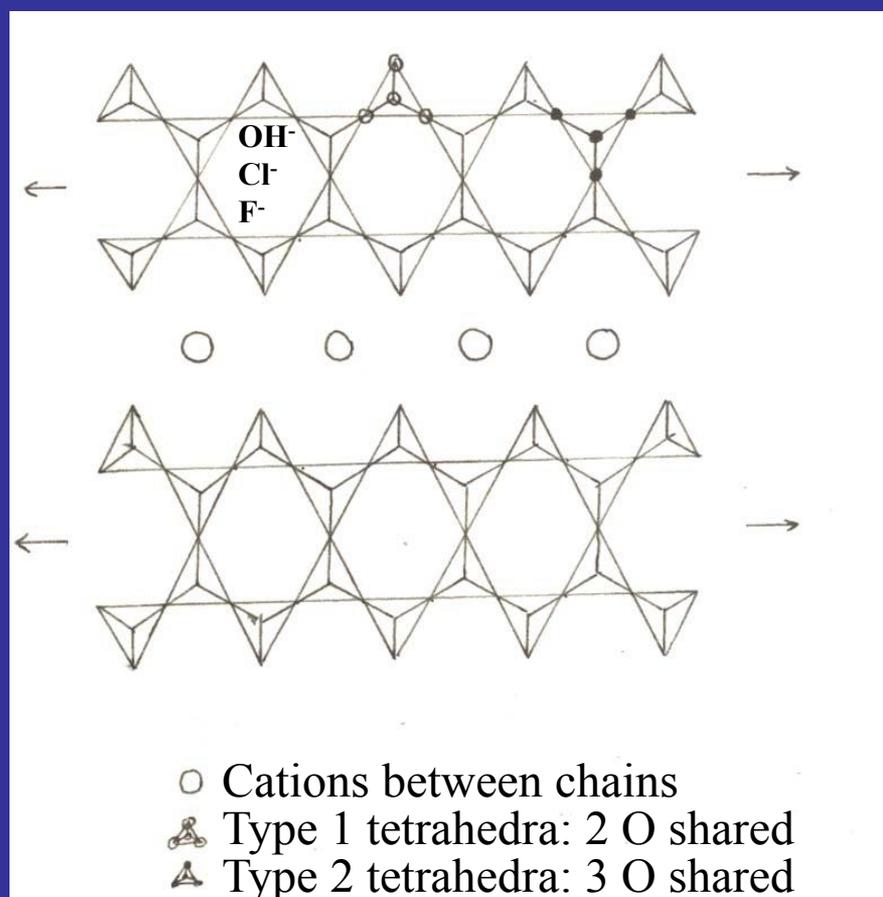
This combination has an excess of -4 charges, which means that this unit cannot stay isolated. What if we have two parallel chains sharing oxygen ions?



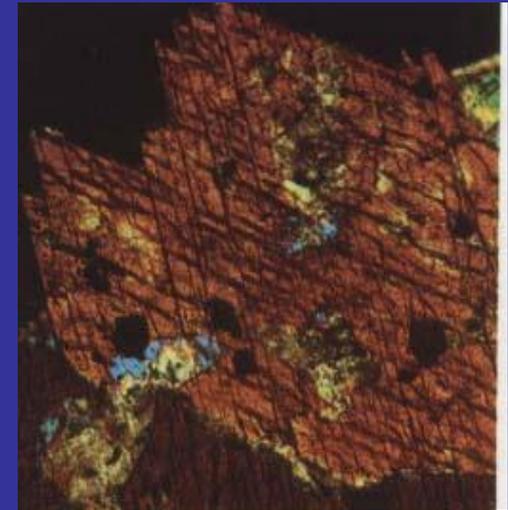
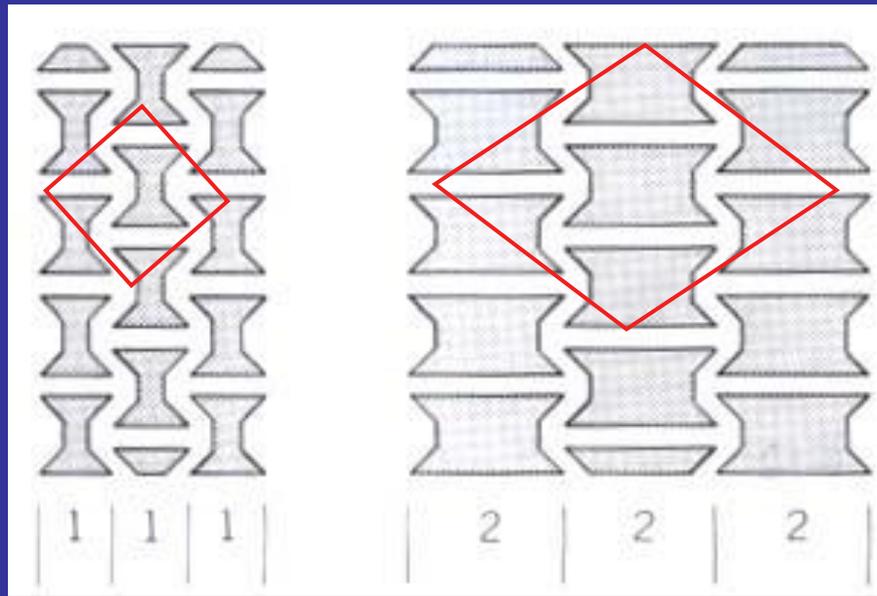
In this case we get -6 charges to satisfy.



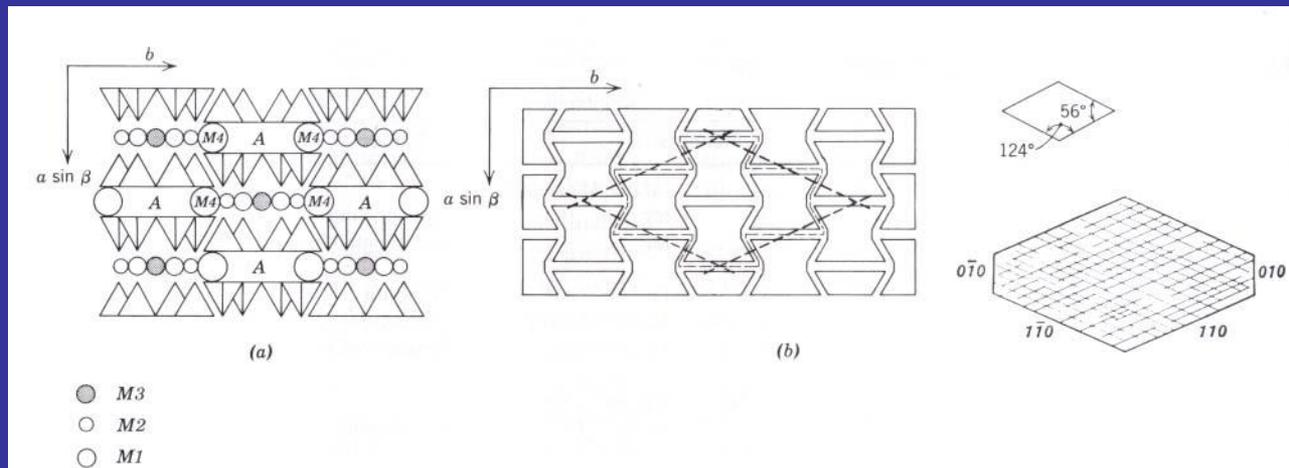
To satisfy the outstanding -6 charges, +6 charges have to be added to neutralise them. By the addition of cations to do so, we generate the *double-chain inosilicates*. The most important double-chain inosilicates are the *amphibole* group of minerals.

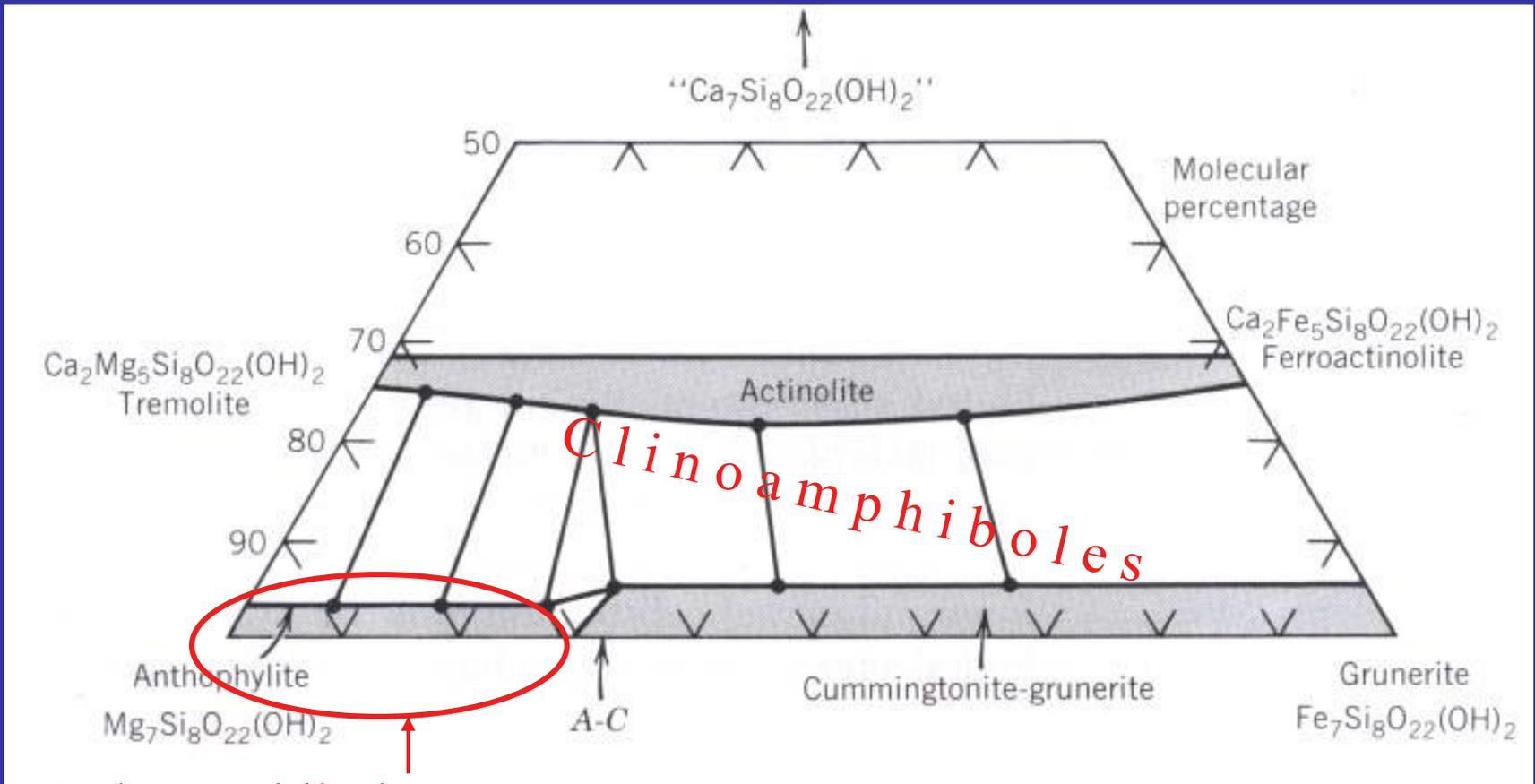


Amphiboles are like sponges: they suck up anything found around them because, to be stable, they need **OH⁻** or a **halogen ion**. When amphiboles were found on the Moon, some thought this indicated the presence of water. But it turned out they were fluorine amphiboles! *On earth if the environment is dry amphiboles will not form.* Their presence tells us that volatiles existed in their environment. If volatiles do not exist, pyroxenes will form instead of amphiboles. Because on earth the amphiboles have **OH⁻** ions, they are called “hydrous” i.e., “watery” minerals



Amphibole cleavage (looking down the c-axis)





The amphibole quadrangle similar to the pyroxene quadrangle.



Tremolite ($\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$)

Named after the Tremola Valley in southern Switzerland

Crystal system: monoclinic

Cleavage: [110] perfect, [010] distinct

Colour: colourless, grayish white, grey, brown, light green

Average density: 3.05

Hardness: 5-6

Streak: white

Luster: vitreous-pearly

Fracture: splintery





Ferroactinolite ($\text{Ca}_2\text{Fe}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$)

The name is derived from the ferrous iron in its composition and from its similarity to actinolite

Crystal system: monoclinic

Cleavage: [110] perfect, [100] parting

Colour: dark green

Average density: 3.24-3.48

Hardness: 5-6

Streak: white

Luster: vitreous

Fracture: brittle, may be fibrous



Anthophyllite from
Altemark, Mo i Rana,
Norway

Anthophyllite $\text{Mg}_7\text{Si}_8\text{O}_{22}(\text{OH})_2$

Named after the latin word for clove,
anthophyllum, on account of its clove-brown
colour

Crystal system: orthorhombic

Cleavage: [210] perfect

Colour: Grey, green and brown

Average density: 3.21

Hardness: 5.5-6

Streak: grey

Luster: vitreous-pearly

Fracture: conchoidal



© Dakota Matrix

Cummingtonite, Kola Peninsula, northwest Russia

Cummingtonite $((\text{Mg}, \text{Fe})_7\text{Si}_8\text{O}_{22}(\text{OH})_2)$

The name is derived from its type locality in Cummington, Hampshire County, Massachusetts, USA

Crystal system: monoclinic

Cleavage: $[110]$ perfect, $[???$ distinct

Colour: white, blackish brown, blackish green, grey

Average density: 3.35

Hardness: 5-6

Streak: greyish white

Luster: vitreous-silky

Fracture: brittle, conchoidal



Grunerite from Dickinson County,
Michigan, USA



Grunerite from Ontario, Canada

Grunerite ($\text{Fe}^{2+}_7\text{Si}_8\text{O}_{22}(\text{OH})_2$)

Named by Kenngtt in 1853 after Louis Emmanuel Gruner (1809-1883), French chemist, who undertook its chemical analysis

Crystal system: monoclinic

Cleavage: [110] perfect, [??] distinct

Colour: greey, brownish grey, dark grey

Average density: 3.45

Hardness: 5-6

Streak: white

Luster: vitreous-silky

Fracture: brittle, may be fibrous



Glaucophane from Ile de
Groix, France

Glaucophane is typical of
blueschist terrains.

Glaucophane



Named after the Greek glaukos (=Blue) and phanos (=appearing); that is why it is also referred to as a “blue amphibole”

Crystal system: monoclinic

Cleavage: [110] perfect, [001] good

Colour: grey, bluish black, lavender or azure blue

Average density: 3.07

Hardness: 6-6.5

Streak: light to white blue, greyish blue

Luster: vitreous-pearly

Fracture: brittle, conchoidal



Riebeckite needles, Golden Horn batholith, Okanogan Co., Washington State, USA



Fibrous riebeckite from the Pomfret Mine, Vryburg, South Africa

Riebeckite



Named after the German traveler Emil Riebeck (1853-1885)

Crystal system: monoclinic

Cleavage: [110] perfect, [???] perfect

Colour: black, dark green, blue

Average density: 3.4

Hardness: 4

Streak: greenish brown

Luster: vitreous-silky

Fracture: brittle, uneven

Glaucophane and riebeckite form a *partial* solid solution series. The intermediate compositions are known as *crossite*.



Named after the United States Geological survey geologist Charles Whitman Cross (1854-1949) in 1894

Crystal system: monoclinic

Cleavage: [110] perfect, [010] good

Colour: grey, grey blue, blue

Average density: 3.16

Hardness: 6

Streak: white

Luster: vitreous

Fracture: brittle, uneven

The phyllosilicates

(from the Greek φύλλο {*füllö* =leaf) sheet silicates.

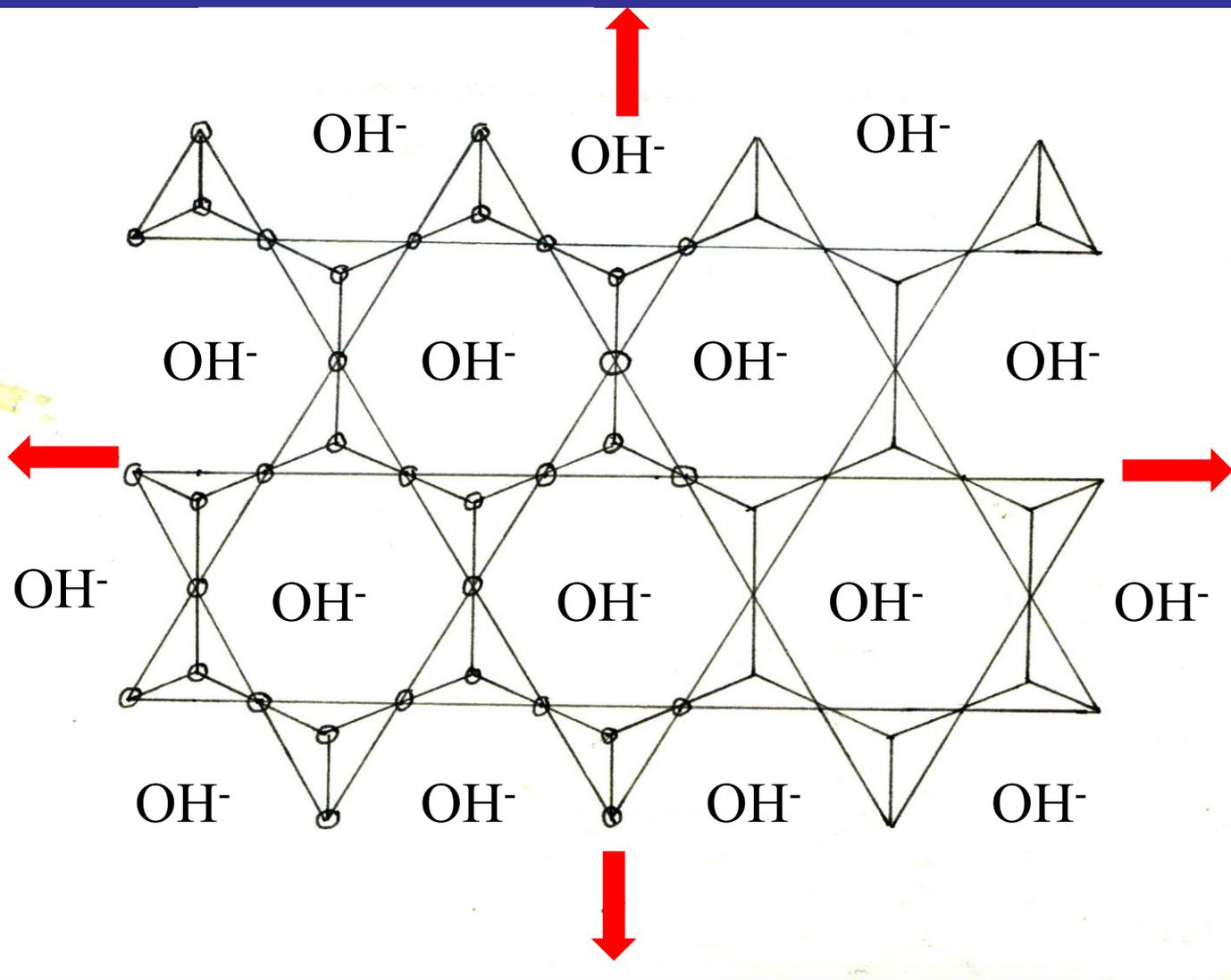
The “sheet” silicates are so called, because their structure consists of SiO_4 tetrahedra so connected as to form continuous sheets held together by cations that localise very well-defined cleavage planes .

Let us look at the electrical charges on a chain of SiO_4 tetrahedra:

The charge of the Si ion is +4, and the O ion is -2, so, in a single chain of silicate tetrahedra:

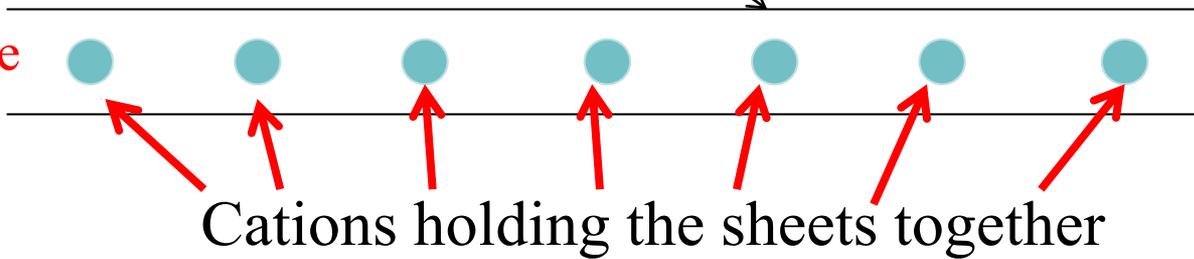


This combination has an excess of -12 charges, which means that this unit cannot stay isolated. A +12 charge has to be added to neutralise it. By the addition of cations to do so, we generate the *phyllosilicates*. The most important phyllosilicates are the *micas* and the *clay minerals*, closely followed by the *serpentine minerals*.



Looking at a sheet of silicon tetrahedra from above. Notice that they too need OH^- ions to be stable. So they too are “hydrous”, i.e., “watery”. But they can also have F^- and Cl^- ions

Sheet of silica tetrahedra



These bonds are weaker than the Si-O bonds within the tetrahedral sheet. Because of that the layer of cations holding the sheets together are weak zones forming a perfect cleavage.

Now let us look at the sheets from the side

Micas

Micas are among the most important rock-building minerals. The name mica comes from the Latin word *mica* meaning a crumb. Some think that the name may have also been influenced by the Latin word *micare*, i.e., to glitter, because mica flakes glitter.

The most common micas are muscovite (K-mica) and biotite (Mg-Fe-mica), followed by phlogopite (K-Mg-mica) and lepidolite (Li-mica). Zinnwaldite (K-Li-Fe-mica) is also considered among the common micas, but it is not as common as the others and occurs mainly in zones of continental melting.



Biotite



Biotite was named in 1847 after the French physicist Jean-Baptiste Biot (1774-1862), because he studied the optical properties of micas

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: dark brown, greenish brown, blackish brown, yellow, white

Average density: 3.09

Hardness: 2.5-3

Streak: grey

Luster: vitreous-pearly

Fracture: uneven

Biotite single crystal
from Otter Lake,
Quebec, Canada
(photo by Michael P.
Klimetz)

Biotite is also known as
“stone of life”



Biotite sheets
Clara May mine, Cheffee County, Colorado, USA



Muscovite from Mitchell
County, North Carolina,
USA

Muscovite



Named after Muscovy-glass. The name appears first in the letters by George Turberville, secretary of the English ambassador to Russia in 1568.

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: white, grey, silver white, brownish white, greenish white

Average density: 2.82

Hardness: 2-2.5

Streak: white

Luster: vitreous

Fracture: brittle-sectile



Muscovite showing the flexibility of its sheets. This is an important property of all micas.



Phlogopite from the
Vesuvius volcano,
Naples, Italy (copyright
by Enrico Bonacina)

Phlogopite



It was named by the German mineralogist Johann Friedrich August Breithaupt in 1841 after the Greek word φλογωποζ (flogopoz) meaning “resembling fire”.

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: brown, grey, green, yellow, reddish brown

Average density: 2.8

Hardness: 2-2.5

Streak: white

Luster: vitreous-pearly

Fracture: uneven



Phlogopite-bearing peridotite from Finero, Italy



Phlogopite sheets

Phlogopite is usually found in ultramafic rocks as a product of metasomatic alteration. As a primary igneous mineral it occurs in lamprophyres. Phlogopite is considered a common trace mineral in the upper mantle.



Pink lepidolite from the mineral region Minas Gerais in Brazil.

The element rubidium (Rb) was discovered in 1861 in Lepidolite

Lepidolite



Originally named “lilalite”, but later the name was changed to lepidolite deriving from two Greek words λεπίδιον (lepidion) meaning scale and λίθος (lithos) meaning stone. So it means “scaly stone”)

Crystal system: monoclinic

Cleavage: [001] perfect

Colour: colourless, grey white, lilac, yellowish, white

Average density: 2.84

Hardness: 2.5-3

Streak: white

Luster: vitreous-pearly, resinous, greasy

Fracture: uneven

Clay minerals

Clay minerals are among the most important rock-building minerals in sedimentary rocks and they have been important for human beings in various rôles ranging from industrial to medicinal uses. From the earliest times they were used to make pottery, ceramics (used not only in making tableware such as plates and cups but also in electrical industry as insulators and in space industry as heat shields; for example the Space Shuttle is covered with ceramics to insulate it against high temperatures developing upon entry into the earth's atmosphere), moulds and weapons, also medication (soothing upset stomachs).

Clay minerals constitute some 60% of all the mudrocks, which themselves constitute nearly 80% of all the sedimentary rocks in the world. That means of all the sedimentary rocks some 48%, i.e., nearly one half, consists of clays!



A potter using clay to make pottery in Bangalore, India



Various industrial
products made from
clays



Comparison of average shale, andesite and arc basalt (from Pacaya Volcano, Guatemala) as weight %

	Shale	Andesite	Arc basalt
SiO ₂	58.10	57.6	51.5
Al ₂ O ₃	15.40	17.3	17.1
Fe ₂ O ₃	4.02	3.1	n.d
FeO	2.45	4.3	8.13
MgO	2.44	3.6	7.0
CaO	3.11	7.2	9.3
Na ₂ O	1.30	3.2	4.3
K ₂ O	3.24	1.5	0.8

The above comparisons show that the shales (most mudrocks form in the sea are shales) are slightly more silicic than andesites.

Clay minerals are so abundant and so variable that they are best studied in subgroups. The clay subgroups are the following:

Illites: Illite and glauconite. Illite is the most common mineral in sedimentary rocks and soils.

Kaolinites: Kaolinite, dickite, halloysite and nacrite

Smectites: Montmorillonite, vermiculite, pyrophyllite, talc, natronite, beidellite, saponite

Chlorites: Chamosite, Pennanite, Clinochlore, Nimitite

Sepiolite (Meerschaum)

Illites

Illite



Named in 1937 after the US State of Illinois from where it was first described in the Makota Shale, Calhoun County, by Ralph E. Grim, R. H. Bray, and W. F. Bradley.

Illite is basically a hydrated microscopic muscovite.

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: white

Average density: 2.75

Hardness: 1-2

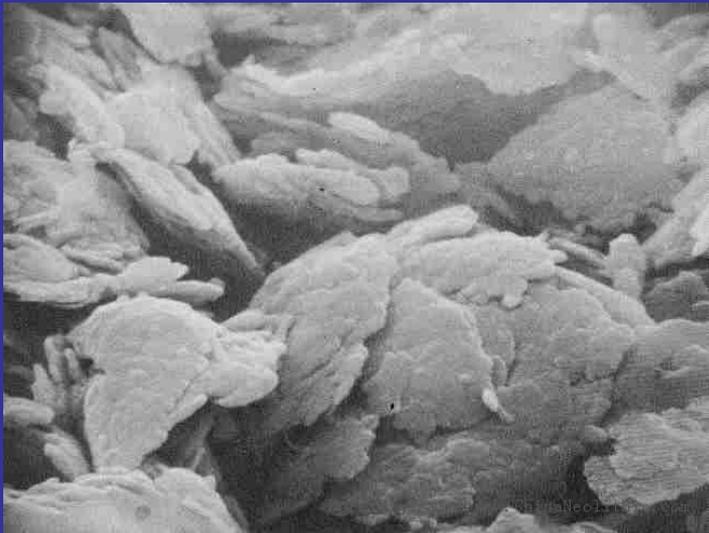
Streak: white

Luster: earthy (dull)

Fracture: none (crumbly)



Rock made up of illite



Illite flakes under electron microscope



© Dakota Matrix

Glauconite from the Wharf Mine, Lead, Lawrence County, South Dakota, USA (copyright Dakota Matrix)

Glauconite



Glauconite was first named in 1828 by the German geologist Christian Keferstein after the Greek word γλαυκος (glaukos) meaning “blue”.

Glauconite is essentially a Na-illite

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: blue-green, green, yellow green

Average density: 2.67

Hardness: 2

Streak: light green

Luster: earthy (dull)

Fracture: none (crumbly)

Glauconite forms in sediments under reducing conditions



Glauconitic sands: New Jersey, USA

Kaolinites

Kaolinite



The name comes from the Chinese *Gaoling*, meaning “high ridge” in Chinese. It is the name of a village in the Jianxi Province, PRC. The name came to Europe via François Xavier d'Entrecolles, the famous French porcelain manufacturer in the 17th and 18th centuries,

Kaolinite flakes growing on a quartz surface under scanning electron microscope



Kaolinite masses

Crystal system: triclinic-pedial

Cleavage: [001] perfect

Colour: white, greyish white, brownish white, yellowish white, greyish green

Average density: 2.60

Hardness: 1.5-2

Streak: white

Luster: earthy (dull)

Fracture: none (crumbly)

Smectites



Pink, chalky, massive
montmorillonite.

Tamminen Quarry,
Greenwood, Oxford
County, Maine, USA.

Montmorillonite



The name was proposed by Damour and Salvétat
in 1847 after Montmorillon in France.

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: white, grey-white, yellow, brownish
yellow

Average density: 2.35

Hardness: 1.5-2

Streak: white

Luster: earthy (dull)

Fracture: none (crumbly)

For an excellent, detailed study of the montmorillonite minerals, see Ross, C. S. and Hendricks, S. B., 1945, *Minerals of the Montmorillonite Group—Their Origin and Relation to soils and Clays*: United States Geological Survey Professional paper 205-B, pp. 23-79

Montmorillonite expands when water is added to it. Some samples can expand up to 9 times their original size.

That is why it is used as a desiccant to absorb water from its surroundings. For this reason, it is employed in building levees and dams to prevent flooding.

It is added to soils to keep them moist in arid regions.

Montmorillonite is also used in drilling mud by the industries using drilling (hydrocarbon industry, mining industries, water providers etc.). They also can form micelles and as such find many uses such as cleaning oil spills.

It is added to some pet foods and even to some chocolate bars because it is supposed to absorb certain toxins and because it expands and keeps the eater full!



Vermiculite



The name comes from the Latin *vermiculus* meaning “little worm”. First described in 1824 from Massachusetts, USA, by Thomas H. Webb. It is called vermiculite because when heated it exfoliates and creates worm-like curls.

Vermiculite forms by the hydrous alteration of biotite or phlogopite

Micaceous vermiculite
Brinton's Quarry, near
West Chester, Chester
County, Pennsylvania,
USA

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: colourless, green, grey-white, yellow-brown

Average density: 2.5

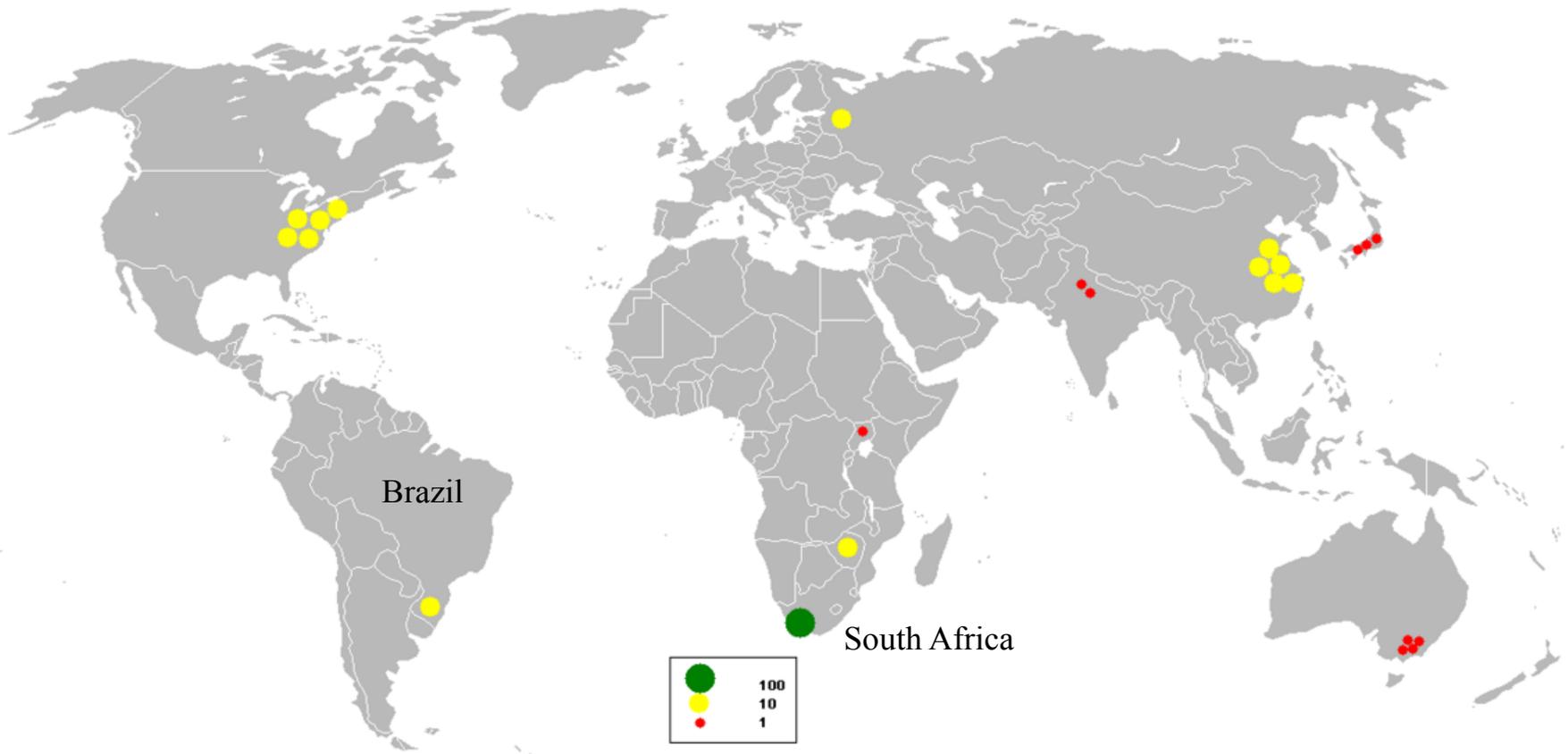
Hardness: 1.5-2

Streak: greenish white

Luster: vitreous (dull)

Fracture: uneven

Vermiculite has a huge range of commercial uses (e.g. from soil conditioners through fungi substrate to hand warmers) and, accordingly, mined widely.



This map shows the main vermiculite producers in the world as percentage of the present top producer (South Africa: 209,801 tonnes) in 2006. Currently South Africa's output is decreasing, while Brazil's increasing.

Pyrophyllite



The name was given to this mineral by R. Hermann in 1829. It comes from the Greek words πῦρ (*pür*=fire) φύλλο (*füllo* =leaf).

Pyrophyllite is an alteration product of kyanite and also occurs as a hydrothermal mineral

Crystal system: triclinic-pinacoidal

Cleavage: [001] perfect

Colour: brown green, brownish yellow, greenish, grey-gren, grey-white

Average density: 2.84

Hardness: 1.5-2

Streak: greenish white

Luster: pearly

Fracture: flexible



Pyrophyllite from Tres Cerritos,
Mariposa County, California,



Pyrophyllite from Zermatt,
Switzerland



Talc from the old talc
mine near Pilottown,
Maryland, USA

Talc



Named, from the Persian word *tâlk*, supposedly by the German miner and physician Georgius Agricola in 1546. But the word was already in use in Medieval French.

Crystal system: monoclinic-prismatic

Cleavage: [001] perfect

Colour: pale green, white, grey-white, yellowish white, brownish white

Average density: 2.75

Hardness: 1

Streak: white

Luster: vitreous-pearly

Fracture: uneven

Making talc from serpentinites (hydrated ultramafic rocks)

serpentine + carbon dioxide → talc + magnesite + water



Making talc as a contact metamorphic product in dolomites

dolomite + silica + water → talc + calcite + carbon dioxide



Making talc in high pressure environments

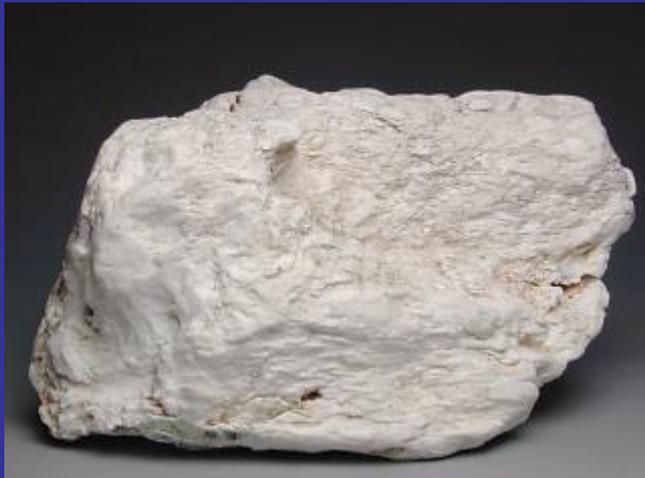
chlorite + quartz → kyanite + talc + water

Sepiolite

Sepiolite is known as meerschaum (from the German words *Meer*= sea and *Schaum*=foam) in the market. It occurs most abundantly in Turkey, near Eskişehir, as an alteration product of the ultramafic rocks along the İzmir-Ankara suture zone. In Turkey it is known as *lületaşı*, *lüle* meaning spout, but also pipe, tube, bowl of tobacco pipe and *taş* meaning stone.



Sepiolite from
Sepetçi, Eskişehir,
Turkey



Sepiolite from Pinos Altos,
Grant County, New
Mexico, USA

Sepiolite

($Mg_4Si_6O_{15} \cdot 6(H_2O)$)

Originally named as meerschaum by the great German mineralogist Abraham Gottlob Werner in 1788, it was renamed as sepiolite by Ernst Friedrich Glocker in 1847. The name comes from the Greek σήπιον (*sepion*=cuttlebone) and λίθος (*lithos*=rock).

Crystal system: orthorhombic-dipyramidal

Cleavage: [???] perfect

Colour: white, greyish white, bluish green white, yellowish white, reddish white.

Average density: 2

Hardness: 2

Streak: white

Luster: earthy (dull)

Fracture: conchoidal



Cuttlebone

Serpentinite minerals

Serpentine is a rock that forms by the low-temperature metamorphism, involving hydration, of ultramafic rocks that originate in the earth's mantle or in layered intrusions in the earth's crust. That is why serpentinites are found mostly in ophiolites , i.e., remnants of oceanic crust and mantle, and in layered intrusions such as Skaergaak in Greenland, Stillwater in Montana, USA, Bushveld in South Africa and Rum in Scotland. Serpentine can also form in skarns where the host rock is dolomite to provide magnesium.

There are three main serpentine minerals (among other less important ones):

Chrysotile, lizardite and antigorite.



Chrysotile



The name was given by the German mineralogist Franz von Kobell in 1843. It comes from the Greek words *Χρυσός* (*khrisos*=gold) and *τίλλειν* (*tillein*=plucking from the ground).

Crystal system: monoclinic-prismatic

Colour: green, whitish green

Average density: 2.53

Hardness: 2.5

Streak: white

Luster: silky

Fracture:

Serpentine, in which the dominant mineral is the fibrous chrysotile from the Sayan Mountains in Central Asia.



Chrysotile Fibers, Mine Lac d'Amiante, Canada



Thetford Mines



Chrysotile fibers from the Thetford Mines, Québec,
Canada



Lizardite crystals from
the Alps

Lizardite



Lizardite was named after the Lizard Peninsula in Cornwall, southwestern England by Eric James, William Whittaker and Jack Zussman in 1955.

Crystal system: triclinic-pinacoidal

Cleavage: [001] perfect

Colour: green, green-blue, yellow, white

Average density: 2.57

Hardness: 2.5

Streak: white



Antigorite from the
Penn-Md Quarry,
Pennsylvania, USA.

Antigorite



Named in 1840 by Matthias Eduard Schweizer for the type locality, Anitgorio Valley, Italian Alps.

Crystal system: monoclinic-domatic

Cleavage: [001], good

Colour: green, grey, bluish grey, brown, black

Average density: 2.54

Hardness: 3.5-4

Streak: greenish white

Luster: vitreous-greasy

Fracture: brittle

APPENDIX: I

Dangers of tremolite asbestos for our health:

From: <http://www.scn.org/~bh162/asbestos2.html>

WHAT IS TREMOLITE ASBESTOS, AND WHY IS IT SO DEADLY?

"Asbestos" is a vernacular name given to a group of naturally occurring amphibole and serpentine minerals. Asbestos is more common in areas where mountain building has occurred. Normally, the minerals are locked up in the earth's crust, and in that form they are harmless to human health, but when asbestos dust is released into the earth's atmosphere by mining or refining operations, it becomes extremely deadly.

There are six minerals that are called "asbestos" and all of them are dangerous when they are in the form of dust particles (particularly dust particles larger than 5 microns in length, and with a length to width ratio of 5:1). In comparison, the grain size of talcum powder is a whopping 30-40 microns in diameter. Different asbestos minerals cause slightly different diseases when inhaled. Tremolite dust is thought to be the most deadly.

The six asbestos minerals are:

- Actinolite
- Amosite
- Anthophyllite
- Crocidolite
- Chrysotile
- Tremolite

How does tremolite asbestos make me sick?

All asbestos minerals are elongated crystals. Some varieties (such as actinolite/tremolite) are needle-like. When dust-size particles are inhaled, the crystals penetrate into the lung tissue by piercing the walls of the alveoli. Once the particles penetrate the lung tissue, they stay in the lungs permanently. There is no way to remove them. Eventually these crystals will cause a scarring of the lungs, called asbestosis, or cause a cancer of the lining (pleura) of the lung, called mesothelioma. Both of these diseases are currently incurable and both are terminal. Mesothelioma is almost exclusively linked to exposure to asbestos dust. In mesothelioma victims, the pleura of the lung becomes thick and leathery, and it loses its elasticity. Death from mesothelioma usually occurs as a progressive suffocation caused by fluid build-up around the lungs. Victims suffering from severe asbestosis have symptoms generally similar to the symptoms of terminal emphysema. Many researchers now believe that in past decades, some asbestosis cases were mis-diagnosed as emphysema. The effects of exposure to tremolite asbestos has not been studied as thoroughly as with other asbestos minerals, but very preliminary research suggests that autoimmune diseases such as psoriasis, lupus, and arthritis sometimes precede the onset of symptoms of tremolite asbestosis and tremolite-induced mesothelioma cancer. Only time will tell if these diseases are warning signs for later tremolite asbestos disease.

As far as funding for medical research is concerned, mesothelioma is considered to be an "orphan disease", meaning that there are so few victims (when compared to other cancers) that the *profitability* of finding drugs or procedures to treat the disease is low. Therefore, except for a couple studies supported by Federal grants, very little privately funded medical research is currently being done to find treatments for mesothelioma cancer.

Symptoms of exposure to tremolite asbestos dust can show up anytime from a couple years up to 40 years after first exposure. *No* "safe" exposure threshold for **any** of the asbestos minerals has been established by the U.S. Environmental Protection Agency. All legislative efforts to place effective safety regulations or bans on asbestos in consumer products have failed, and an EPA ban was overturned by an appeals court in 1991. The legislative efforts have failed due to lobbying efforts by mining and energy corporations. W. R. Grace, and another company, Halliburton Corp., are only two of many obstructionist corporations in this regard. Even Canada, which exports large amounts of chrysotile asbestos into the U. S., has lobbied the U.S. Congress for *no* regulations on asbestos.

Is there anything I can do to prevent the onset of disease?

In a word, no. Once the asbestos dust has imbedded itself in the lungs, there are no proven preventative measures. However, just because you inhaled tremolite dust in the past doesn't mean that you will *necessarily* develop symptoms. Chest X-rays will diagnose tremolite asbestosis disease long before symptoms are noticed by the patient. From anecdotal evidence, it appears that a *few* people develop symptoms later in life than do other people. This phenomenon may be related to the particular genetic disposition of the individual and it needs to be investigated further. In any case, the onset of asbestos-related disease might be delayed a *few* years by practicing healthy life habits.

The first thing to do is to **stop smoking**. Smoking damages lung tissue and it damages DNA. Eat a diet rich in antioxidants (green leafy vegetables and orange-colored vegetables). Additionally, people who suspect that they may have been exposed to tremolite asbestos dust should **get a flu shot** every fall (even if they currently have no symptoms of asbestos-related disease). They should also be **vaccinated for pneumonia**. One theory (currently unproven) is that repeated lung infections increase the likelihood of the development, or the acceleration, of asbestos-related disease much later in life.

In what consumer products is tremolite asbestos a contaminant?

In the Libby, Montana area, tremolite asbestos is associated with a hydrated mica ore mineral called vermiculite. Vermiculite (trade name Zonolite™) was mined and was sold in housing insulation and as a soil conditioner for gardens. Libby's Rainy Creek Mine provided at least 80% of the world's supply of vermiculite. If you have Zonolite™ vermiculite insulation in your house or in your garden, it probably came from the Libby mine. It has been shown that Libby's vermiculite insulation and potting soil that was sold to consumers contains tremolite asbestos as a contaminant. In recent years, some companies that sell potting soil have stopped using the term "vermiculite" on their label of contents. Some contents labeled as "wetting agents" are actually vermiculite.

How do I know if I have vermiculite on my property?

Vermiculite (Zonolite™) was sold mainly in the form of loose flakes. Look for the presence of shiney tan to golden-colored flakes in your insulation or in your garden soil and potting soil. The vermiculite often occurs as clumps of flakes, and it has the appearance of bellows on an accordion. Old weathered vermiculite resembles uncooked oatmeal flakes. Don't expect to see the asbestos. The tremolite dust that coats the vermiculite flakes is so fine that it is usually invisible to the unaided eye.

How can I safely remove the vermiculite from my house and property?

If you live in Libby, Montana, you're in luck. EPA will remove the vermiculite from your property for free.

But if you live in another part of the United States, then you will have to pay an EPA-qualified business to remove the vermiculite. And the cost of removal isn't cheap.

Warning: Do **not** attempt to remove the vermiculite yourself. The removal process can expose the worker to dangerous levels of microscopic tremolite asbestos dust. If done improperly, the removal can contaminate a larger area of your property than was originally contaminated. Only hazardous waste specialists that are trained in vermiculite removal or asbestos removal should decontaminate your property. A special dust-control protocol, a special protective suit, and a special breathing apparatus are needed to protect the worker (hardware store dust masks are ineffective).

References

1. Mortality in Libby, Montana (1979-1998). Agency for Toxic Substances and Disease Registry health consultation. U. S. Department of Health and Human Services. Publication date 2002. [Persons who would like to receive a copy should contact ATSDR epidemiologist Steve Dearwent, toll free, at 1-888-422-8737. Callers should refer to the "Libby, Montana site"].
2. Boettcher, A. L. 1963. Geology and Petrology of the Rainy Creek intrusive near Libby, Montana. Unpublished M. S. thesis, Pennsylvania State University. 70 pages.
3. Boettcher, A. L. 1966. The Rainy Creek igneous complex near Libby, Montana. Unpublished Ph.D. Dissertation, Pennsylvania State University. 155 pages.
4. Johns, W. M. 1970. Geology and Mineral Deposits of Lincoln and Flathead Counties, Montana. *Montana Bureau of Mines and Geology Bulletin 79*, 182 pages.
5. *Libby, Montana - Asbestos and the Deadly Silence of an American Corporation*. By Andrea Peacock. Johnson Books, Boulder, CO. 2003. ISBN 1-55566-319-2. [Buy it now.](#)
6. *An Air That Kills - how the asbestos poisoning of Libby, Montana uncovered a national scandal*. By Andrew Schneider and David McCumber. 2004. G. P. Putnam and Sons, New York. ISBN 0-399-15095. [Buy it now.](#)
[Listen to a radio interview with the authors of **An Air That Kills**](#)
7. *Pathology of Asbestos-Associated Diseases, 2nd Edition*, edited by Victor L. Roggli, Tim D. Oury, and Thomas A. Sporn. 2004. Springer Verlag. 424 pages. ISBN 0387200908. [Buy it now.](#)