**L14 Aluminosilicate.**

**Aluminosilicate** minerals are minerals composed of aluminium, silicon, and oxygen, plus countercations. They are a major component of kaolin and other clay minerals.

Andalusite, kyanite, and sillimanite are naturally occurring aluminosilicate minerals that have the composition $Al_2SiO_5$.[2][3][4] The triple point of the three polymorphs is located at a temperature of 500 °C and a pressure of 0.4 GPa. These three minerals are commonly used as index minerals in metamorphic rocks.

Hydrated aluminosilicate minerals are referred to as zeolites and are porous structures that are naturally occurring materials.

The catalyst silica-alumina is an amorphous substance which is not an aluminosilicate compound.

**Aluminium silicate** (or **aluminum silicate**) is a name commonly applied to chemical compounds which are derived from aluminium oxide, $Al_2O_3$ andsilicon dioxide, $SiO_2$ which may be anhydrous or hydrated, naturally occurring as minerals or synthetic. Their chemical formulae are often expressed as $xAl_2O_3.ySiO_2.zH_2O$ These include the compounds:-

- $Al_2SiO_5$, ($Al_2O_3.SiO_2$), which occurs naturally as the minerals andalusite,kyanite and sillimanite which have different crystal structures.
- $Al_2Si_2O_5(OH)_4$, ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$), which occurs naturally as the mineralkaolinite and is also called aluminium silicate dihydrate.[1] It is a fine white powder and is used as a filler in paper and rubber and also used in paints.[1]
- $Al_2Si_2O_7$, ($Al_2O_3.2SiO_2$), called metakaolinite, formed from kaolin by heating at 450 °C (842 °F).[1]
- $Al_6SiO_{13}$, ($3Al_2O_3.2SiO_2$), the mineral mullite, the only thermodynamically stable intermediate phase in the $Al_2O_3$-$SiO_2$ system at atmospheric pressure.[2] This also called '3:2 mullite' to distinguish it from $2Al_2O_3.SiO_2$, $Al_4SiO_8$ '2:1 mullite'.
- $2Al_2O_3.SiO_2$, $Al_4SiO_8$ '2:1 mullite'.[2]

Aluminium silicate composite materials, fibres[edit]

Aluminium silicate is a type of fibrous material made of aluminium oxide and silicon dioxide, (such materials are also called aluminosilicate fibres). These are glassy solid solutions rather than chemical compounds. The compositions are often described in terms of % weight of alumina, $Al_2O_3$ and silica, $SiO_2$. Temperature resistance increases as the % alumina increases. These fibrous materials can be encountered as loose wool, blanket, felt, paper or boards.[3]

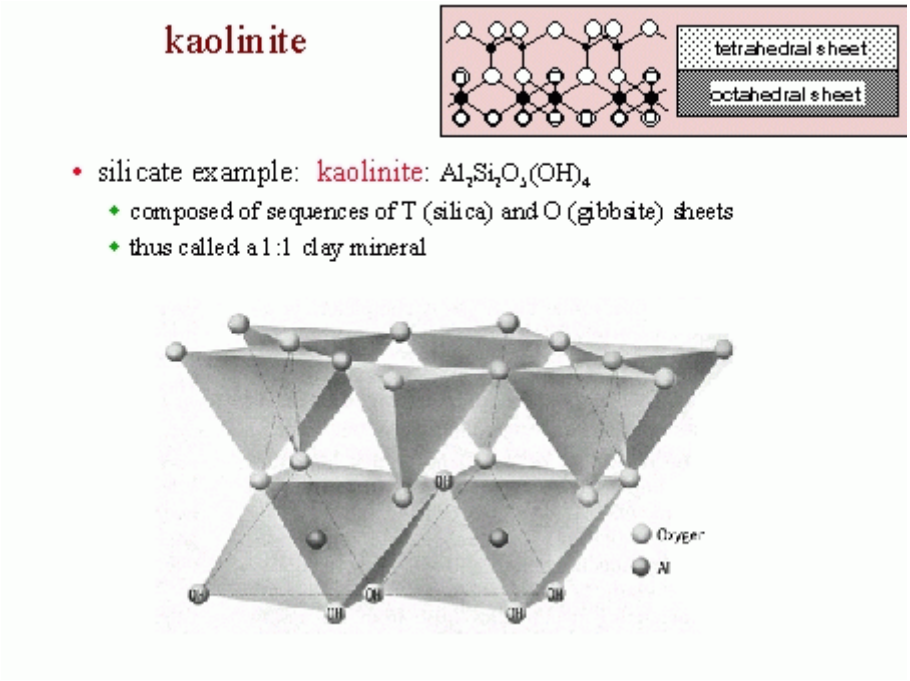
**Aluminum Silicates**

**Aluminum Silicates**

Alumina, $Al_2O_3$, and silica, $SiO_2$, are two most abundant minerals of the earth crust. The class of minerals containing aluminum oxide and silicon oxide is called aluminum silicates.

Many minerals contain aluminum and silicon oxides. For example, three minerals **andalusite, sillimanite**, and **kayanite** all have the same chemical composition of $Al_2O(SIO_4)$. Topaz is closely related in chemical composition, $Al_2O(SIO_4)(OH,F)_2$.

Beryl, $Be_3Al_2(Si_6O_{18}$, contains rings of $(SiO_3)_6$ type. It is usually found in cavities of granite. This mineral is also known as aquamarine, a precious stone. This is the main source of Be metal. A closely related mineral is cordierite, $Al_3(Mg, Fe)_2(SI_5AlO_{18})$.




Layer aluminum silicates such as kaolinite goup of minerals of $Al_4(Si_4O_{10})(OH)_8$ is resulted from weathering of feldspar group of minerals, (K, Na)($AlSi_3O_8$, or Ca($Al_2Si_2O_8$. The koalinite group is an important clay mineral. The picture shown here is the structure of kaolinite. Two layers are shown here, the bottom octahedral layer represent the oxygen atoms and the 6-coordinated Al atoms or ions. Some of these oxygen atoms are shared with 4-coordionated silicon on the top layer, each tetrahedron represent a $SiO_4$ group.

Zeolites are the most important group of aluminum silicates. About 40 natural zeolites are known and 150 zeolites have been synthesized.

Jadeite is often confused with nephrite. These are aluminum silicates.

**What are aluminosilicates?**

*Inorganic Chemistry* by Swaddle calls the group of minerals **aluminosilicate** when some of the $Si^{4+}$ ions in silicates are replaced by $Al^{3+}$ ions. For each $Si^{4+}$ ion replaced by an $Al^{3+}$, the charge

must be balanced by having other positive ions such as $Na^+$, $K^+$, and $Ca^{2+}$ ions. Feldspar group and zeolites are typical aluminosilicates by this definition.

For example, the following minerals belong to the feldspar group.

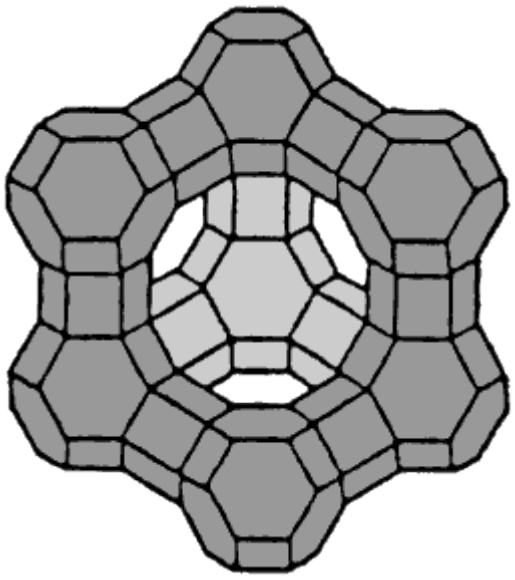
Sanidine, $[(K,Na)AlSi_3O_8]_4$
Orthoclase, $[(K, Na)AlSi_3O_8]_4$
Albite, $[NaAlSi_3O_8]_4$
Anorthite, $Ca[Al_2Si_2O_8]$

The alkali ions are held in place to balance the charges due to the presence of $Al^{3+}$ ions instead of $Si^{4+}$ ions. The $Al^{3+}$ ions seem replace $Si^{4+}$ ions in the chains of corner shared tetrahedra of $SiO_4$ groups.

However, the bonding between Al and Si can be different. Silicon atoms or ion tend to be bonded to 4 oxygen atoms in a tetrahedral fashion, but aluminum ions tend to be bonded to 6 oxygen atoms in an octahedral fashion.

**What are zeolites?**

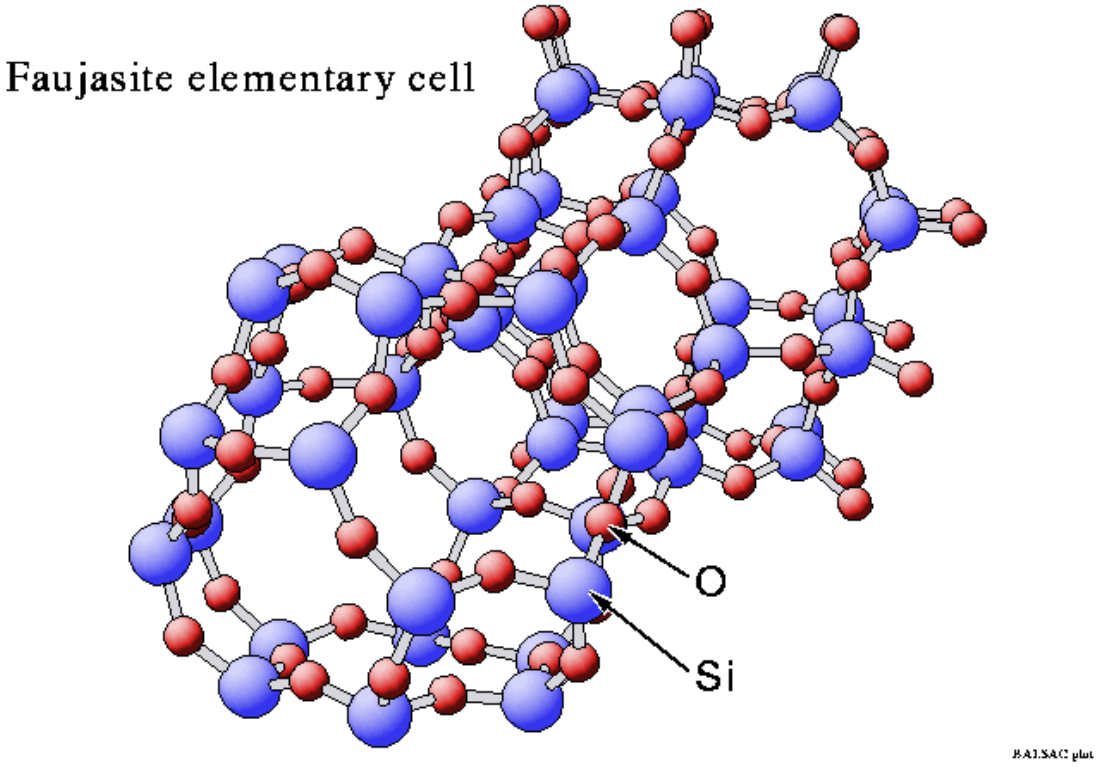
Zeolite is a class of hydrated aluminosilicates found in certain volcanic rocks. Once upon a time, geologists thought these minerals were interesting because they consist of large cage-like structures with open channelways. Today, these materials are highly valued for their applications.



Jaujasite is a representative zeolite. This link represented its structure using large polyhedra. All lines in the structure shown are oxygen bridges -O-, the oxygen atom is located not on the line but somewhere next to it. The angle -O- of the two bonds is about 110ш. Points where lines meet are the locations of $Si^{4+}$ that are surrounded tetrahedrally by four oxygen atoms. They can be substituted by $Al^{3+}$. As a result, the frame work is negatively charged. Thus, zeolites can trap positive ions: $H^+$, $Na^+$, $K^+$, $Ca^{2+}$, $Cu^{2+}$ or $Mg^{2+}$.

The name 'zeolite' is said to have its origin in the two Greek words *zeo* and *lithos* which mean 'to boil' and 'a stone'. The phenomena of melting and boiling at the same time is a novel property. The name 'zeolite' was first used by the Swedish mineralogist Cronstedt to describe stilbite, the first recognized mineral zeolite, which was discovered in 1756. Over 100 years later, the reversible desorption/adsorption of water in this mineral was recognized.

A Faujasite elementary cell is shown in ball-and-stick model below.




While you are admiring this beautiful picture of faujasite, remember that the oxygen atoms have two unshared electron pairs in addition to the (Al,Si)-O-Si(or Al) bonds. Thus the oxygen atoms are sites to interact with positive site of molecules that passes by these structures.

At present over 150 synthetic zeolites & zeotypes and 40 natural zeolites are known. Synthesis of zeolite is a very active field of study.

Aluminosilicates have three major minerals: **Andalusite, sillimanite**, and **kyanite**. Zeochem has been developing and manufacturing molecular sieve adsorbents since 1977. Simply put, their adsorbents are used to "screen" out impurities from a variety of applications by attracting and trapping the targeted contaminants. For example, in natural gas processing, Zeochem sieves are used to remove specific molecules from the gas stream to allow for more efficient downstream processing.

A rather large model of zeolite (faujasite) is brought to the class on Nov. 12. This is a typical zeolite, and spaces within the cage and channels through the structures cannot be appreciated without the model.

**What are some of the applications of zeolites?**

As you have read above that there are many different kinds of zeolites, each with a definite structure and associate with it are unique properties. In terms of applications, we are assuming zeolites as porous aluminosilicates with large tunnels and cages for a fluid (gas and liquid) to pass through. The applications are based on the interactions between the fluid phase and the atoms or ions of the zeolites. In general terms, zeolites have many applications:

1. As selective and strong adsorbers: remove toxic material, selective concentrate a particular chemical, as Molecular Sieve. This link will be avery good to discuss zeolites. Currently, the site is under construction, but it has a very good framework. Even many deorderants are zeolite type.
2. As selective ion exchangers: for example used in water softener.
3. Superb solid acid catalysts, when the cations are protons $H^+$. As catalysts, their environmental advantages include decreased corrosion, improved handling, decreased environmentally toxic waste and minimal undesirable byprducts.
4. As builder: a material that enhance or protecting the cleaning power of a detergent. Sodium aluminosilicate is an ion exchange builder often used in lundary detergent as a builder. A builder inactive the hardness of water by either keeping calcium ions in solution, by precipitation, or by ion exchange.

**References:**

**https://en.wikipedia.org/wiki/Aluminosilicate**

**https://en.wikipedia.org/wiki/Aluminium_silicate**

**http://www.science.uwaterloo.ca/~cchieh/cact/applychem/alsilicate.html**