AUSTRALIAN EARTH SCIENCE EDUCATION

Silicate Minerals Student Activity

Introduction

Silicate minerals make up most of the rocks of Earth's crust. The main building block of these minerals is the silica tetrahedron (SiO_4).

Felsic minerals are mostly silicates mixed with some other atoms, such as potassium. They melt at relatively low temperatures. The name comes from FEL for feldspar and SIC for silicate.

Mafic minerals are silicates that contain iron and magnesium, making them darker in colour and higher density. They melt at relatively high temperatures. The name comes from MA for magnesium and FIC from ferric, meaning iron.

Aim

To build the silica tetrahedron and model common mafic mineral structures.

Materials (per student)

- 4 Marshmallows
- 1 Smartie
- 2 Jubes
- 3 Toothpicks, cut in half (6 pieces)
- Scissors


Materials

Risk Assessment

- Don't eat anything that you handle in the science lab.
- Wash your hands after the activity.
- Take care cutting toothpicks in half. They may scatter far from the scissors.

Method

1. Construct a silicate tetrahedron model (SiO_4)

Use four marshmallows, six toothpick pieces and a smartie. The marshmallows represent oxygen atoms, the smartie is the silicon atom. The toothpicks hold your marshmallows together. They do NOT represent chemical bonds. The real chemical bonds go from the silicon atom to the oxygen atoms.


Figure 1: Place the toothpicks to connect your marshmallows


Figure 2: After connecting the first three 'oxygen' marshmallows, place the smartie 'silicon' in the centre


Figure 3: Place the final 'oxygen' marshmallow on top of the silicate tetrahedron

2. Construct a model of olivine $(Mg,Fe)_2SiO_4$

Olivine is a type of mafic mineral containing magnesium and/or iron. The silica in olivine is isolated and surrounded by metal atoms. Olivine minerals are common in peridotite, gabbro and basalt.

Construct your model by getting together with your classmates and arranging your silica with jubes (representing iron and/or magnesium) as show in Figure 5.

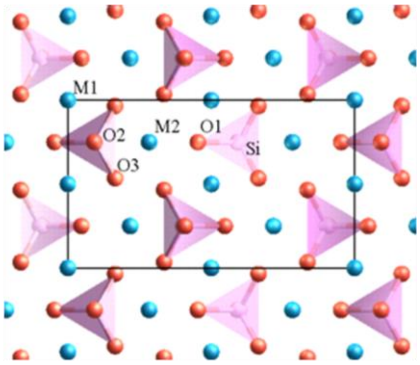


Figure 4: Diagram of the structure of olivine (Wikipedia, public domain)


Figure 5: The arrangement of silica (marshmallow tetrahedra) and metal (jubes) in olivine minerals

3. Construct a single chain of silica molecules and model a pyroxene mineral $(Mg, Fe, Ca)_2Si_2O_6$

Figure 6: Diagram of a silicate chain (Bubenik 2012, Wikimedia Creative Commons)

The pyroxene family of minerals is made of single chains of silica molecules (Figure 6) with metals such as calcium, magnesium or iron between them. Pyroxene minerals are common in peridotite, basalt and gabbro.

Start your chain with a whole silicate. Add another silicate by removing one 'oxygen' to connect. The completed chain should look like Figure 7.

Create a mineral model by placing 'metal' jubes between chains of silicates as shown in Figure 8.

Figure 7: A single chain silicate model

Figure 8: Pyroxene mineral model using a short (left) or long (right) silicate chain

4. **Create a double chain of silicates and model an amphibole mineral**

Amphibole minerals have double chains of silicates (Figure 9) with metals such as iron, magnesium and aluminium in the silicates. These minerals are commonly seen as the black specks in igneous rocks.

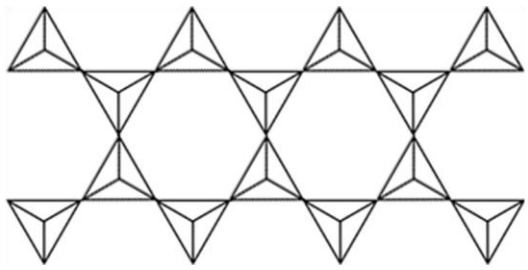


Figure 9: Diagram of a double silicate chain (Hungarian Wikipedia user F Halfdan, Wikimedia Creative Commons)

Move the jubes away from your single chains. Make a double chain by removing marshmallow 'oxygens' along one chain to connect the two chains together. These are marked with arrows in Figure 10.

Figure 10: Remove the marshmallows marked with arrows in order to connect the two chains.

Figure 11: Small model of double silicate chain

Now add some 'metal' jubes to complete the amphibole model (Figure 12).

Label the 'atoms' in Figure 12.

Figure 12: Model of an amphibole mineral

Questions

1. What element is decreased as silicates begin to connect to each other?__________________

2. Which of the structures you modelled had the highest metal:silicate ratio? _______________

3. Olivine, pyroxene and amphibole are types of mineral grouped by their silicate structure. Each type of mineral has many named minerals within it. Why is there so much variation? _______

   ____

4. Quartz is pure silicate with the tetrahedra arranged in a three-dimensional framework. Is quartz mafic or felsic? What general properties would it have because of this classification?_______

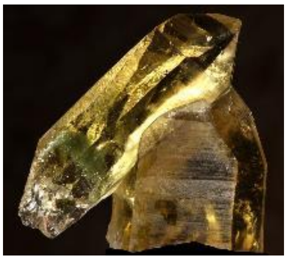
   ____

Fun fact: rose quartz, amethyst and citrine are all quartz with different amounts of iron substituted for silicon, creating the distinctive colour. Rose quartz also has trace amounts of titanium or manganese. Citrine has traces of iron and a yellow colour can be manufactured by heating amethyst.


Pure quartz


Rose quartz


Amethyst


Citrine

(quartz photos by J St John, Wikimedia Creative Commons; citrine by P Gery, public domain)

Extension

Mica is made of sheets of silicate tetrahedra. Connect two double chains to get an idea of how the silicate layers are structured.

Quartz and feldspar are felsic silicate minerals with silicates arranged in 3-dimensional frameworks. Try creating these with a molecular modelling kit. The marshmallow model is not strong enough.