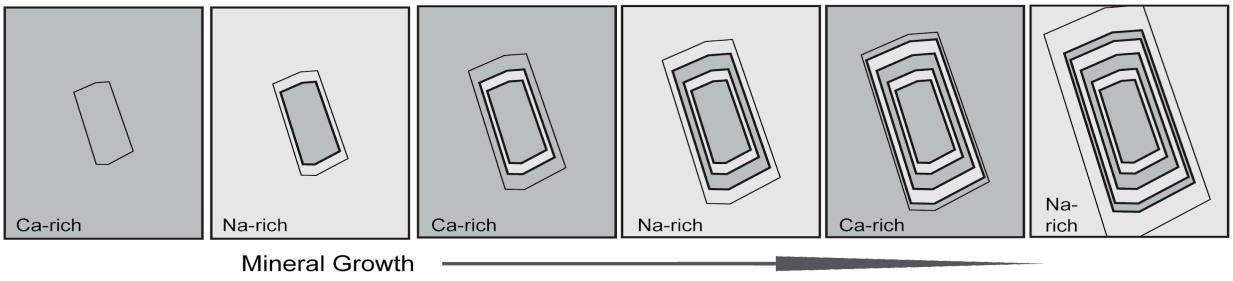
First some review of Mineral Variations:

Solid Solution Series

Some minerals allow for substitution of similar ions within their crystal structure. For instance, a solid solution exists between calcium (Ca) rich anorthite ($CaAl_2SI_2O_8$) and sodium (Na) rich albite ($NaAlSI_3O_8$). These are collectively known as the plagioclase solid solution series. Because Ca and Na are similar sized ions, the plagioclase structure can substitute one for the other.

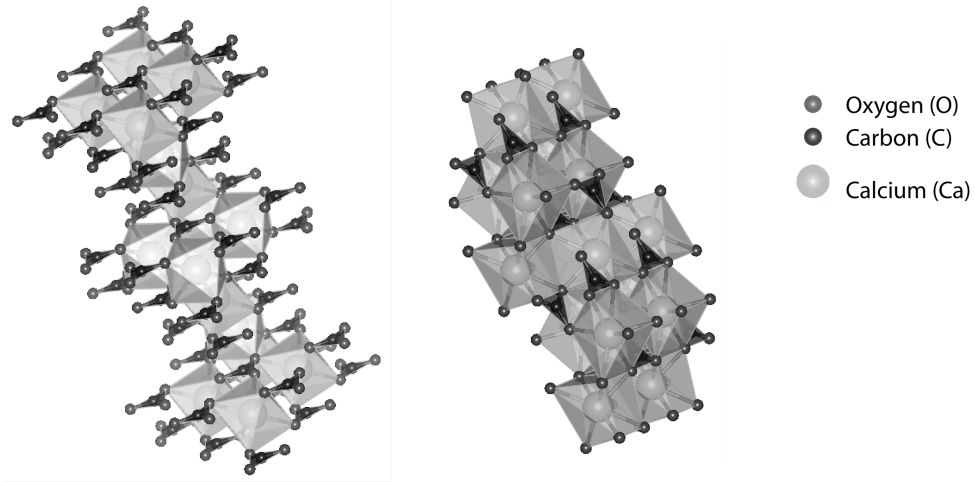
Compositional Zoning



Compositional (Oscillatory) Zoning

In minerals that have solid solution, an oscillatory (back and forth) zoning pattern may form during crystal growth. In the above example, the initial crystal growth uses up a lot of the surrounding Calcium ions, in turn making the surrounding melt more Na-rich. Consequently, a more Na-rich rim grows on the crystal and the system then oscillates back to Ca-rich, and so on.

Polymorph



Calcite
$Ca(CO_3)$

Aragonite
$Ca(CO_3)$

Polymorphs are two individual minerals with the same chemical composition, but formed with different crystal structures. In the above models, shapes (polyhedral) are drawn around certain atoms to make the repeated patterns more visible.

Now, test your knowledge:

Briefly define the following terms:

solid solution -

compositional zoning -

polymorph -

Answer the following:

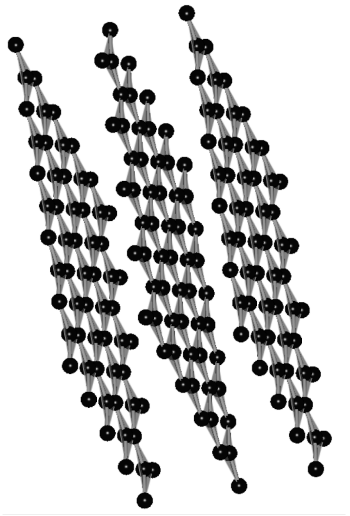
1. In the mineral olivine, the compositional end-members are:

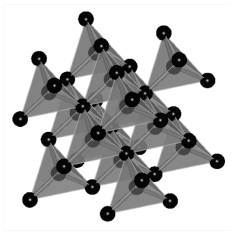
   forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4).

   These two minerals are an example of _____.
   A. Compositional Twins
   B. Polymorphs
   C. Solid Solution Series
   D. Mica Groups
   E. Silicate Structures

2. In the olivine example (previous question), what elements are being substituted in the atomic structure?
   A. Si, O
   B. Fe, O
   C. Mg, Fe
   D. Fe, Si
   E. Mg, Si

2. At higher temperatures, the plagioclase structure is more accommodating of large calcium ions. Therefore, as a magma (liquid rock) cools, which end-member of the plagioclase series do you suppose will crystallize firstly?
   A. Albite (Na-plag)
   B. Anorthite (Ca-plag)
   C. Plagioclase
   D. Forsterite
   E. Fayalite





Graphite
C

Diamond
C

3. In the above example, the two minerals graphite and diamond are an example of _____>
    A. Compositional Twins
    B. Polymorphs
    C. Solid Solution Series
    D. Mica Groups
    E. Silicate Structures

4. Which mineral do you suppose is more stable at higher pressure conditions? (Hint: decide which atomic structure represents the closest packed arrangement of individual atoms.)
    A. Graphite
    B. Diamond

5. The atomic structure of graphite is made of individual sheets of carbon rings. What type of bond is holding the individual sheets together?
    A. Ionic
    B. Covalent
    C. Metallic
    D. Weak Electric Force

Now, think deeper:

On your own:

6. In chemistry, we're often interested in liquid solutions.
    a. What do *liquid solutions* and *solid solutions* have in common?

    b. What makes *liquid solutions* unique from *solid solutions*?

7. Is a mineral with compositional zoning likely to have unique crystal structures amongst the alternating mineral zones? Why or why not?

Working in groups of 2 or 3 answer the following:

8. Compare your answers to questions 6. Write down interpretations that were unique from your own.

9. Compare your answers to questions 7. Write down interpretations that were unique from your own.

10. Decide as a group; what are the primary physical (environmental) factors that lead to the formation of different polymorphs.