Chemographic Diagrams

Most common natural rocks contain the major elements: SiO$_2$, Al$_2$O$_3$, K$_2$O, CaO, Na$_2$O, FeO, MgO, MnO and H$_2$O such that C = 9.

Three components is the maximum number that we can easily deal with in two dimensions.

What is the “right” choice of components?

We turn to the following simplifying methods:

1. Simply “ignore” some components
   - Trace elements
   - Elements that enter only a single phase (we can drop both the component and the phase without violating the phase rule)
   - Perfectly mobile components

2. Combine components
   - Components that substitute for one another in a solid solution: (Fe + Mg)

3. Limit the types of rocks to be shown
   - Only deal with a sub-set of rock types for which a simplified system works

4. Use projections

The ACF Diagram

Illustrate metamorphic mineral assemblages in mafic rocks on a simplified 3-C triangular diagram.

Concentrate only on the minerals that appeared or disappeared during metamorphism, thus acting as indicators of metamorphic grade.

Rules

More Rules

2. Combine components
   - Components that substitute for one another in a solid solution: (Fe + Mg)

3. Limit the types of rocks to be shown
   - Only deal with a sub-set of rock types for which a simplified system works

4. Use projections

The ACF Diagram
The ACF Diagram

- The three pseudo-components are all calculated on an atomic basis:
  \[ A = \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 - \text{Na}_2\text{O} - \text{K}_2\text{O} \]
  \[ C = \text{CaO} - 3.3 \text{P}_2\text{O}_5 \]
  \[ F = \text{FeO} + \text{MgO} + \text{MnO} \]

Why the subtraction?

- Na and K in the average mafic rock are typically combined with Al to produce Kfs and Albite
- In the ACF diagram, we are interested only in the other K-bearing metamorphic minerals, and thus only in the amount of Al\(_2\text{O}_3\) that occurs in excess of that combined with Na\(_2\text{O}\) and K\(_2\text{O}\) (in albite and K-feldspar)
- Since the ratio of Al\(_2\text{O}_3\) to Na\(_2\text{O}\) or K\(_2\text{O}\) in feldspars is 1:1, we subtract from Al\(_2\text{O}_3\) an amount equivalent to Na\(_2\text{O}\) and K\(_2\text{O}\) in the same 1:1 ratio

The ACF Diagram

\[ A = \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 - \text{Na}_2\text{O} - \text{K}_2\text{O} \]

- Water is omitted under the assumption that it is perfectly mobile
- Note that Si\(_2\text{O}_3\) is simply ignored
  - This is equivalent to projecting from quartz
- In order for a projected phase diagram to be truly valid, the phase from which it is projected must be present in the mineral assemblages represented

The ACF Diagram

An example:

- Anorthite CaAl\(_2\text{Si}_2\text{O}_8\)
- \[ A = 1 + 0 - 0 - 0 = 1, \quad C = 1 - 0 = 1, \quad F = 0 \]
- Provisional values sum to 2, so we can normalize to 1.0 by multiplying each value by \(\frac{1}{2}\), resulting in
  \[ A = 0.5 \]
  \[ C = 0.5 \]
  \[ F = 0 \]
A typical ACF compatibility diagram, referring to a specific range of P and T (the kyanite zone in the Scottish Highlands)

The AKF Diagram
Because pelitic sediments are high in AlO₃ and K₂O, and low in CaO, Eskola proposed a different diagram that included K₂O to depict the mineral assemblages that develop in them.

- In the AKF diagram, the pseudo-components are:
  \[ A = \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 - \text{Na}_2\text{O} - \text{K}_2\text{O} - \text{CaO} \]
  \[ K = \text{K}_2\text{O} \]
  \[ F = \text{FeO} + \text{MgO} + \text{MnO} \]

Notice that three of the most common minerals in metapelites andalusite, muscovite, and microcline, all plot as distinct points in the AKF diagram:

- Andalusite and muscovite plot as the same point in the ACF diagram, and microcline wouldn’t plot at all, making the ACF diagram much less useful for pelitic rocks that are rich in K and Al.
Expanded Grt-St-Chl-Bt quadrilateral.  
a. At the isograd tie-line flip. Composition Y loses Grt and gains St.  
b. As reaction proceeds, Fe-rich chlorite breaks down and the Chl-Grt-Bt triangle shifts to the right. 
c. Further shift of the Chl-Grt-Bt triangle. Rocks of composition Y lose chlorite at this grade, and staurolite develops in rocks of composition Z.  