Chemographic Diagrams

Reading:
Winter, Chapter 24

Chemographic Diagrams

- Most common natural rocks contain the major elements: SiO_2, Al_2O_3, K_2O, CaO, Na_2O, FeO, MgO, MnO and H_2O 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:

Rules

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

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

- 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

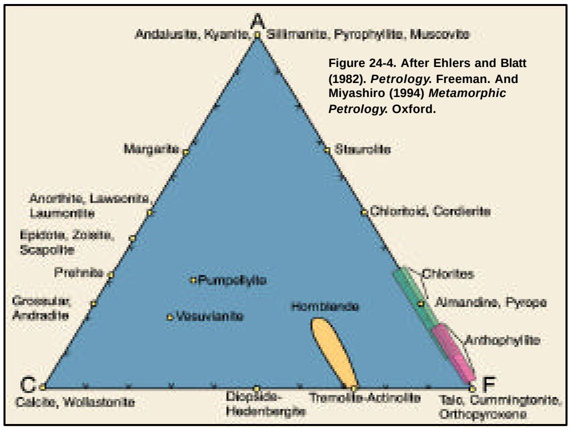


Figure 24-4. After Ehlers and Blatt (1982). *Petrology.* Freeman. And Miyashiro (1994) *Metamorphic Petrology.* Oxford.

The ACF Diagram

- The three pseudo-components are all calculated on an atomic basis:
  - $A = Al_2O_3 + Fe_2O_3 - Na_2O - K_2O$
  - $C = CaO - 3.3\ P_2O_5$
  - $F = FeO + MgO + MnO$

The ACF Diagram

$A = Al_2O_3 + Fe_2O_3 - Na_2O - K_2O$ 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_2O_3 that occurs in excess of that combined with Na_2O and K_2O (in albite and K-feldspar)
- Since the ratio of Al_2O_3 to Na_2O or K_2O in feldspars is 1:1, we subtract from Al_2O_3 an amount equivalent to Na_2O and K_2O in the same 1:1 ratio

---

The ACF Diagram

$$C = CaO - 3.3\ P_2O_5$$

$$F = FeO + MgO + MnO$$

The ACF Diagram

By creating these three pseudo-components, Eskola reduced the number of components in mafic rocks from 8 to 3

- Water is omitted under the assumption that it is perfectly mobile
- Note that SiO_2 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 $CaAl_2Si_2O_8$
- A = 1 + 0 - 0 - 0 = 1, C = 1 - 0 = 1, and F = 0
- Provisional values sum to 2, so we can normalize to 1.0 by multiplying each value by ½, resulting in
  - A = 0.5
  - C = 0.5
  - F = 0

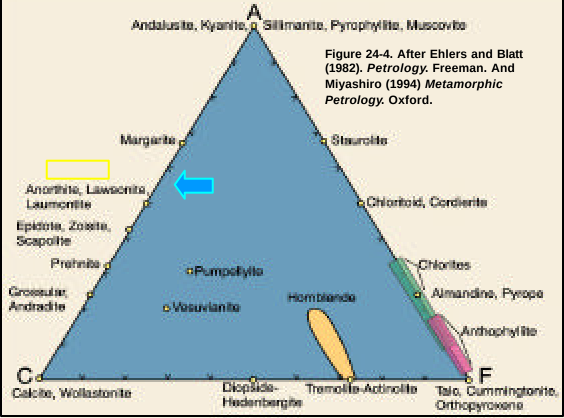
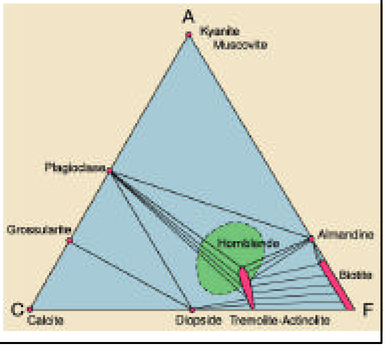


Figure 24-4. After Ehlers and Blatt (1982). *Petrology.* Freeman. And Miyashiro (1994) *Metamorphic Petrology.* Oxford.

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 Al_2O_3 and K_2O, and low in CaO, Eskola proposed a different diagram that included K_2O to depict the mineral assemblages that develop in them

- In the AKF diagram, the pseudo-components are:

$A = Al_2O_3 + Fe_2O_3 - Na_2O - K_2O - CaO$

$K = K_2O$

$F = FeO + MgO + MnO$

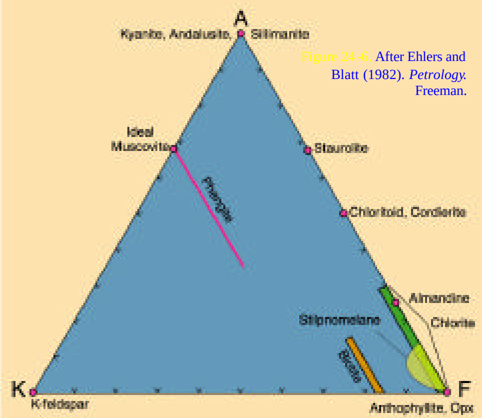


Figure 24-4. After Ehlers and Blatt (1982). *Petrology.* Freeman.

AKF compatibility diagram (Eskola, 1915) illustrating paragenesis of pelitic hornfelses, Orijärvi region Finland

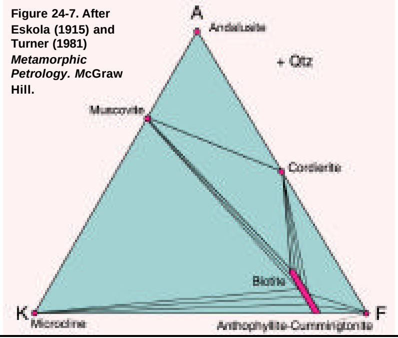
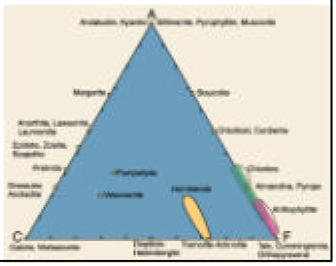


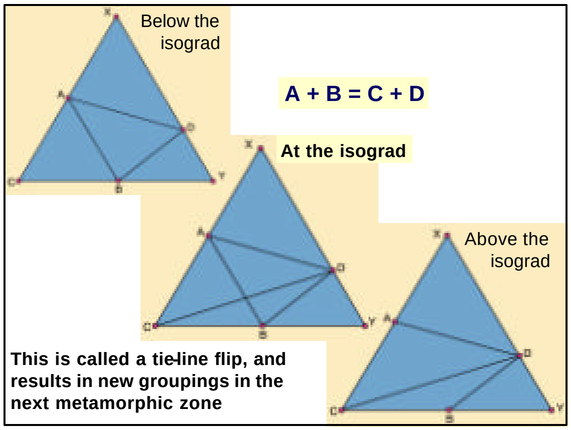
Figure 24-7. After Eskola (1915) and Turner (1981) *Metamorphic Petrology*. McGraw Hill.

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

Figure 24-7. After Ehlers and Blatt (1982). *Petrology*. Freeman.





Below the isograd

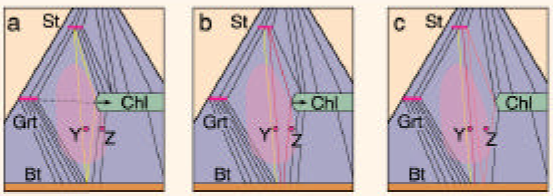
A + B = C + D

At the isograd

Above the isograd

This is called a tie-line flip, and results in new groupings in the next metamorphic zone

Tie-line Flip: Staurolite



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. Winter (2001).