Chemographic Diagrams

Chemographic (or compatibility) diagrams for metamorphic rocks graphically show stable mineral assemblages for different rock compositions at a particular P & T. Most diagrams use three components with the specific components chosen optimized to the type of protolith being evaluated. The most common types of chemographic diagrams, which we will work with here, are ACF (mafic rocks and sediments), AKF (pelitic rocks), and AFM (mixed rocks). Refer to Chapter 24 section 3 for help in making the calculations and plots.

**Procedure:** Given the following mineral compositions, calculate and plot the components for A) ACF, B) AKF and C) AFM chemographic diagrams on the following pages.

Staurolite (St) \((\text{Fe,Mg})_2\text{Al}_9\text{O}_6[(\text{Si}_3\text{Al})\text{O}_{16}](\text{OH})_2\)
Chloritoid (Ctd) \((\text{Fe,Mg})_2\text{Al}_4\text{O}_2[\text{Si}_2\text{O}_8](\text{OH})_4\)
Anorthite (An) \(\text{CaAl}_2\text{Si}_2\text{O}_8\)
Glaucophane (Glc) \(\text{Na}_2\text{Mg}_3\text{Al}_2[\text{Si}_8\text{O}_{22}](\text{OH})_2\)
Vesuvianite (Ves) \(\text{Ca}_{10}(\text{Fe,Mg})_2\text{Al}_4[\text{Si}_2\text{O}_7]_2[\text{Si}_4\text{O}_4]_5(\text{OH})_4\)
Calcite (Cal) \(\text{CaCO}_3\)
Epidote (Ep) \(\text{Ca}_2\text{Fe}^{+3}\text{Al}_2\text{O}[\text{Si}_2\text{O}_7][\text{Si}_4\text{O}_4](\text{OH})\)
Kyanite (Ky) \(\text{Al}_2\text{SiO}_5\)
Biotite* (Bt) \(\text{KFeMg}_2[\text{AlSi}_3\text{O}_{10}](\text{OH})_2\)
Garnet* (Grt) \(\text{Fe}_{2.1}\text{Mg}_{0.9}\text{Al}_2[\text{Si}_3\text{O}_{12}]\)
Muscovite (Ms) \(\text{KAl}_2[\text{AlSi}_3\text{O}_{10}](\text{OH})_2\)
Cordierite (Crd) \((\text{Fe,Mg})_2\text{Al}_4\text{Si}_5\text{O}_{18}.\text{H}_2\text{O}\)
Diopside (Di) \(\text{Ca(Fe,Mg)Si}_2\text{O}_6\)
Grossular (Grs) \(\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}\)
Andalusite (And) \(\text{Al}_2\text{SiO}_5\)
Hypersthene (Hy) \((\text{Fe,Mg})\text{SiO}_3\)
Wollastonite (Wo) \(\text{CaSiO}_3\)
A) Calculate the ACF components St, Ctd, Ves, Cal, An, Glc, and Ep and plot their normalized compositions on an ACF diagram. (2 pts for each mineral =14pts)

\[ A = \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 - \text{Na}_2\text{O} - \text{K}_2\text{O} \]
\[ C = \text{CaO} - 3.3\text{P}_2\text{O}_5 \]
\[ F = \text{FeO} + \text{MgO} + \text{MnO} \]

<table>
<thead>
<tr>
<th>Mineral Formula</th>
<th>A</th>
<th>C</th>
<th>F</th>
<th>A(^n)</th>
<th>C(^n)</th>
<th>F(^n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St- (Fe,Mg)(_2)Al(_9)O(_6)((\text{Si}_3\text{Al})\text{O}_16)(OH)(_2)</td>
<td>10/2=5</td>
<td>0</td>
<td>2</td>
<td>71.4</td>
<td>0</td>
<td>28.6</td>
</tr>
<tr>
<td>Ctd- (Fe,Mg)(_2)Al(_4)O(_2)<a href="OH">Si(_2)O(_8)</a>(_4)</td>
<td>4/2=2</td>
<td>0</td>
<td>2</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Ves- Ca(_{10})(Fe,Mg)(_2)Al(_4)[Si(_2)O(_7)]2[SiO(_4)]5(OH)(_4)</td>
<td>4/2=2</td>
<td>10</td>
<td>2</td>
<td>14</td>
<td>72</td>
<td>14</td>
</tr>
<tr>
<td>Cal- CaCO(_3)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>An- CaAl(_2)Si(_2)O(_8)</td>
<td>2/2=1</td>
<td>1</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Glc- Na(_2)Mg(_3)Al(_2)<a href="OH">Si(_8)O(_22)</a>(_2)</td>
<td>2/2-2/2=0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Ep- Ca(_2)Fe(^{+3})Al(_2)[Si(_2)O(_7)]<a href="OH">SiO(_4)</a>(_4)</td>
<td>2/2+1/2=1.5</td>
<td>2</td>
<td>0</td>
<td>43</td>
<td>57</td>
<td>0</td>
</tr>
</tbody>
</table>
B) Calculate the AKF components Ky, Bi, Grt, and Ms and plot their normalized compositions on an AKF diagram. (2 pts for each mineral = 8 pts)

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

\[ K = \text{K}_2\text{O} \]

\[ F = \text{FeO} + \text{MgO} + \text{MnO} \]

<table>
<thead>
<tr>
<th>Mineral Formula</th>
<th>A</th>
<th>K</th>
<th>F</th>
<th>A^n</th>
<th>K^n</th>
<th>F^n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ky- Al$_2$SiO$_5$</td>
<td>2/2=1</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bi- KFeMg$_2$<a href="OH">AlSi$<em>3$O$</em>{10}$</a>$_2$</td>
<td>1/2-1/2=0</td>
<td>1/2</td>
<td>3</td>
<td>0</td>
<td>14</td>
<td>86</td>
</tr>
<tr>
<td>Grt- Fe$<em>{2.1}$Mg$</em>{0.9}$Al$_2$[Si$<em>3$O$</em>{12}$]</td>
<td>2/2=1</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>Ms- KAl$_2$<a href="OH">AlSi$<em>3$O$</em>{10}$</a>$_2$</td>
<td>3/2-1/2=1</td>
<td>1/2</td>
<td>0</td>
<td>67</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>
C) Calculate the AFM components Bt and Grt (projected from Mu) and plot their normalized compositions on an AFM diagram. (2 pts for each mineral = 4 pts)

\[ A = \text{Al}_2\text{O}_3 - 3\text{K}_2\text{O} \]
\[ F = \text{FeO} \]
\[ M = \text{MgO} \]

\[
\begin{array}{c|c|c|c}
\text{Bio-} & \text{FeMg}_2(\text{AlSi}_3\text{O}_{10}) (\text{OH})_2 & A & F & M \\
\text{Grt-} & \text{Fe}_{2.1}\text{Mg}_{0.9}\text{Al}_2(\text{Si}_3\text{O}_{12}) & 2/2-0/6=1 & 2.1 & 0.9 \\
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c}
& A & F & M & A^n & F^n & M^n \\
\text{Bio-} & 3/6-1/6=1/3 & 1 & 2 & 10 & 30 & 60 \\
\text{Grt-} & 2/2-0/6=1 & 2.1 & 0.9 & 25 & 52.5 & 22.5 \\
\end{array}
\]
D) You are studying a suite of rocks from a field area. You notice that the rocks contain the following mineral assemblages:

- And-An-Crd
- An-Di-Grs
- Grs-Di-Wo
- An-Crd-Hy
- An-Hy-Di

Calculate and plot these assemblages on an ACF diagram (page 3, plot the minerals, and connect coexisting phases with tie-lines). (3 Pts) What metamorphic facies is represented (see Chapter 25)? (1 pt) Why do some rocks have cordierite and others diopside? (1 pt)

Pyroxene Hornfels Facies
Calcium-rich protoliths will form Di; Ca-poor protoliths will form Crd