Metamorphic Rocks

- Metamorphic rocks form from pre-existing rocks.
- Metamorphic rocks change with increasing temperature (and pressure to a lesser extent).
- Minerals in metamorphic rocks will depend both on composition and metamorphic grade.

Typical Composition of Rocks

<table>
<thead>
<tr>
<th></th>
<th>Peridotite</th>
<th>Gabbro</th>
<th>Granite</th>
<th>Shale</th>
<th>Limestone</th>
<th>Dolostone</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>0.05</td>
<td>0.05</td>
<td>0.07</td>
<td>0.25</td>
<td>0.20</td>
<td>0.41</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>FeO</td>
<td>0.10</td>
<td>0.09</td>
<td>0.19</td>
<td>0.15</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>MnO</td>
<td>0.06</td>
<td>0.07</td>
<td>0.15</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>MgO</td>
<td>0.48</td>
<td>0.48</td>
<td>0.39</td>
<td>2.62</td>
<td>1.59</td>
<td>2.19</td>
</tr>
<tr>
<td>CaO</td>
<td>5.05</td>
<td>8.47</td>
<td>3.00</td>
<td>53.06</td>
<td>32.87</td>
<td>32.87</td>
</tr>
<tr>
<td>Na₂O</td>
<td>0.49</td>
<td>2.91</td>
<td>3.05</td>
<td>1.13</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.34</td>
<td>1.10</td>
<td>4.30</td>
<td>3.96</td>
<td>0.24</td>
<td>0.05</td>
</tr>
</tbody>
</table>

What elements are ESSENTIAL to describe each rock?
Essential Components of Rocks

<table>
<thead>
<tr>
<th>Peridotite</th>
<th>Gabbro</th>
<th>Granite</th>
<th>Shale</th>
<th>Carbonate Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>SiO₂</td>
<td>SiO₂</td>
<td>SiO₂</td>
<td>SiO₂</td>
</tr>
<tr>
<td>FeO</td>
<td>Al₂O₃</td>
<td>Al₂O₃</td>
<td>Al₂O₃</td>
<td>MgO</td>
</tr>
<tr>
<td>MgO</td>
<td>FeO</td>
<td>Na₂O</td>
<td>FeO</td>
<td>CaO</td>
</tr>
<tr>
<td>CaO</td>
<td>CaO</td>
<td>K₂O</td>
<td>CaO</td>
<td></td>
</tr>
</tbody>
</table>

Chemographic Analysis: SiO₂-CaO-MgO Diagrams

Chemographic Analysis: ACF Diagrams

- What minerals (pink dots) would you need to have in a rock with composition X? Y?

Fig. 26-12. From Winter (2001) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
Chemographic Analysis: SiO₂-CaO-MgO Diagrams

What minerals might you find in a rock with composition “A”?

Chemographic Analysis: SiO₂-CaO-MgO Diagrams

What minerals might you find in a rock with composition “B”?

Chemographic Analysis: ACF Diagrams

What minerals might you find in a rock with composition “C”?

Chemographic Analysis

- There can be many combinations of minerals for a given rock composition that are chemographically allowable…
- Are they all probable, or even possible?
**General Rules of Metamorphism**

- Metamorphism is isochemical with respect to non-volatile components.
- Most metamorphic reactions liberate volatiles ($H_2O$ and $CO_2$).
- The minerals in low-grade metamorphic rocks have more volatiles than high-grade metamorphic rocks.
  - e.g., micas $\rightarrow$ amphiboles $\rightarrow$ pyroxenes.

**Petrogenetic Grids**

- P-T diagrams for multicomponent systems that show a set of reactions, generally for a specific rock type.

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**Chemographic Analysis: ACF Diagrams**

**Petrogenetic Grid for mafic rocks**

- Simplified petrogenetic grid for metamorphosed mafic rocks showing the location of several determined univariant reactions in the CaO-MgO-Al$_2$O$_3$-SiO$_2$ system ("C-NAMASH") Winter (2001). An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
Progressive Metamorphism of Metabasites

Progressive Metamorphism of Peridotites

Progressive Metamorphism of Carbonate Rocks

Chemographic Analysis:
$\text{SiO}_2$-CaO-MgO Diagrams
Progressive Metamorphism of Carbonate Rocks

Progressive Metamorphism of Peridotites

Chemographic Analysis: AFM Diagrams

Progressive Metamorphism of Pelitic Rocks