LECTURE TWENTY ONE: Carbonates and Calc-Silicates

IN THIS LECTURE
- Calcite marbles
- Decarbonation
- Dolomitic marbles
- Calc-silicate rocks
- Fluid composition in marbles
- Carbonate minerals

MARBLES
- The term marble is used for metamorphosed calcareous rocks in which carbonate minerals dominate.
- This represents essentially two end-member compositions
  - Very pure calcite limestones
  - Impure calcite or dolomitic limestones
- Metamorphism of these two end-member compositions produces two different rock types
  - Pure calcite marbles which are petrologically not very interesting
  - Dolomitic marbles which are petrologically interesting
- Distinguishing calcite, dolomite and other rhombohedral carbonates from each other can be very difficult without obtaining chemical analysis or using chemical stains.
- Often can use associated mineralogy to help decide

CALCITE MARBLES
In general, metamorphism of a pure calcite limestone simply produces a pure calcite marble.
Petrologically not very interesting since calcite is stable to very high pressures and temperatures.
Relatively pure limestones that contain a small amount of quartz are more interesting as they show one of the simplest examples of the most common reaction type in carbonate rocks, decarbonation reactions.

\[
\text{CaCO}_3 + \text{SiO}_2 \rightarrow \text{CaSiO}_3 + \text{CO}_2
\]

Calcite + quartz \rightarrow \text{wollastonite} + \text{fluid}

However, at pressures of more than a couple of kilobars the temperature required to form wollastonite is beyond the range of normal regional metamorphism

DOLOMITE MARBLES
Limestones that contain dolomite provide much more useful indicators of metamorphic grade because of a range of Ca-Mg silicates can form in the more usual P-T conditions of metamorphism, such as talc, tremolite and diopside.
With prograde metamorphism there is a zonal sequence of mineral-appearance isograds similar to what we saw with pelites.
This zonal sequence in regionally metamorphosed dolomitic limestones appears to be
  - Talc (not always present), Tremolite, Diopside or forsterite, Diopside + forsterite
Dolomitic marbles can be described by five components CaO, MgO, SiO\(_2\), H\(_2\)O and CO\(_2\).
No assemblages have more than five phases, normally four minerals and a mixed fluid phase.
Therefore according to the phase rule, there should be two degrees of freedom in most systems and thus most mineral assemblages will occur over a wide range of pressures and temperatures depending on what the composition of the fluid phase is.

CALC-SILICATES
Calc-silicates are rocks rich in Ca-Mg silicate minerals but with only minor amounts of carbonate present.
Like dolomitic marbles, calc-silicates are useful indicators of metamorphic grade.
They can be correlated with the pelite zones in the following manner

<table>
<thead>
<tr>
<th>Pelite zone</th>
<th>Calc-silicate zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garnet</td>
<td>Zoisite-calcite-biotite</td>
</tr>
<tr>
<td>Staurolite</td>
<td>Zoisite-hornblende</td>
</tr>
<tr>
<td>Kyanite</td>
<td>Anorthite-hornblende</td>
</tr>
<tr>
<td>Sillimanite</td>
<td>Anorthite-pyroxene</td>
</tr>
</tbody>
</table>

Calc-silicates contain significant amounts of other chemical components especially Al, K and Fe.
Therefore their mineralogy is more complex than that of dolomite marbles and additional phases include: Zoisite, Garnet, Hornblende, tremolite, Ca-pyroxene like diopside, Calcic-plagioclase, K-feldspar, Phlogopite and vesuvianite.
In general zoisite and grossular garnet are only stable if the fluid phase is rich in water, while calcic-plagioclase is favoured by CO\(_2\) dominated fluids.