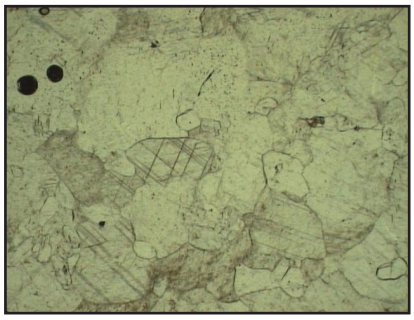
LECTURE TWENTY ONE: Carbonates and Calc-Silicates

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



Calcite and Dolomite are the only minerals that show twinning in both ppl and xpl

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.

$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$
Calcite + quartz -> wollastonite + fluid

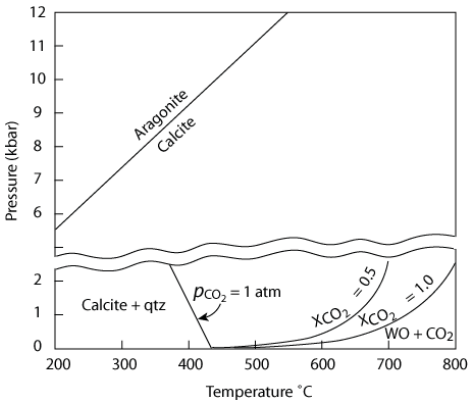
However, at pressures of more than a couple of kilobars the temperature required to form wollastonite is beyond the range of normal regional metamorphism

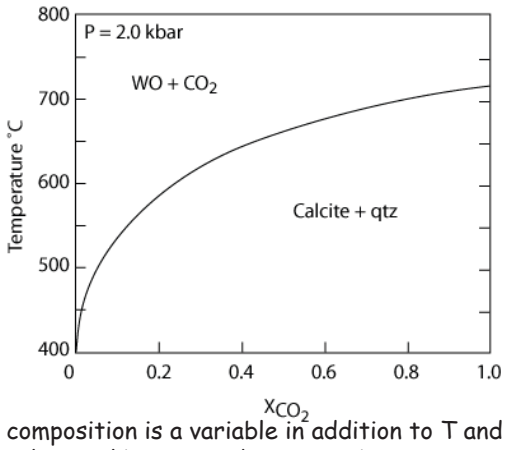
How then do we explain the presence of wollastonite in marbles that have not been to such high temperatures?

Reduce the pressure of the CO_2 phase.

At temperatures of the green-schist facies and above, H_2O and CO_2 supercritical fluids are completely miscible

Hence the partial pressure of CO_2 in a mixed H_2O-CO_2 fluid may be much less than the total fluid pressure.





We can tell from the phase rule that luid composition is a variable in addition to T and P and by specifying one of these three variables the equilibrium conditions can be represented by a univariant curve on a plot with the other two variables as axes.
NOTE: You do not need to know the above information and diagrams on fluid composition for the exam

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_2O 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

Pelite zone	Calc-silicate zone
Garnet	Zoisite-calcite-biotite
	Zoisite-hornblende
Staurolite	Anorthite-hornblende
Kyanite	
Sillimanite	Anorthite-pyroxene

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.