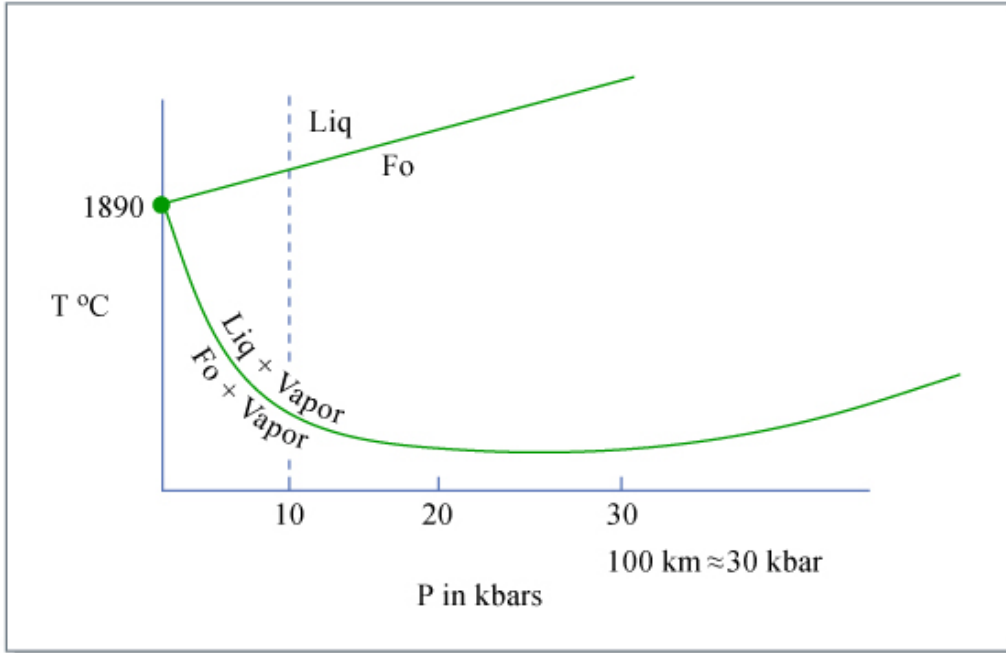


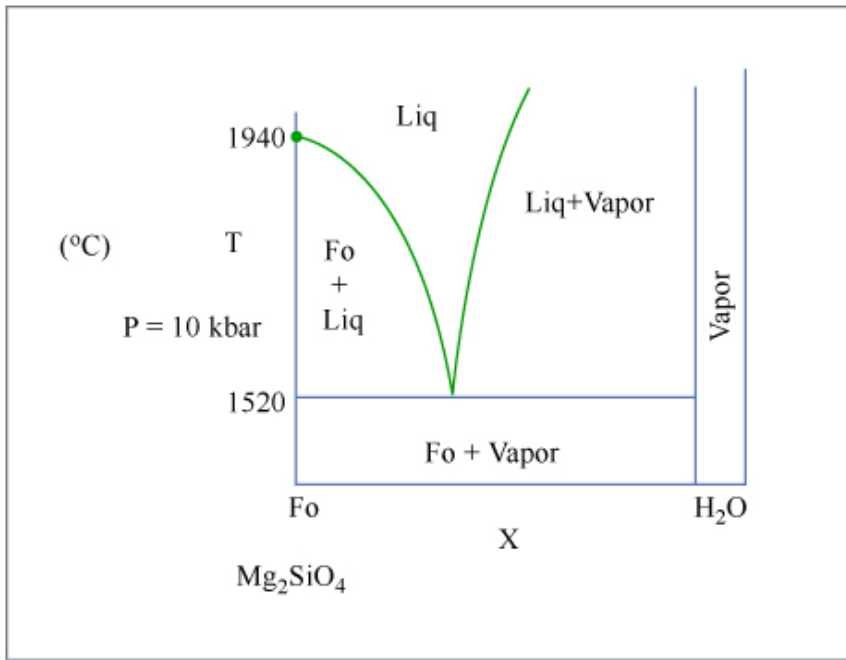
12.109 Petrology
Melting of silicate solids in the presence of H₂O

The system Fo-H₂O:

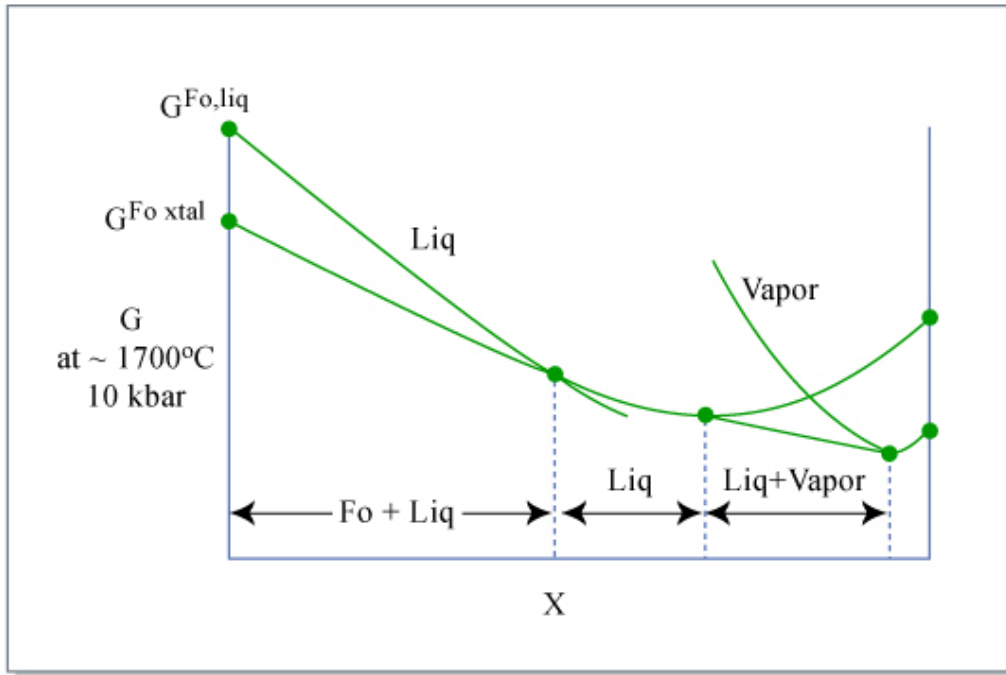


The presence of excess H₂O lowers the melting point of H₂O by 600°C at 20 to 30 kbar!

Look at T-X at 10 kbar:



The addition of H₂O lowers the G curve for the melt phase.



Recall the Clausius-Clapeyron equation. It expresses the P-T of melting or another phase transition...

$$\frac{dT}{dP} = \frac{\Delta V_{melting}}{\Delta S_{melting}} = \frac{(\bar{V}_{melt} - \bar{V}_{xtal})}{(\bar{S}_{melt} - \bar{S}_{xtal})}$$

When no H₂O is present, the slope is positive.

$$\bar{V}_{melt} > \bar{V}_{crystals} \text{ (crystalline phase is usually denser than its melt)}$$

$$\bar{S}_{melt} > \bar{S}_{crystals}$$

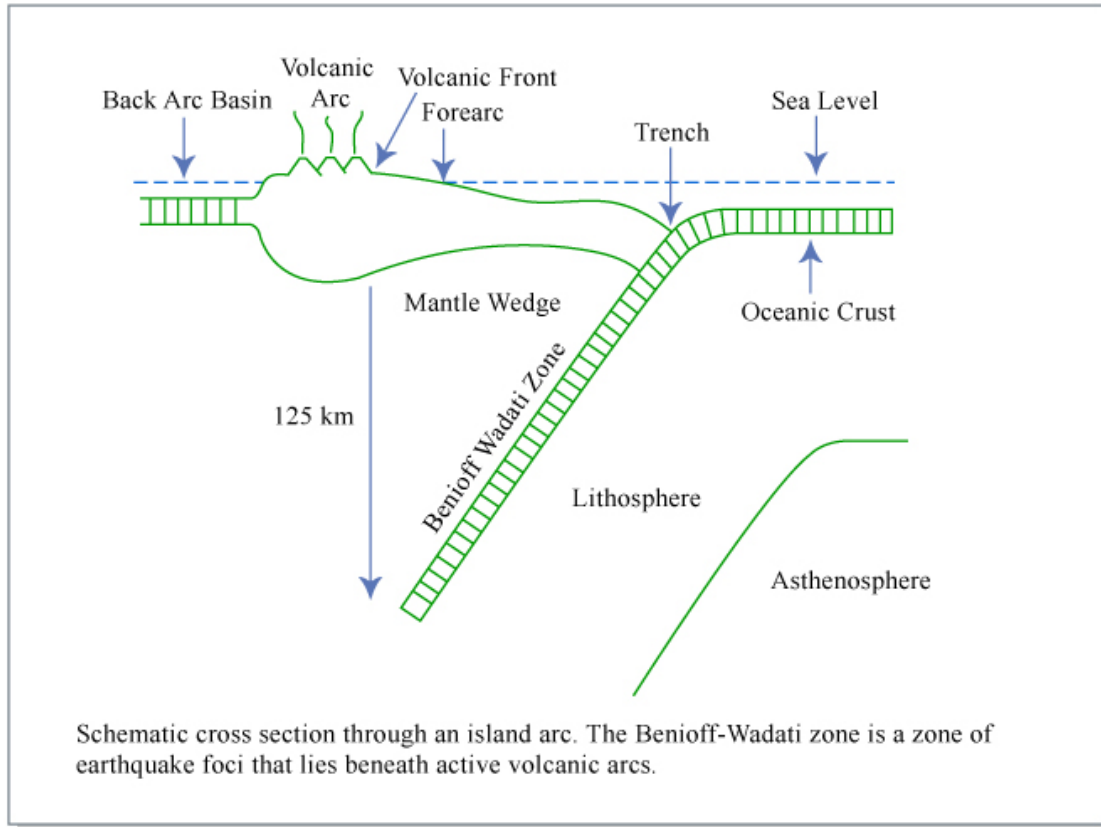
The presence of water switches the sign of $\frac{dT}{dP}$, for vapor-saturated melting.

$$\frac{dT}{dP} = \frac{\bar{V}_{melt} - (\bar{V}_{xtals} + \bar{V}_{vapor})}{\bar{S}_{melt} - (\bar{S}_{xtals} + \bar{S}_{vapor})} \rightarrow \frac{-}{+}$$

Note that ΔV_{rxn} gets smaller for vapor saturated melting of silicates. At some point, the slope goes to zero, then positive. This occurs because the compressibility of vapor is > that of solid and melt.

Island arc/subduction zone processes

When ocean crust is subducted beneath older ocean crust or continental crust, we find island arc volcanoes. The spatial relationship of volcanic arc and subduction is remarkably constant.



The zone of magmatic activity is about 125 km above the slab. Why? Dehydration reactions, but no single mineral that might be present in subducted hydrated crust seems to be the culprit.

Compositional variations of island arc lavas – suites of related lavas – called “rock series” – include basalt, andesite, and dacite.

There is a large range of variability of magmas produced in subduction processes. One classification:

Shoshonite series

High-K series (Aleutian arc)

Calc-alkaline series (South Sandwich islands)

Low-K series

A trend of decreasing FeO with increasing SiO₂ and decreasing MgO, distinct from the ocean floor suites, was recognized early on as calc-alkaline vs. tholeiitic trend...

Graph of the effects of H₂O on plagioclase/melt equilibria and comparisons of minerals in arc affinity rocks with those in other geologic settings shows that arc rocks cluster around 90-95% anorthite and 70-80% forsterite, in contrast to layered igneous intrusions, which have compositions along the anorthite%=forsterite% line from 65-85%.

Slab melting vs. mantle wedge melting? (from where does the magma in arc volcanoes melt?)

Because the slab is the coldest part of the system, this question seems poorly posed. Certainly, something is coming from the slab. But, basalts and basaltic andesites in the global island arc suite do not resemble melts of a basaltic subducted slab.