Magma Generation – Hawaiian Islands

Under normal mantle conditions magma cannot be generated without a shift in the geotherm or mantle solidus. The two lines must come in contact for even a small melt fraction to form. Mantle plumes have the benefit of a high thermal budget sourced by the core. As a result, the geotherm within the plume is a higher temperature than a typical oceanic geotherm. The result is a range of temperature and pressure conditions that are conducive to partial melting.

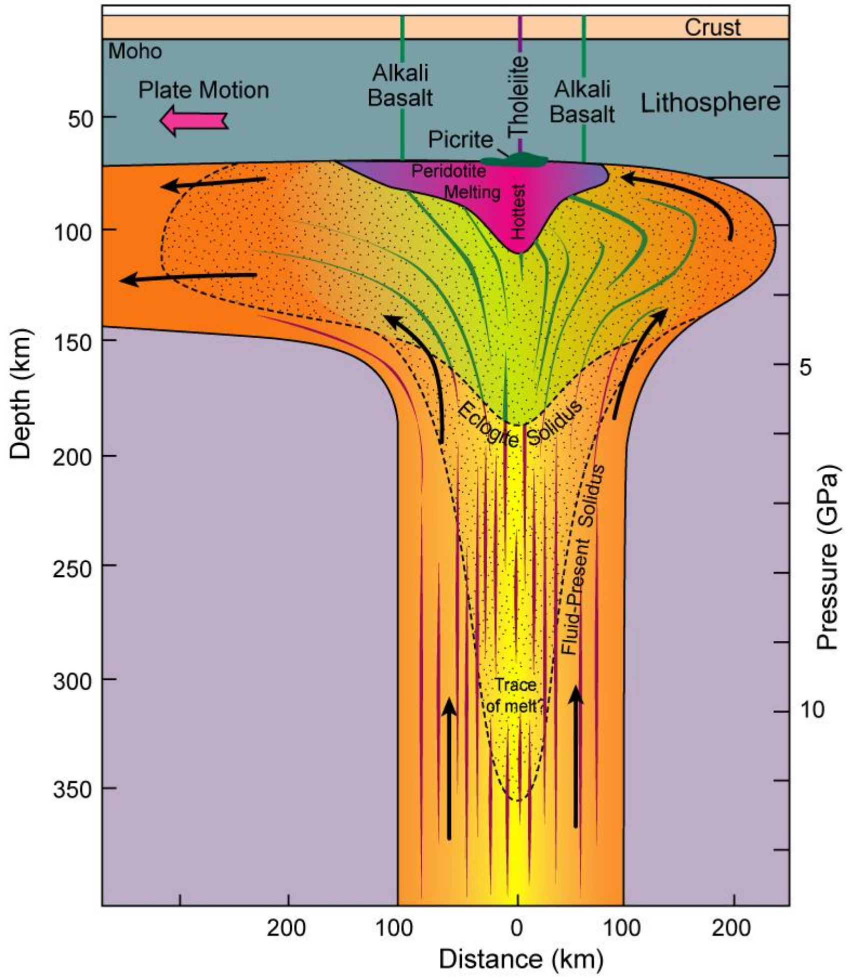

Figure 1: A cross section of a mantle plume like the one fueling Hawaiian volcanism. After Wyllie, 1988b.

As a plume rises through the mantle it stalls when it reaches the bottom of the lithosphere. It plumes out further and is dragged slightly in the direction of plate motion (Fig. 1). Melts force their way to the surface and form the hotspot vent through which heat from the mantle can dissipate. As more melt rises the pressure of the system decreases slightly creating an environment of slight decompression melting.

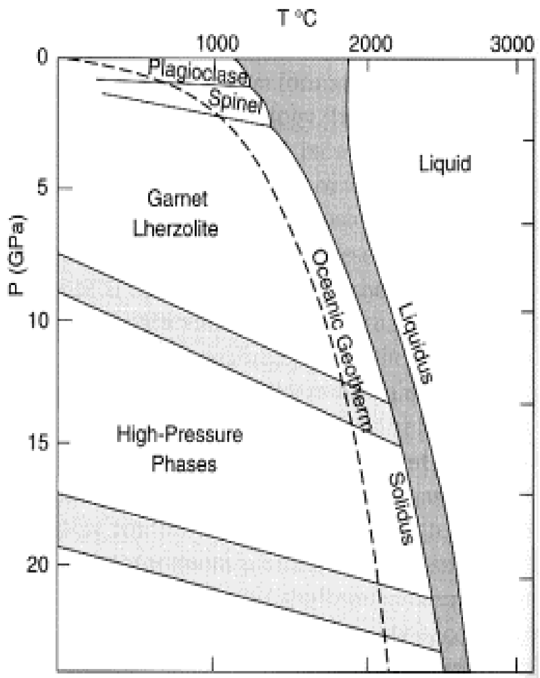

Figure 2: Mantle phase diagram (Winter, 2001) that shows that under standard conditions melting does not occur in the mantle.

Plumes are compositionally varied within due to the magma generating conditions on the outside versus the inside of the plume. The interior of the plume has the most heat to melt source rock with and thus, creates a higher melt fraction. The outer most layers of the plumes cylindrical form are the coolest and a small melt fraction forms there. This variation in melt fraction size has geochemical implications which are addressed in the geochemical data section of this exhibit.

References

Wyllie, P. J. (1988). Solidus curves, mantle plumes, and magma generation beneath Hawaii. *Journal of Geophysical Research: Solid Earth (1978–2012)*,*93*(B5), 4171-4181.

Winter, J. D. (2001). *An introduction to igneous and metamorphic petrology*. Upper Saddle River, NJ: Prentice Hall.