# Are ‘hotspots’ ‘wetspots’? Clare de Villanueva

**The presence of water lowers the solidus of mantle material, increasing the degree of melting at a given temperature.**

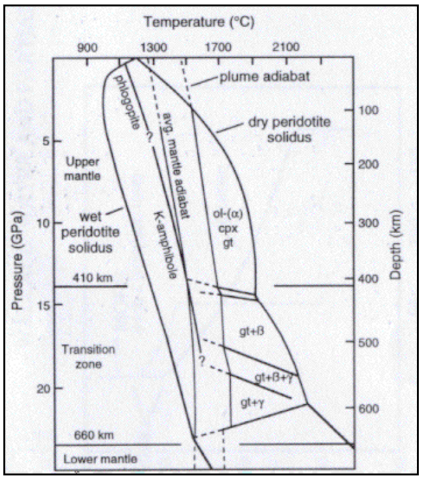



***Figure 1 (left).*** *P-T diagram (after Thompson, 1992). Near-solidus phase relations in peridotite; temperature distribution in the upper mantle, and the possible minerals in which $H_2O$ could be stored. The upwelling mantle plume adiabat shown is ~200° C hotter than average mantle.*

## Azores hot spot (Mid-Atlantic Ridge) (Schilling et al 1983)

This region exhibits elevated water contents in tholeiitic volcanic glasses. This may explain the higher rate of volcanic activity compared to elsewhere along the MAR.

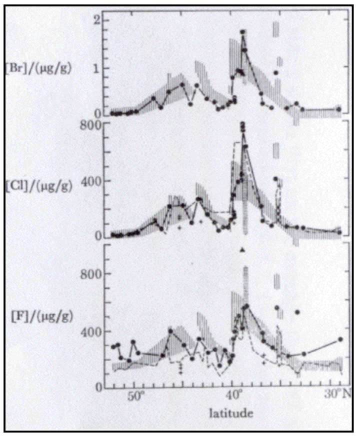



***Figure 2 (right).*** *The peaks shown in Br, Cl and F occur at the locality of the Azores Island alkali basalts.*

The water content of M.A.R. basalts is significantly higher over the Azores platform than along the two normal ridge segments. (H2O = 0.52 ± 0.17% and 0.33± 0.12% respectively).

The role that volatiles play in this phenomenon is not well understood but they may lower the melting point of an advecting mantle as well as influence the composition of such melts.

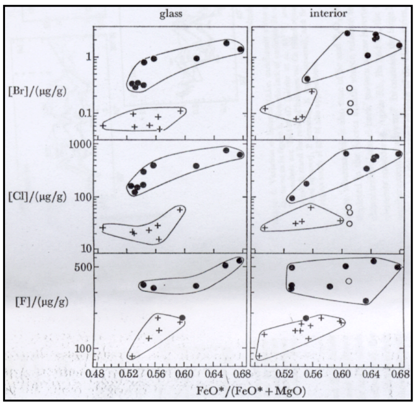


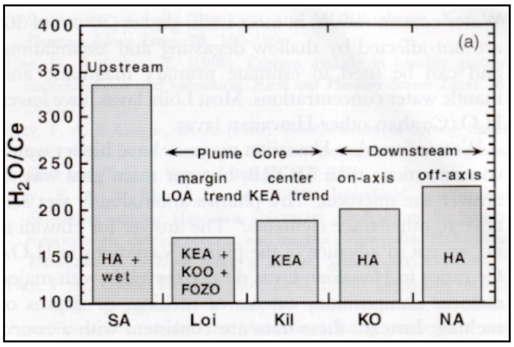

***Figure 3 (left)*** *Halogen versus FeO/(FeO + MgO) of M.A.R. samples for the ridge transect over the Azores platform (filled circles) and the two NMORB (crosses), show two separate populations.*

Therefore, the high enrichment of water and halogens in basalts from the Azores ridge transect suggests that the Azores is not only a ‘hotspot’ but also a ‘wetspot’.

## Hawaiian Basaltic Magmas.

Mantle plume source for Kilauea estimated to contain 450±190 ppm $H_2O$. ~3 times greater than that estimated for the mantle source for depleted mid-ocean ridge basalts.

Water undersaturated melting of upwelling Hawaiian plume prob begins at a depth of ~250 km (compared to ~120 km beneath ridges), primarily because of the greater water content of the plume source.




Dixon et al (2001), studied basaltic glasses from the Loihi seamount of Hawaii, and found evidence for a *relatively dry plume component.* They used $H_2O$/Ce as an indication of enrichment or depletion of $H_2O$ relative to other incompatible trace elements.

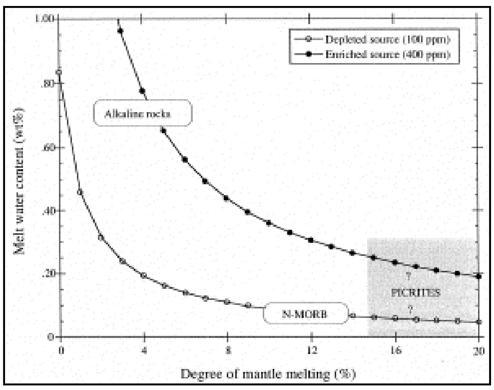
This could be evidence for a compositionally zoned plume model – wet-rim/dry core.

## The Reykjanes Ridge and Iceland

Water contents are higher in samples from Iceland than in samples from along the Reykjanes Ridge.

$H_2O$ values increase sharply northwards towards Iceland, ~650 km from the centre of the Iceland plume.

Such a rise in the mantle water content has important implications on mantle melting, increasing the degree of melting by up to 10%, from ~10% furthest from plume to 20-30% beneath Iceland (An increase in mantle temp of almost 100°C would be required to generate a similar rise in melt fraction).



## The North Atlantic Volcanic Province (Jamtveit et al 2001)

This figure shows expected water contents of mantle-derived melts as a function of degree of mantle melting and the initial mantle $H_2O$ contents.

It shows two different initial water contents.

It may be that here we have a source region within a 'wet' asthenospheric mantle (i.e. 'plume' material), though contributions from a 'fertile' lithosphere cannot be ignored.

Basaltic melts with $H_2O$ contents >0.2 wt% *cannot* be obtained by melting a mantle containing less than about 300 ppm $H_2O$ at any reasonable degree of mantle melting.

## Where does this water come from?

• An enrichment of water in the transition zone relative to the upper mantle due to recycling of water stored in subducted ocean crust is suggested by Wallace, 1998.

•If subducted slabs penetrate into the lower mantle and suitable OH-bearing phases are stable, then the lower mantle could also be enriched in water.

•Because mantle plumes are mainly believed to originate from the 660 km discontinuity or deeper, water contents of basaltic magmas formed in upwelling plumes can provided information on water in the deep mantle.

An alternative mechanism is the metasomatism of shallow mantle by water derived from both hydrous and nominally anhydrous minerals residing in the upper mantle.

• Bonatti attributes the elevated degree of melting beneath the Azores to a metasomatised $H_2O$- and $CO_2$-rich mantle source, rather than higher mantle temperatures. The metasomatised material may rise by causing instabilities in the mantle, or it may become entrained in ridge upwelling or local asthenospheric convection cells.

***Problems with analysing water contents***

*Degassing of water becomes significant only at low pressure, when the equilibrium vapour phase is much more water-rich. This pressure depends on the initial $H_2O/CO_2$ ratio and in typical MORB results in significant degassing of water at eruption pressures below approximately 50 kbar. Crystallisation, assimilation of hydrous crustal material and post-eruption hydrothermal alteration also need to be considered before the measured water contents can be used to infer any information about the source. Water is incompatible during crystallisation in MORB and mantle plume basalts and as a result, crystallisation will lead to the enrichment of water in the residual melts. Assimilation and post-eruption hydrothermal alteration will also lead to higher water contents.*

## Summary

- Hawaii lavas contain about 3 times more water than MORBs.
- Northern MAR data show that the water contents increase towards the Iceland hot spot.
- Water concentrations in olivine melt inclusions in tholeiites erupted in the Lakagigar eruption on Iceland in 1783 are 1.5-4 times higher than typical for MORB.
- NAVP magmas are derived from sources significantly enriched in water relative to those of MORB.
- The water may be derived from subducted material recycled to the surface by a mantle plume. However, whether water can reach the deep mantle through subduction is a matter for debate.
- Alternatively, metasomatism of shallow mantle may have occurred by water derived from both hydrous and nominally anhydrous minerals residing in the upper mantle.
- Water plays a significant role in the generation of melts beneath Iceland and in the NAVP, Hawaii and the Azores platform, thus providing support for the wet hypothesis of Schilling et al.

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