AN ALTERNATIVE MODEL FOR BIMODAL VOLCANISM IN THE SOUTHERN CASCADIA BACK-ARC REGION SINCE ~12 Ma

Vic Camp, Dept. of Geologic Sciences
San Diego State University
SNAKE RIVER PLAIN:
The rate of rhyolite migration is consistent with plate velocity over a fixed hotspot at least since 10Ma (Anders et al., 2019).

Nelson and Grand (2018)
Slab rollback models:

- Long et al. (2009; 2012)
- Durken et al. (2011)
- Ford et al. (2013)
- Till et al. (2013)
Slab fragmentation tomography:
Xue and Allen (2007, 2010)
Burdick et al. (2008)
Sigloch et al. (2008)
Obrebski et al. (2010, 2011)
Schmandt and Humphreys (2010)
Tian et al. (2011)
Long (2016): *The Cascadia Paradox*

“... it is difficult to reconcile this model with the increasingly convincing evidence for some type of fragmentation of the Cascadia slab at depth . . .”

“... the identification of alternative models for mantle flow beneath the HLP is important.”
Lowry et al. (2000): Dynamic elevation model for the Yellowstone Swell

Yellowstone Geoid Anomaly (Smith and Milbert, 1999)
Lowry et al. (2000): Dynamic elevation model for the Yellowstone Swell

Lowry et al. (2000): Thermal structure
Estimated temperature at 5 km depth (Bouligand et al., JGR, 2009)
Estimated temperature at a depth of 5 km (Bouligand et al., JGR, 2009)

-3% surface contour of LV body of Wagner et al. (2010) at 50-70 km depth

3% Surface contour of Low Velocity body of Wagner et al. (2010)
Low-velocity surface of Wagner et al. (2010)
Low-velocity surface of Wagner et al. (2010)
Low-velocity surface of Wagner et al. (2010)
Low-velocity surface of Wagner et al. (2010)

Thickness of the LV feature varies from 50-200 km. Is the LV volume derived from the Yellowstone plume?
CONSTRAINTS ON PLUME FLUX

- SRP basalt isotopes reflect a primary plume source that comprises mass fractions >95% in the derivative lavas (Hanan et al., 2008).

- A near constant supply of this fertile source is necessary to generate a steady state in the volume and composition of SRP tholeiite.

- Plume volume is therefore assumed to keep pace or surpass the pace of plume material being dragged to the west by plate motion.
ESTIMATE OF PLUME VOLUME FLUX:

Melt accumulation rate = 48,571 km$^3$/Ma*
Range in partial melting = 5-10%**

Estimated range in volume flux of the melt zone = 31 m$^3$ s$^{-1}$ to 15 m$^3$ s$^{-1}$

* Based on the volume mantle-derived melt added to the YSRP crust between 11-4 Ma, (340,000 km$^3$; McCurry and Rodgers, 2009).
** Based on data for central SRP tholeiites (Shervais et al., 2005)
MINIMUM MANTLE FLOW RATE:

Cross-sectional area for plume channel (Stachnick et al., 2008) = 8250 km²

The *most conservative value* for plume volume flux (15 m³ s⁻¹):

Mantle flow rate = 59 km/Ma

TOTAL VOLUME OF PLUME SOURCE SINCE 12 Ma:

Since 12 Ma, this minimum flow rate for the plume source is capable producing a 20-km-thick layer equivalent in area to the 3% LV surface contour of Wagner et al. (2010), but higher values for plume flux could generate a 40-km-thick layer.
Slice through the upper part of the LV feature at 75 km depth
(derived from the model of James et al. [2011])
△ = Quaternary volcanism (from Smithsonian GVP)
Young flow-line channels of hot mantle form within the broader region of warm plume material (Sleep, 2008).

Plume-modified mantle: spreading and entrainment since ~16.7 Ma.
Rapid, buoyancy-driven channel flow across an abrupt slope at the cratonic boundary, westward into a thin lithosphere beneath the HLP.
Down-track spreading of plumes can entrain a significant amount of colder, depleted mantle, with temperatures decreasing in the down-stream direction (e.g., Richards and Griffiths, 1989; Harp and White, 2001).
The progressive decrease in $^{3}\text{He}/^{4}\text{He}$ to the west is consistent with increasing entrainment of depleted mantle and dilution of a plume component.
HAOT trace-element pattern:
Similar to EMORB and Steens Basalt thought to be derived from plume-modified mantle.