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

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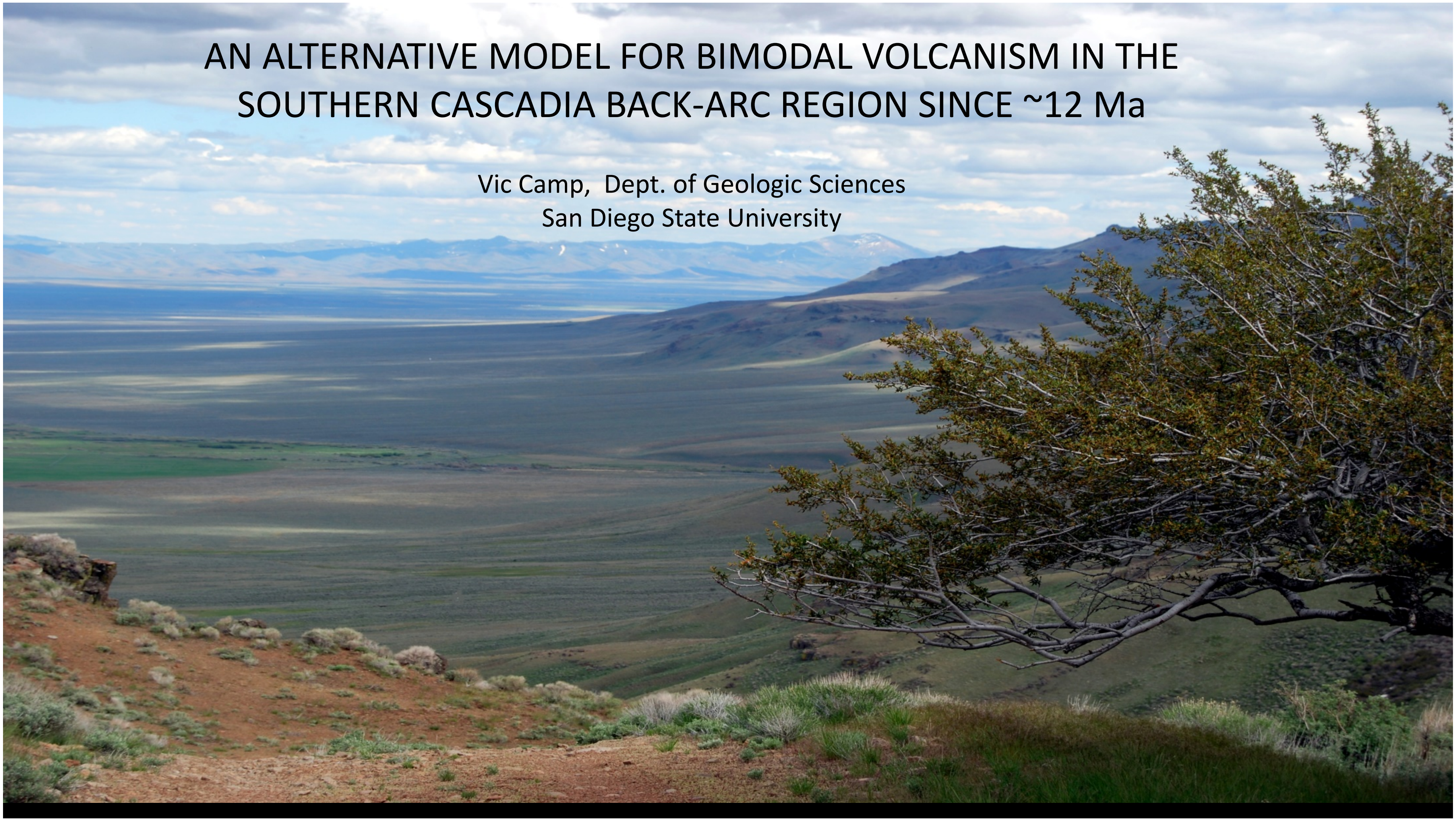
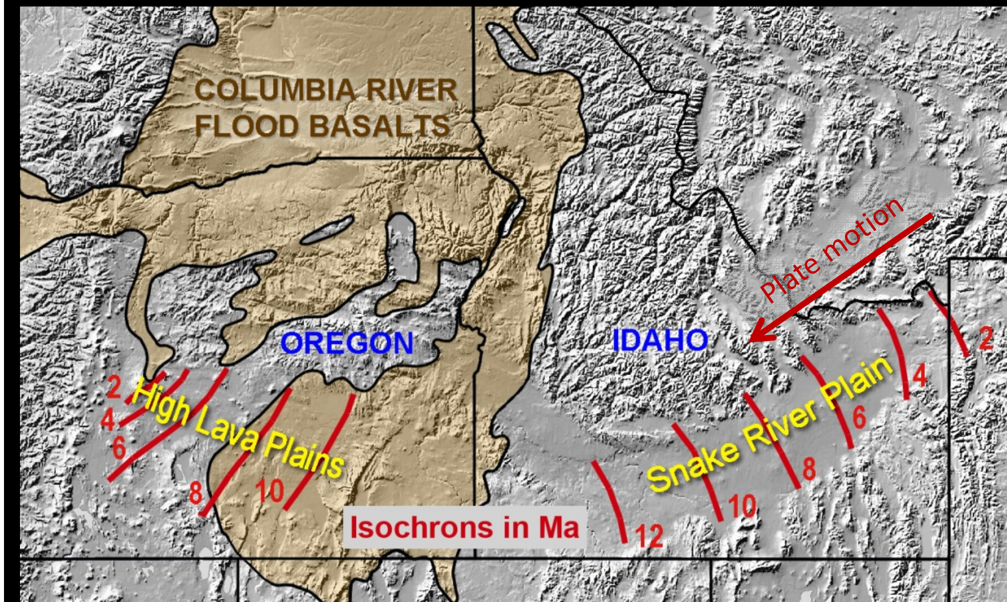
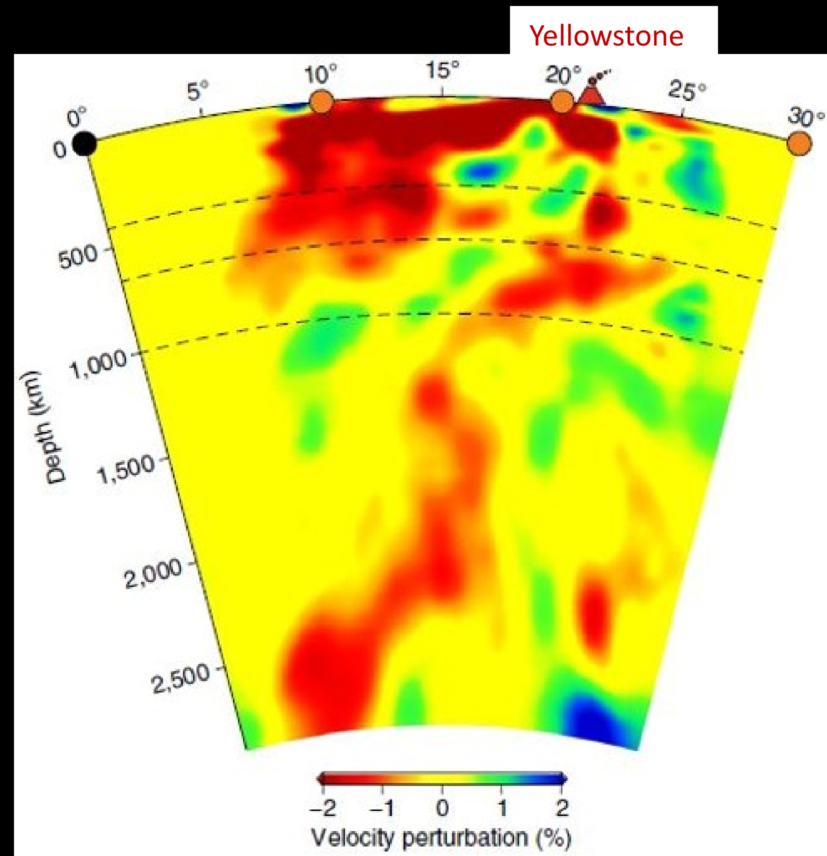




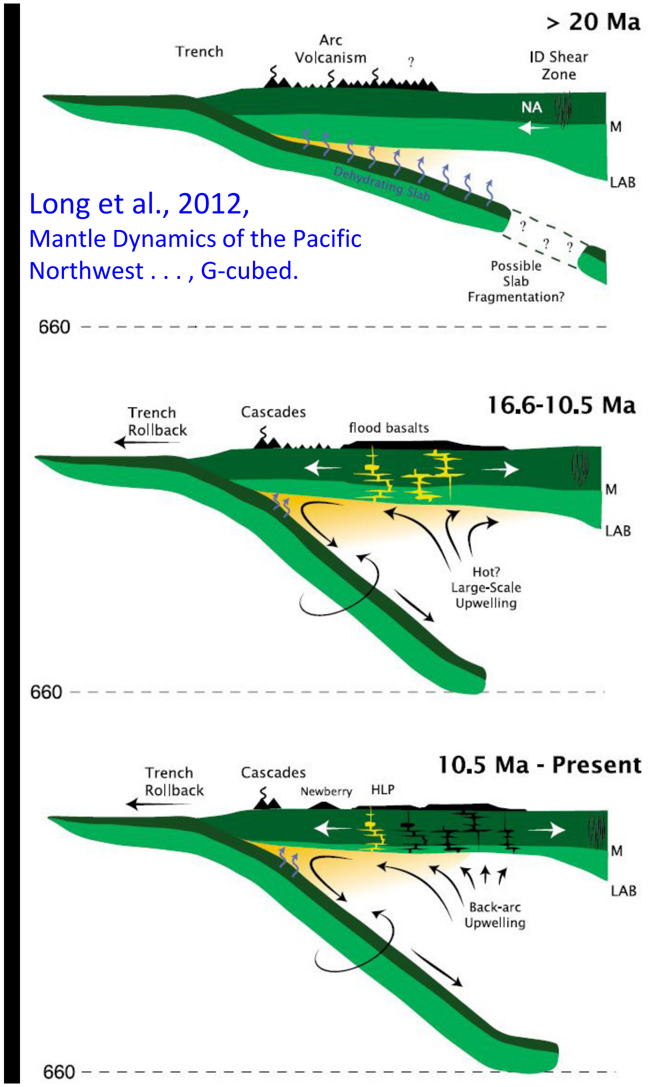

SNAKE RIVER PLAIN:
The rate of rhyolite migration is consistent with plate velocity over a fixed hotspot at least since 10Ma (Anders et al.,. 2019).



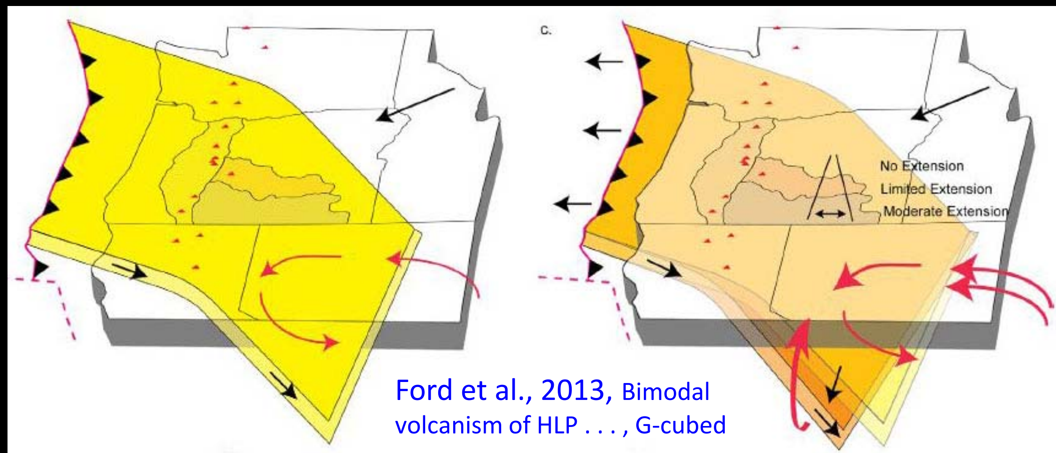

Nelson and Grand (2018)

# Slab rollback models:

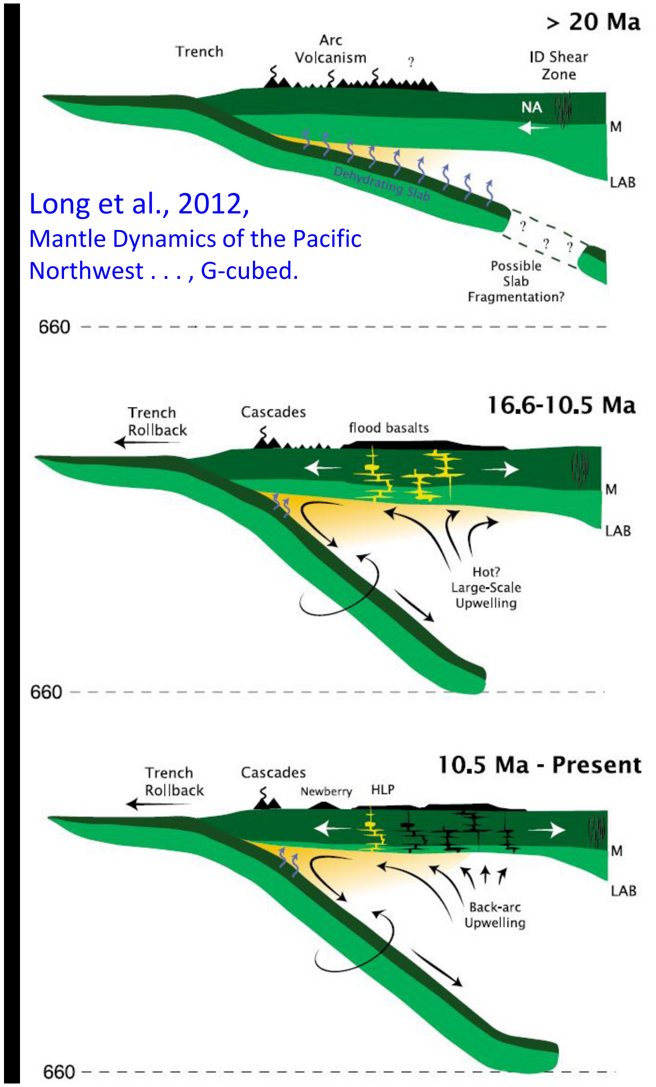
Long et al. (2009; 2012)
Durken et al. (2011)
Ford et al. (2013)
Till et al. (2013)

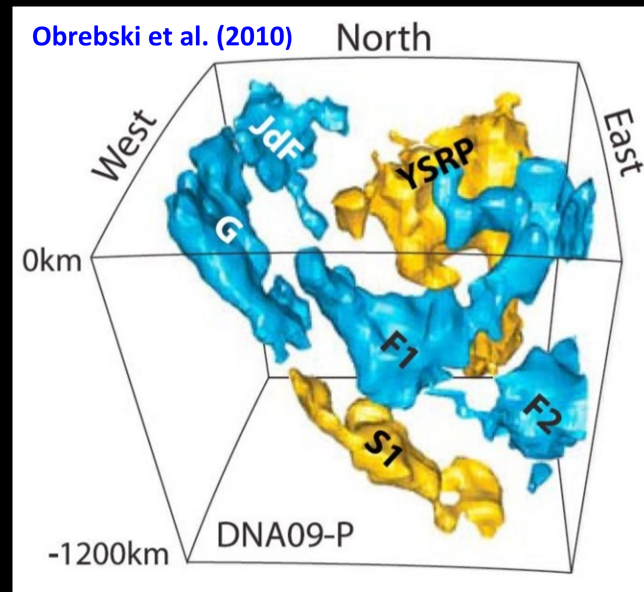



Long et al., 2012, Mantle Dynamics of the Pacific Northwest . . . , G-cubed.



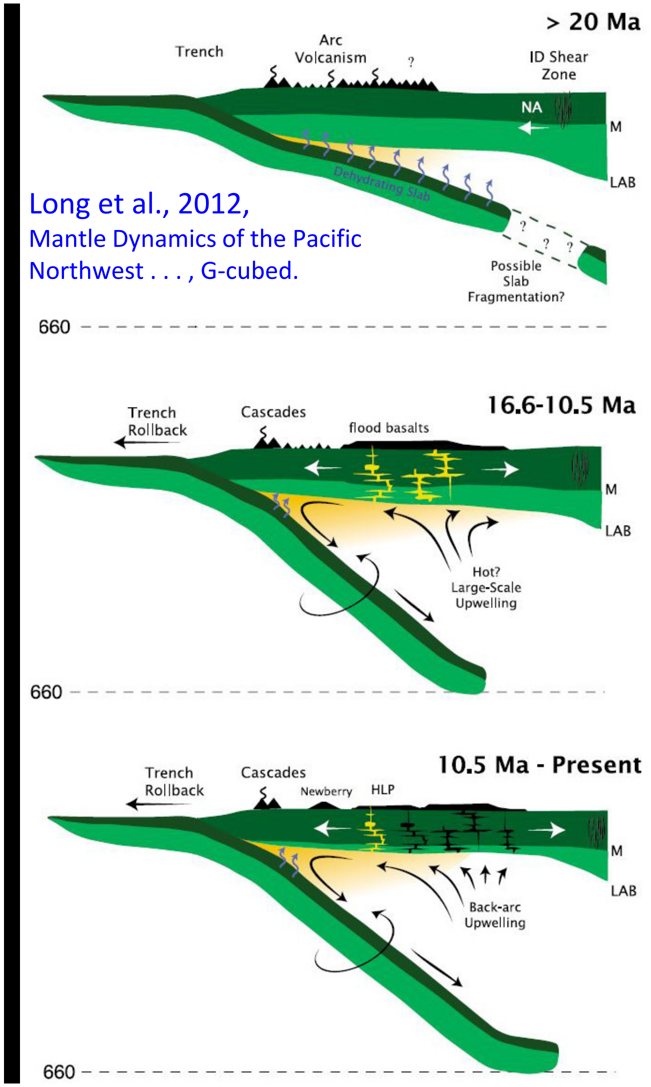

Ford et al., 2013, Bimodal volcanism of HLP . . . , G-cubed




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)

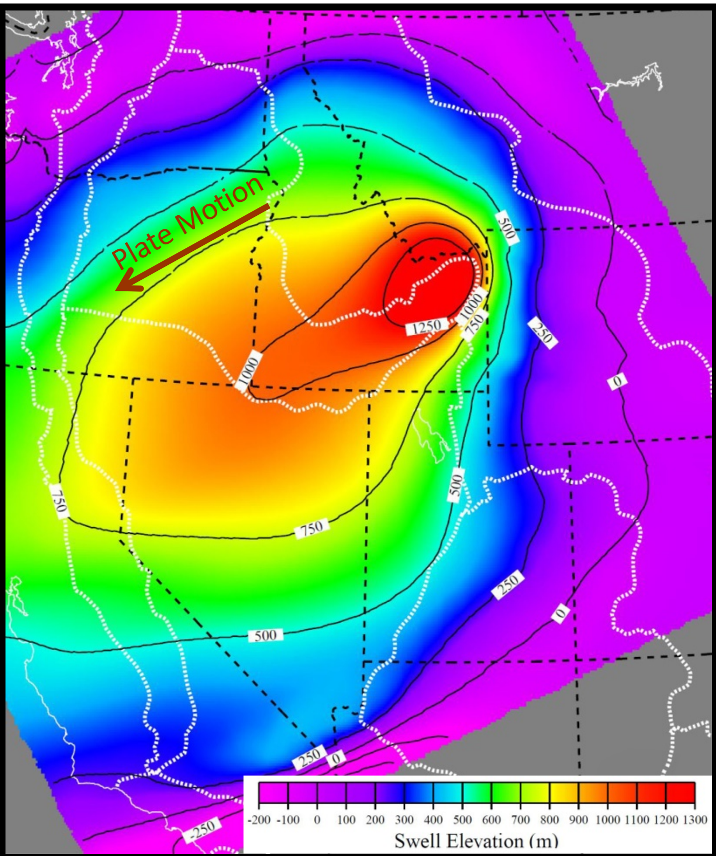



Long et al., 2012,
Mantle Dynamics of the Pacific Northwest . . . , G-cubed.

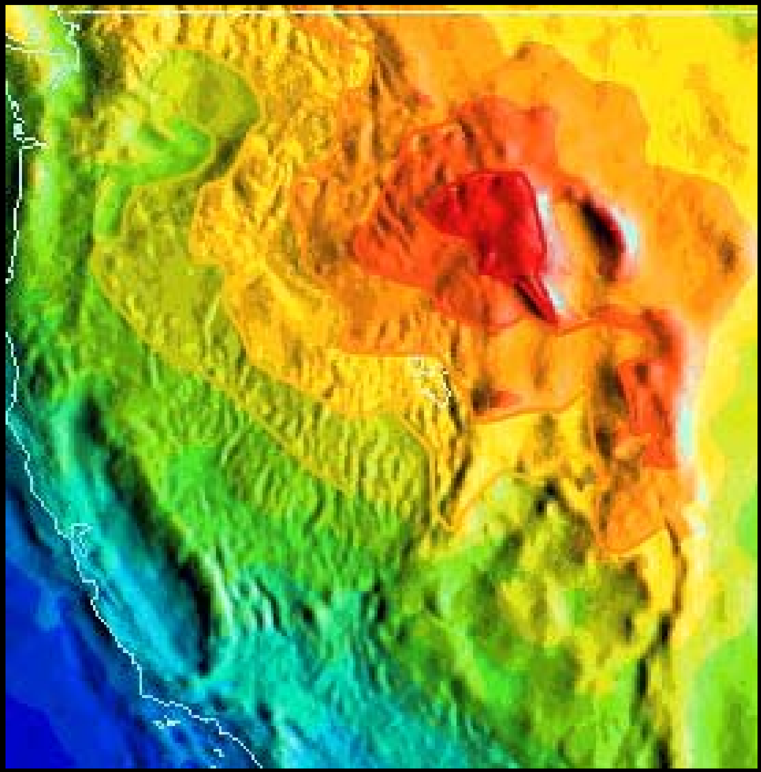
Long (2016): *The Cascadia Paradox*

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

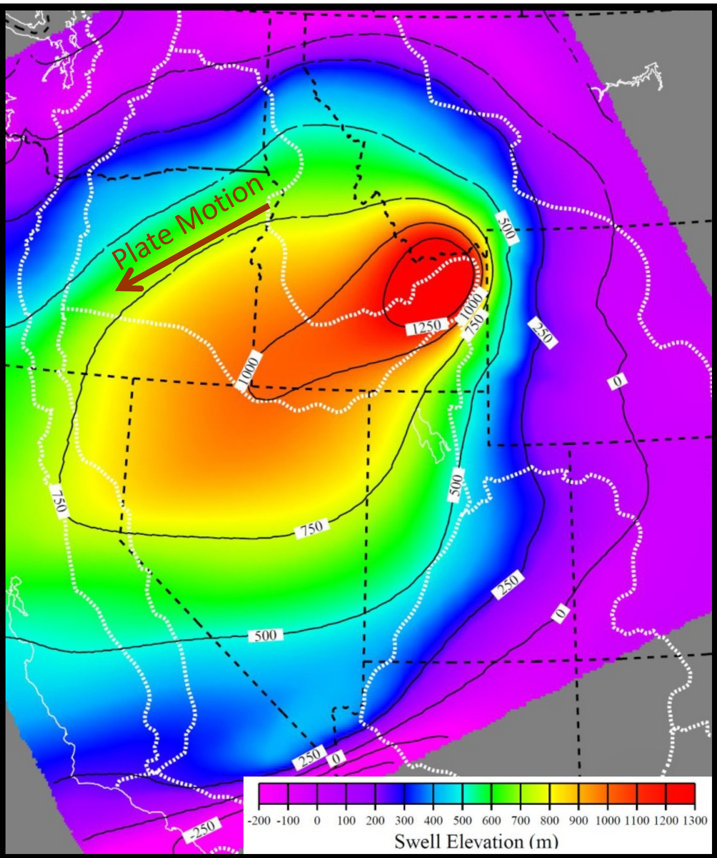
"... the identification of alternative models for mantle flow beneath the HLP is important."




Lowry et al. (2000): Dynamic elevation model for the Yellowstone Swell



Yellowstone Geoid Anomaly (Smith and Milbert, 1999)

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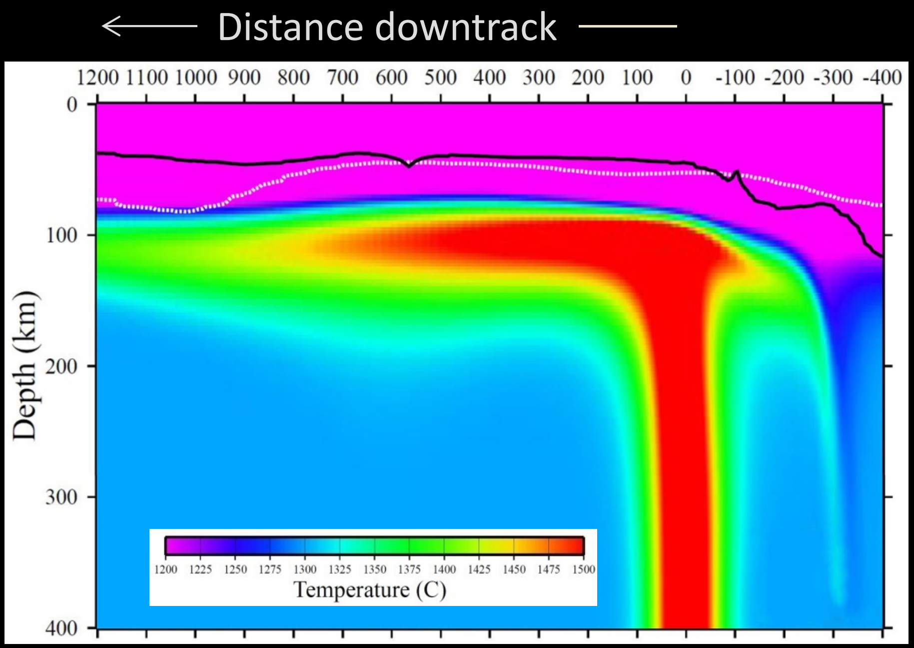
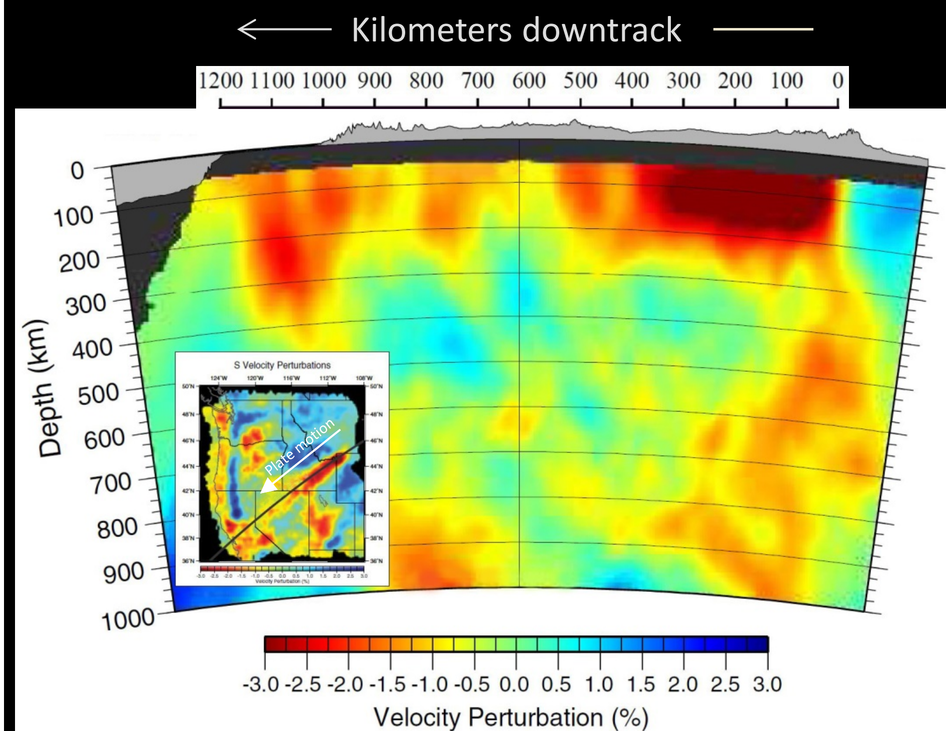
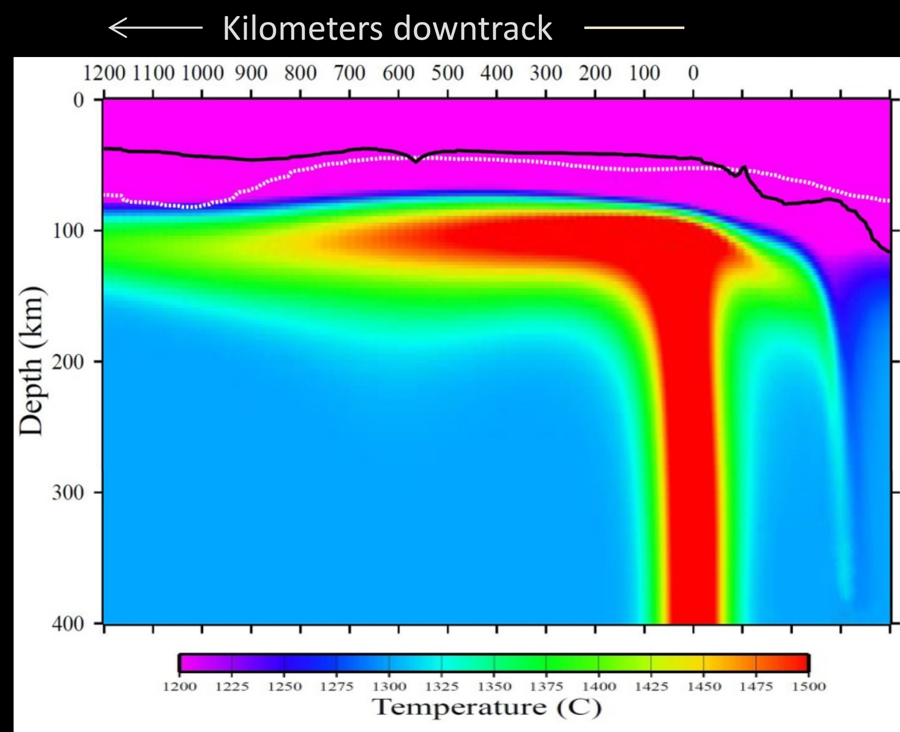


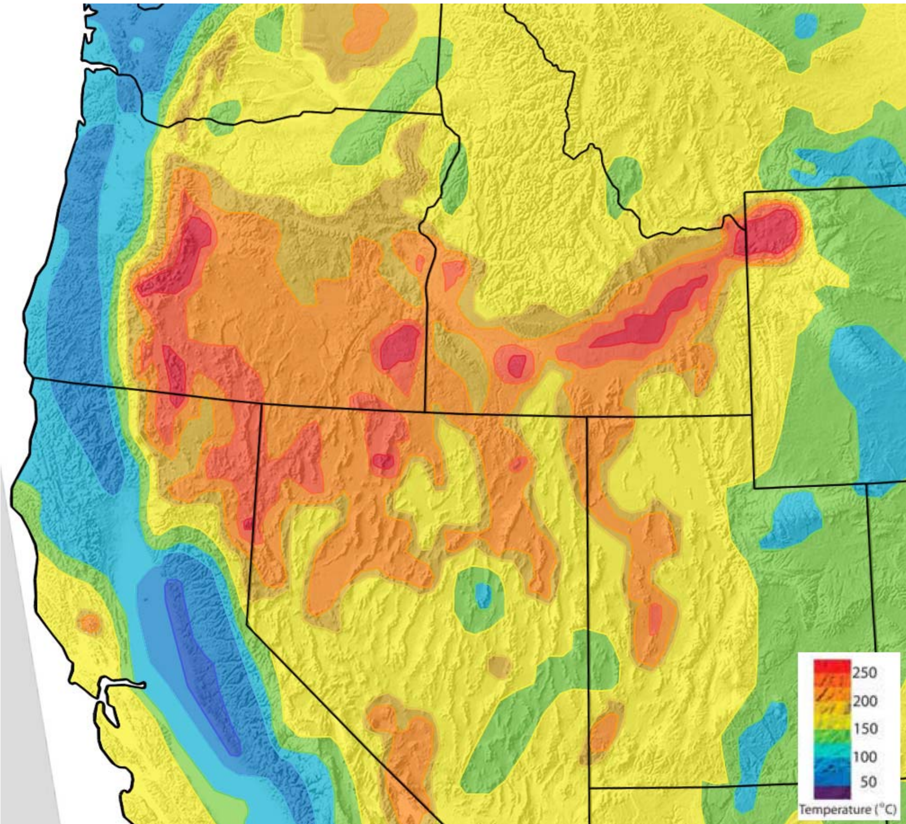

Lowry et al. (2000): Thermal structure



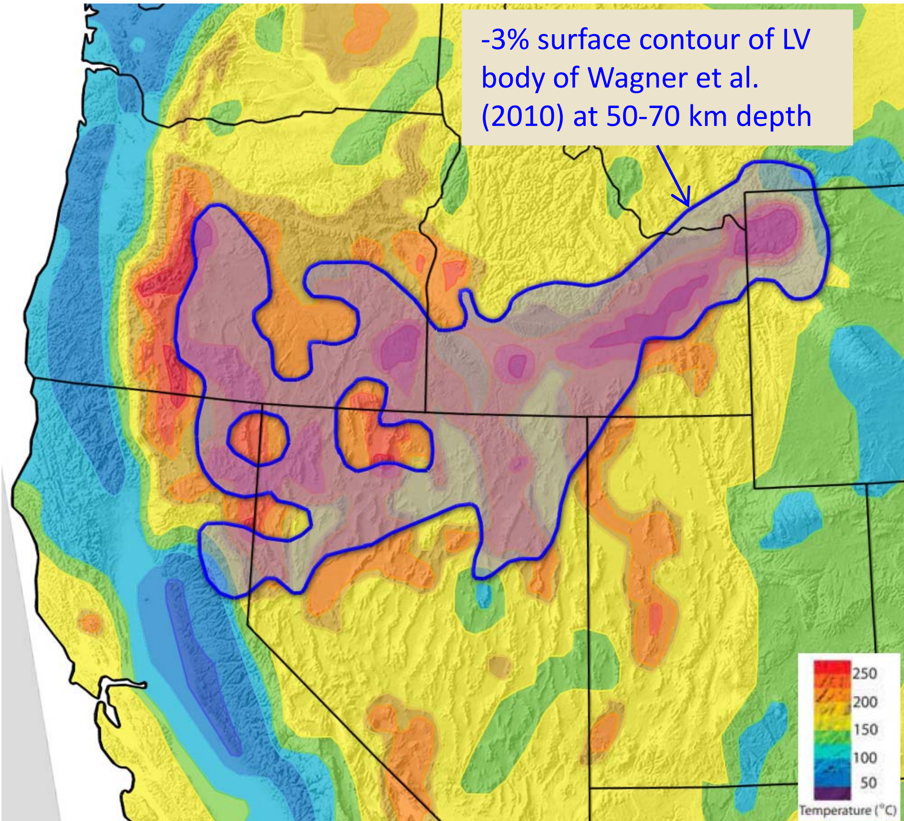

Low-density structure (James et al., 2011)



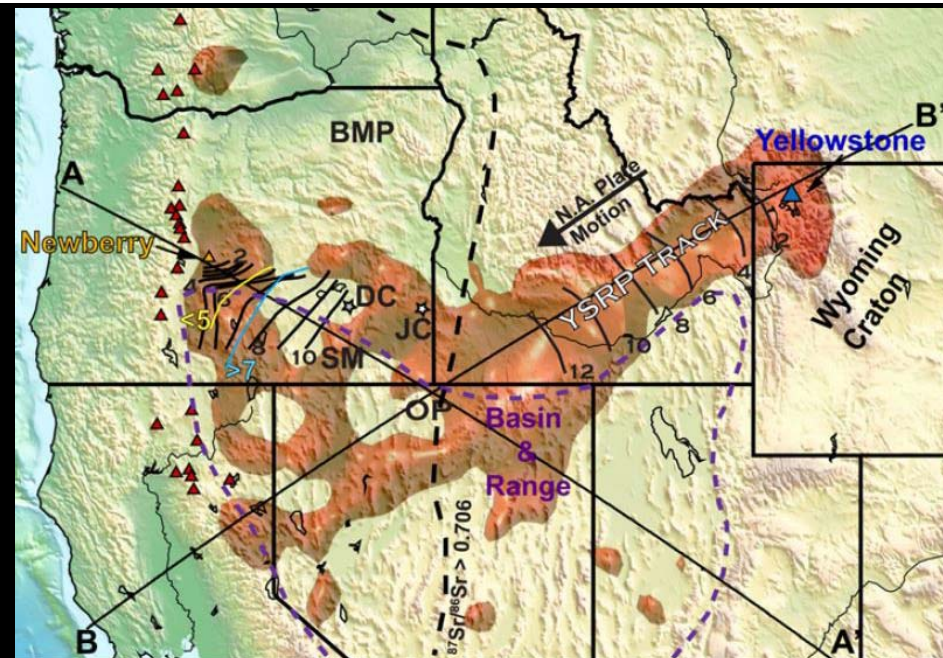

Modelled thermal structure (Lowry et al., 2000)



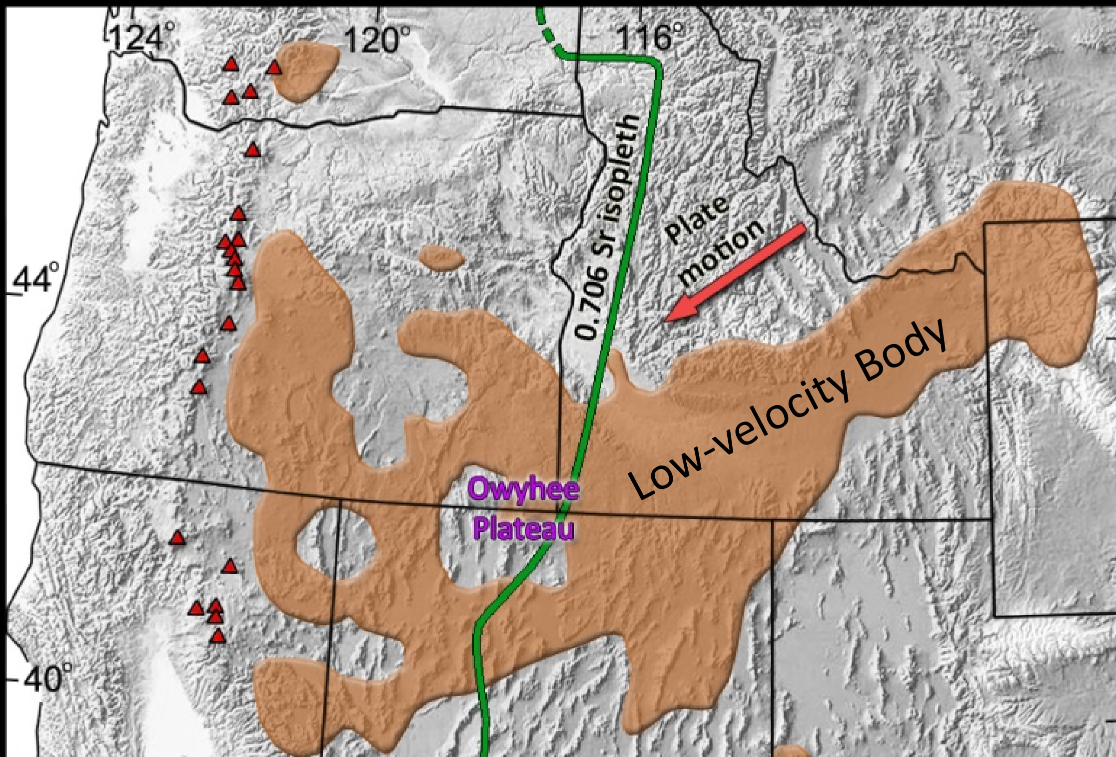

Estimated temperature at 5 km depth
(Bouligand et al., JGR, 2009)



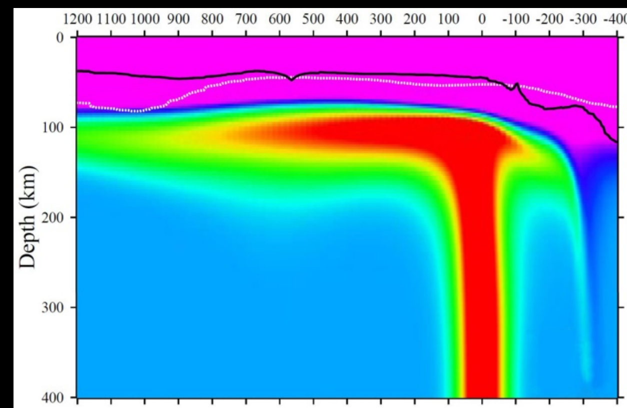

Estimated temperature at a depth of 5 km (Bouligand et al., JGR, 2009)

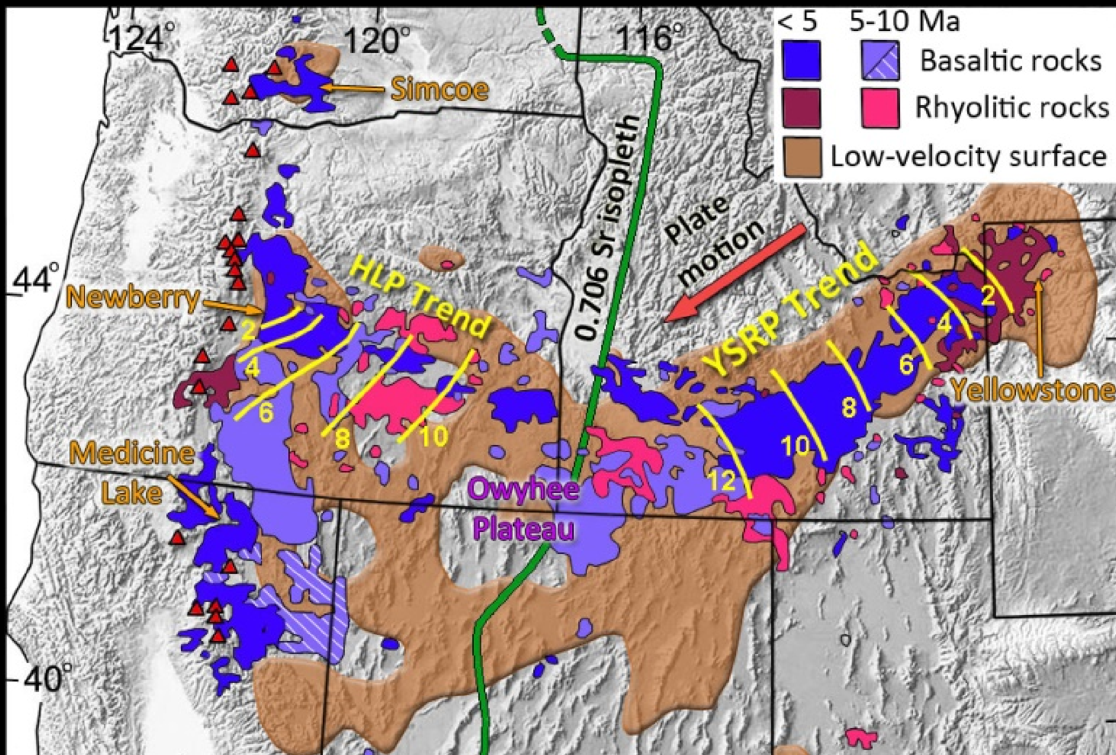



3% Surface contour of Low Velocity body of Wagner et al. (2010)

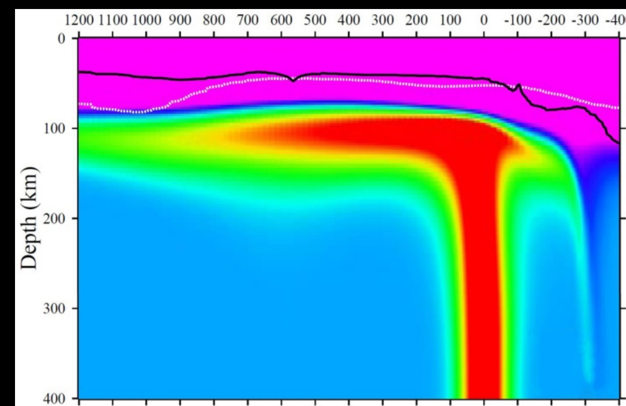


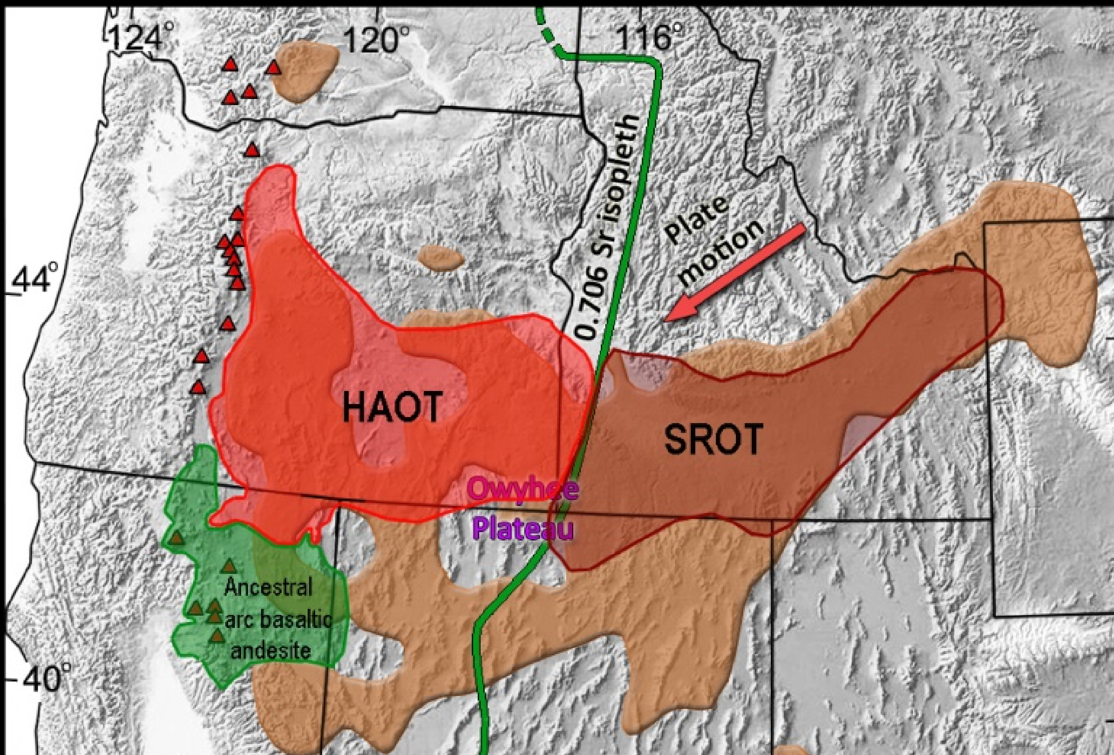

Low-velocity surface of Wagner et al. (2010)



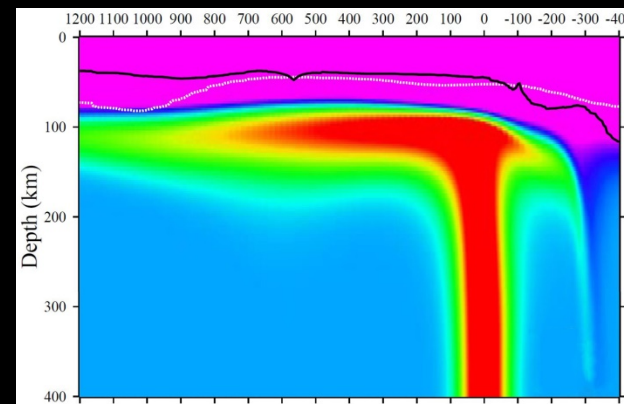


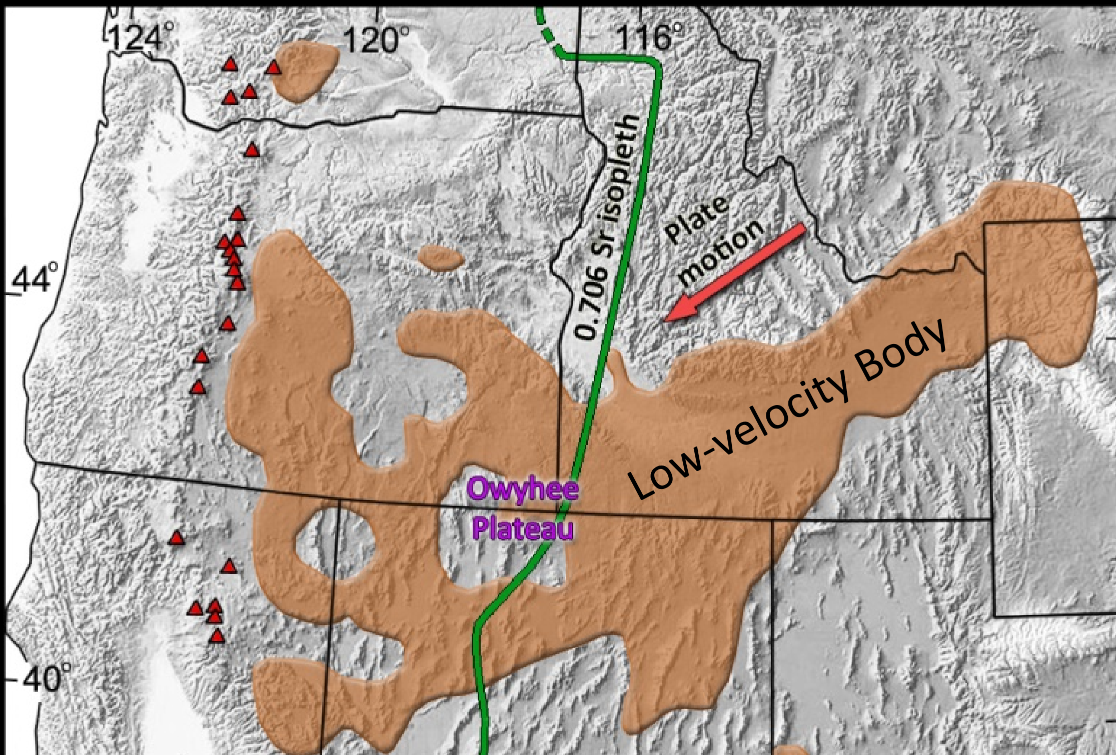

Low-velocity surface of Wagner et al. (2010)



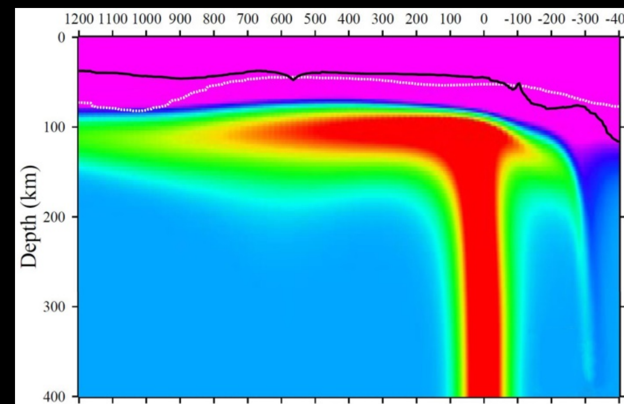



Low-velocity surface of Wagner et al. (2010)





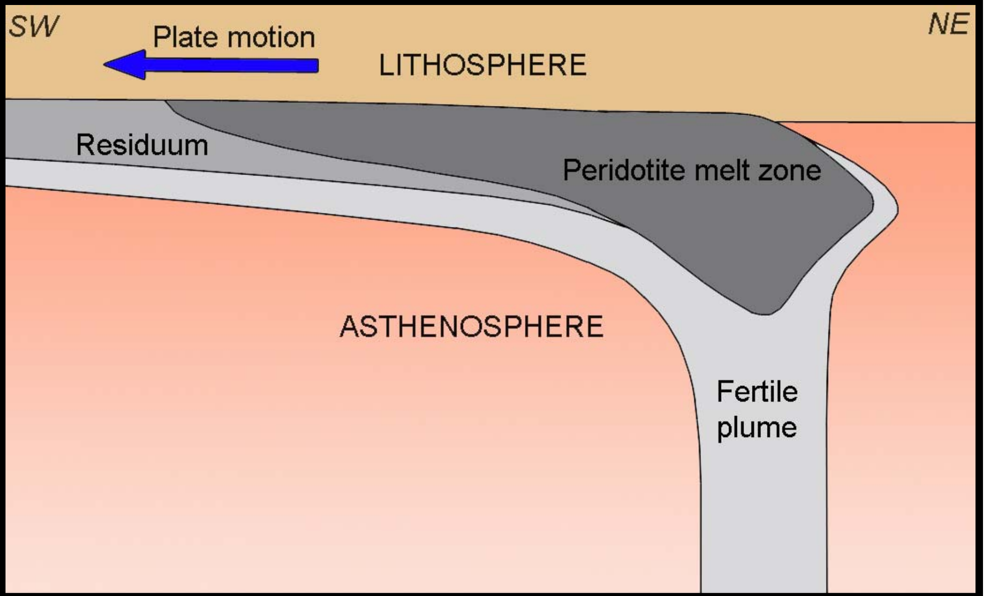

Low-velocity surface of Wagner et al. (2010)




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

# CONSTRAINTS ON PLUME FLUX

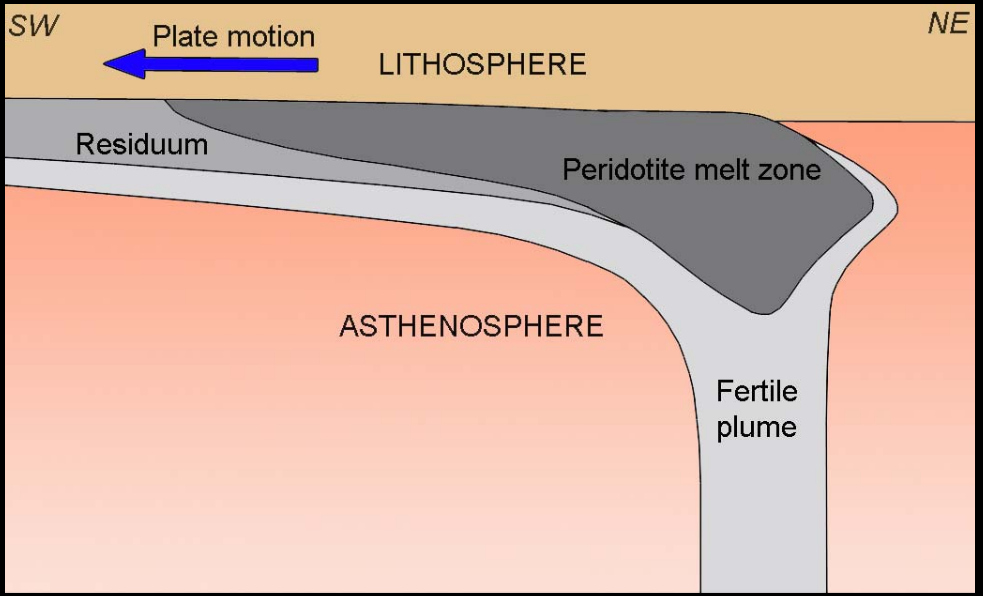
- SRP basalt isotopes reflect a primary plume source that comprises mass fractions >95% in the derivative lavas (Hanan et al., 2008).
- A near constant supply of this fertile source is necessary to generate a steady state in the volume and composition of SRP tholeiite.
- Plume volume is therefore assumed 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 $15\ m^3\ s^{-1}$

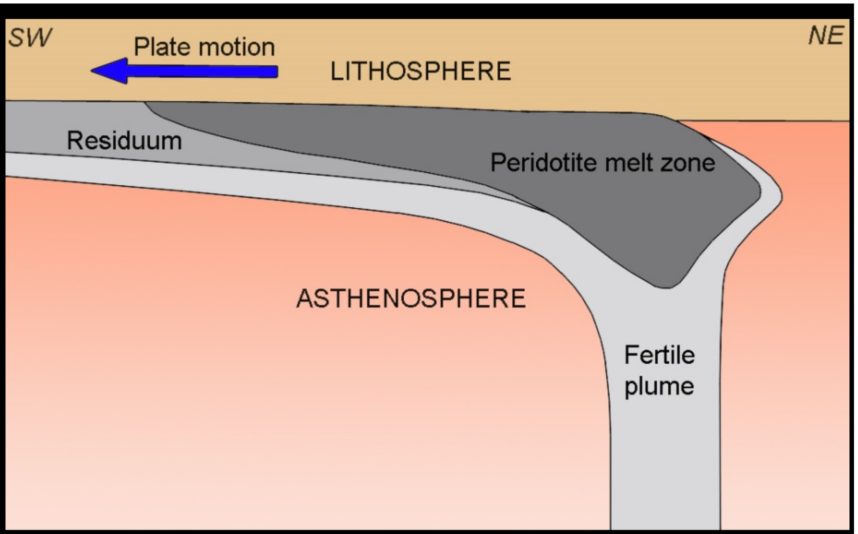



* Based on the volume mantle-derived melt added to the YSRP crust between 11-4 Ma, (340,000 $km^3$; McCurry and Rodgers, 2009).
** Based on data for central SRP tholeiites (Shervais et al., 2005)

## MINIMUM MANTLE FLOW RATE:

Cross-sectional area for plume channel (Stachnick et al., 2008) = 8250 $km^2$

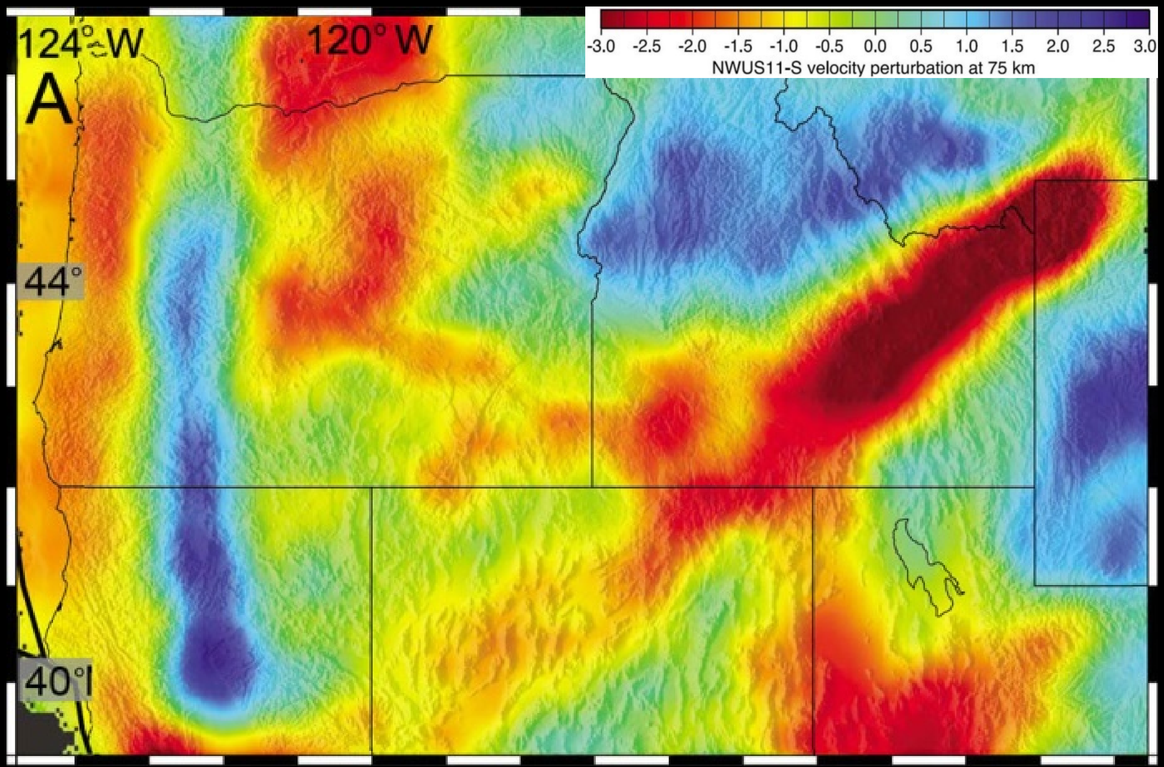
The *most conservative value* for plume volume flux (15 $m^3 s^{-1}$):




Mantle flow rate = 59 km/Ma

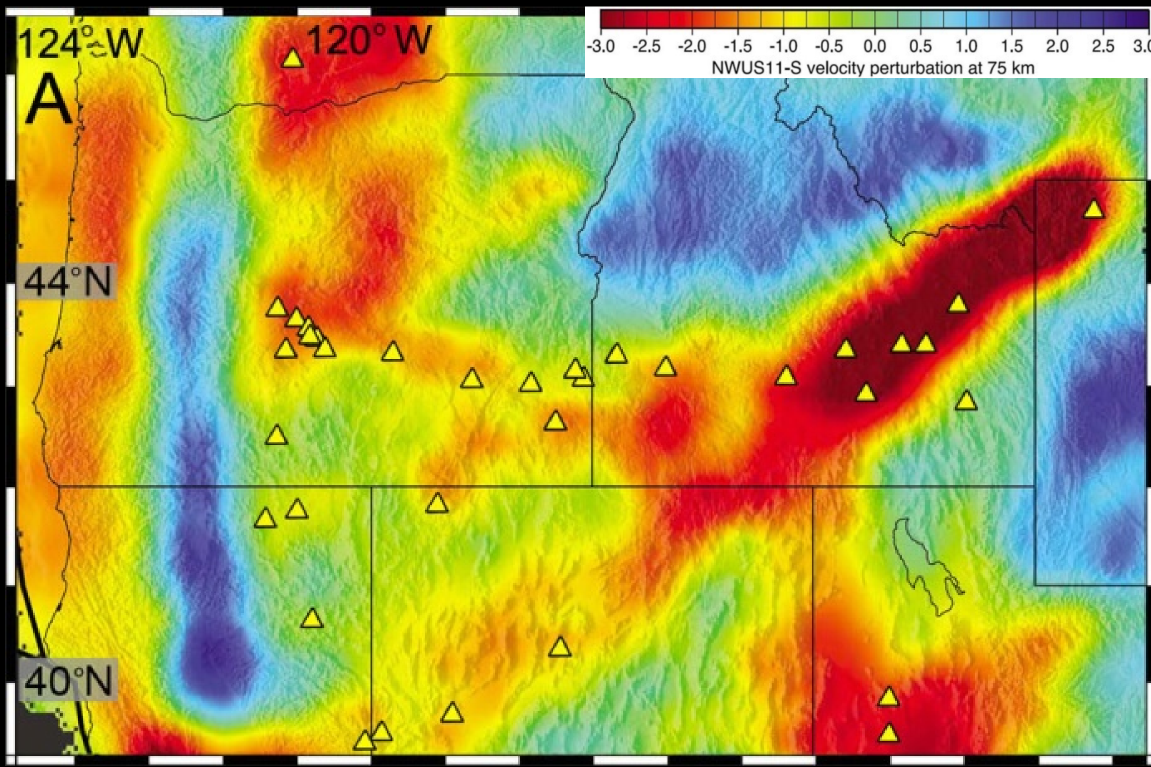
## TOTAL VOLUME OF PLUME SOURCE SINCE 12 Ma:

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.

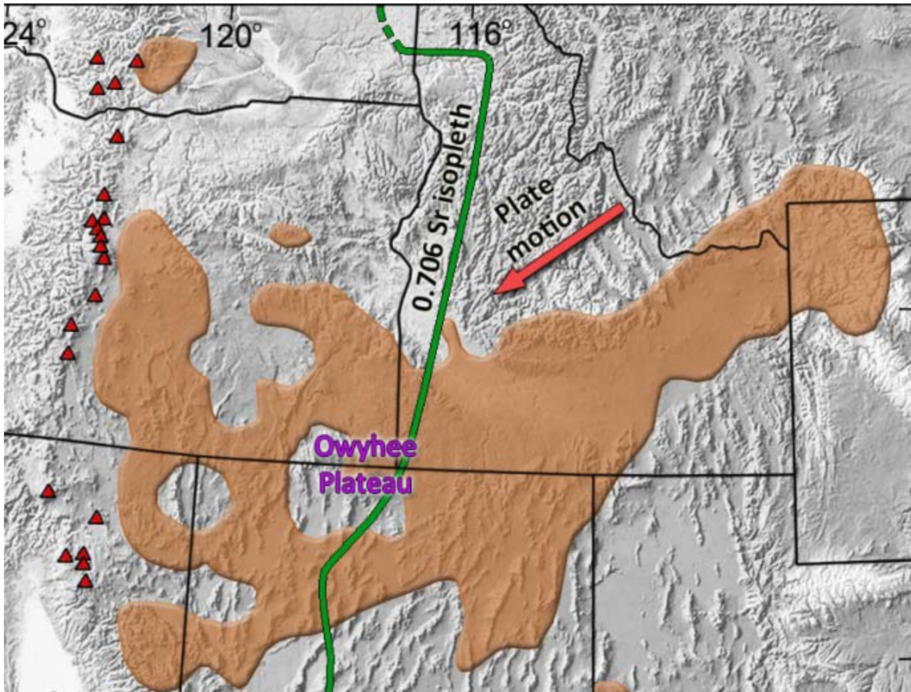



Slice through the upper part of the LV feature at 75 km depth

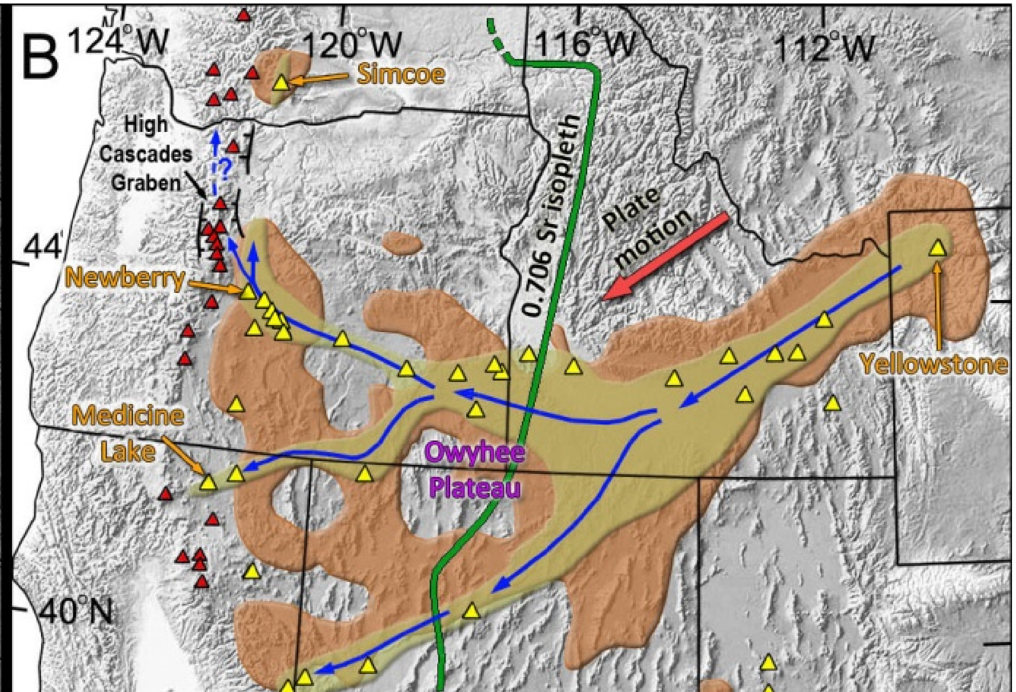
(derived from the model of James et al. [2011])




▲ = Quaternary volcanism (from Smithsonian GVP)

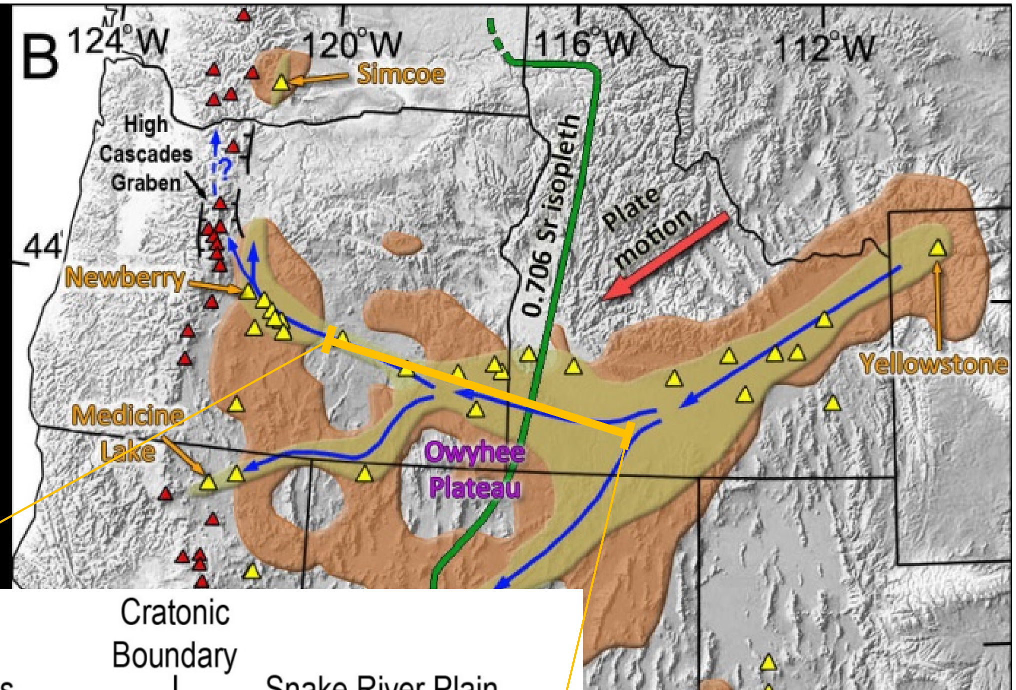


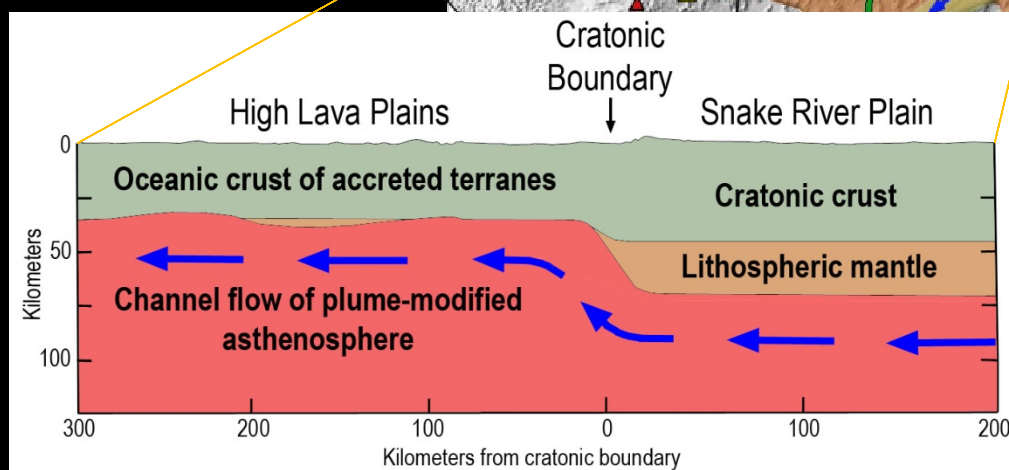

Plume-modified mantle: spreading and entrainment since ~16.7 Ma.



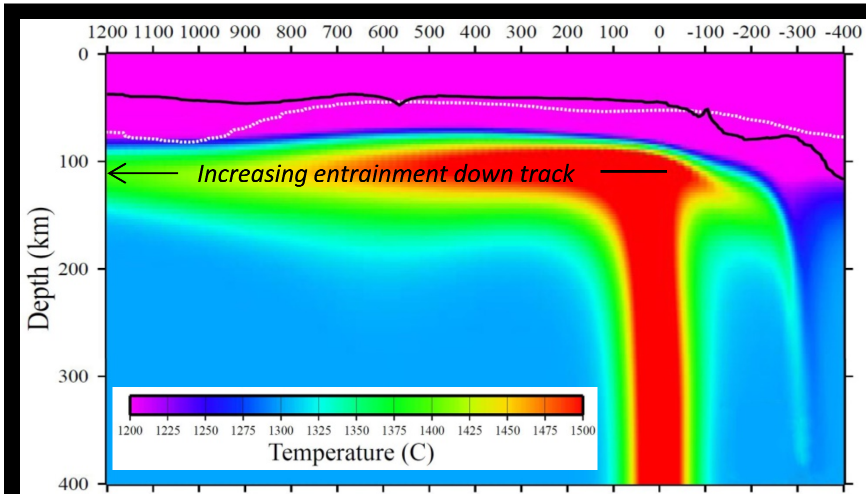

Young *flow-line channels of hot mantle* form within the broader region of warm plume material (Sleep, 2008).

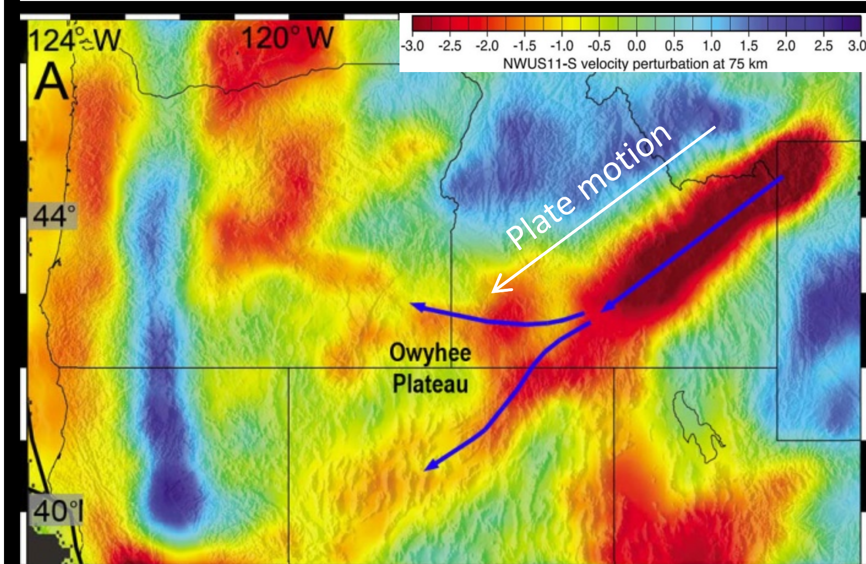
Rapid, buoyancy-driven channel flow across an abrupt slope at the cratonic boundary, westward into a thin lithosphere beneath the HLP.

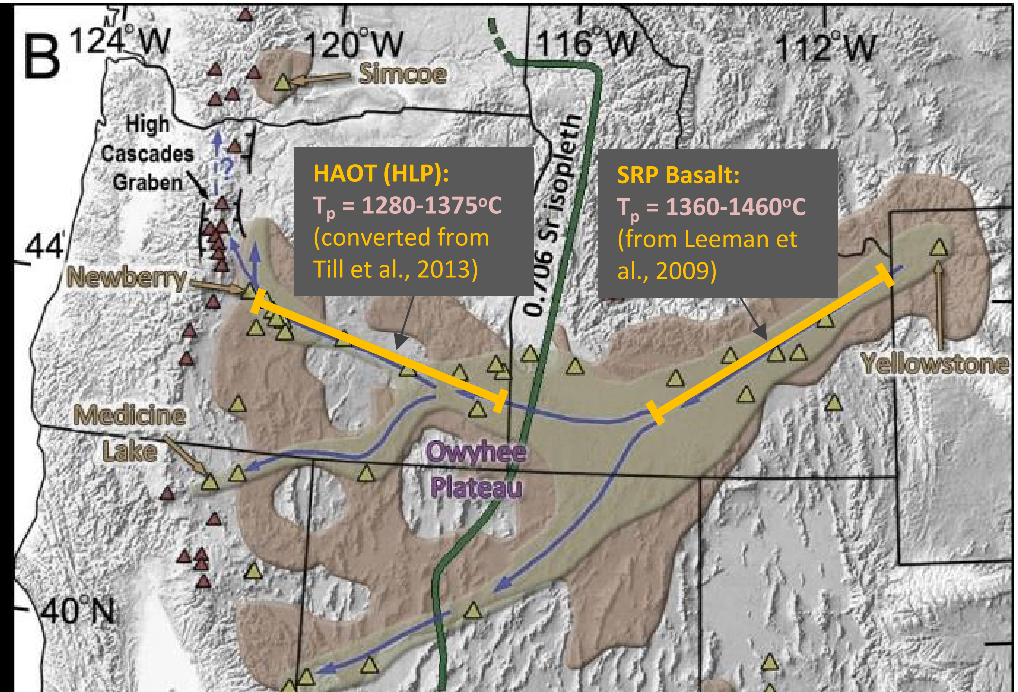


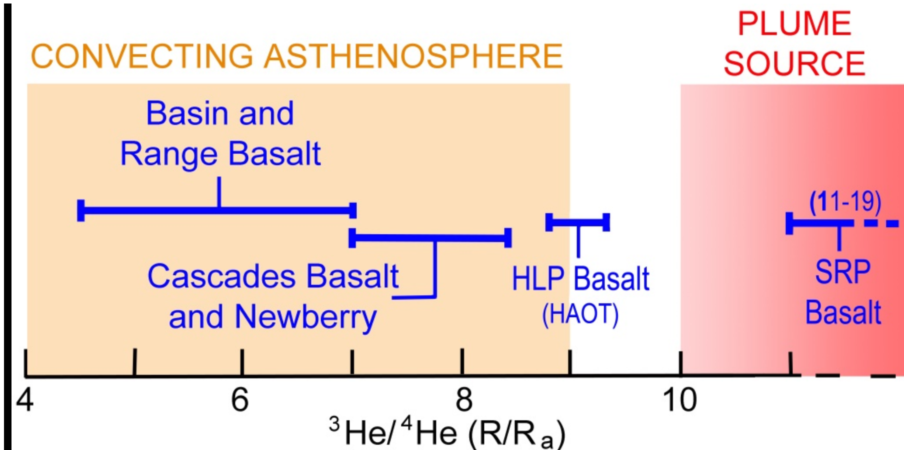

Asthenosphere depths from Chen et al. (2013)

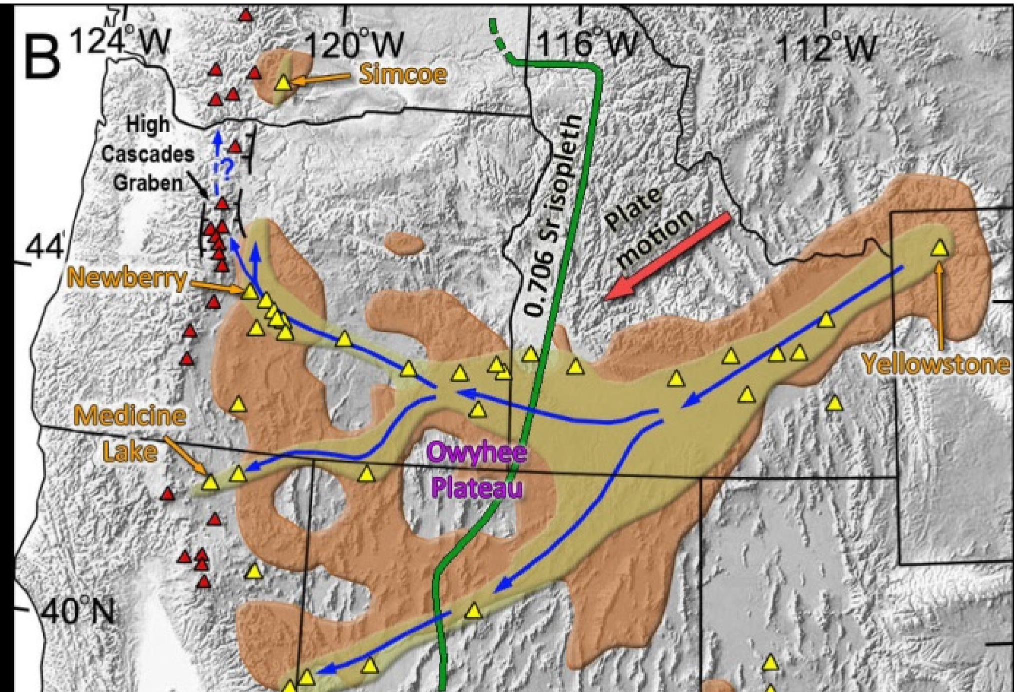


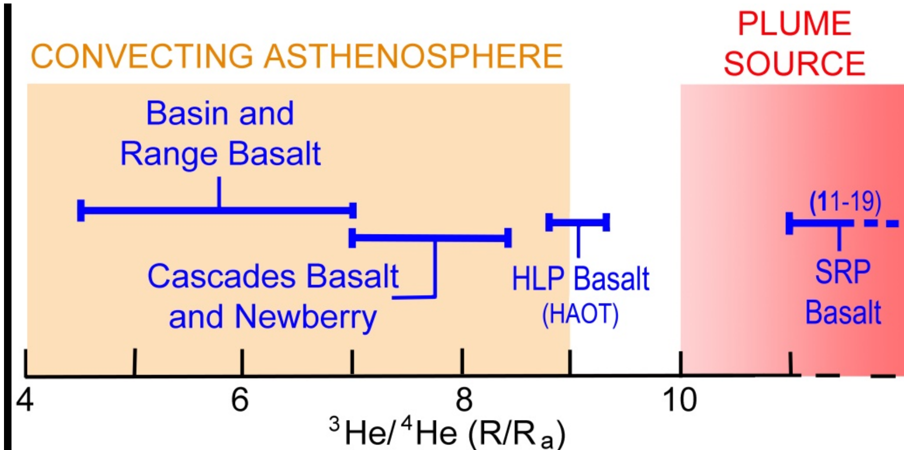



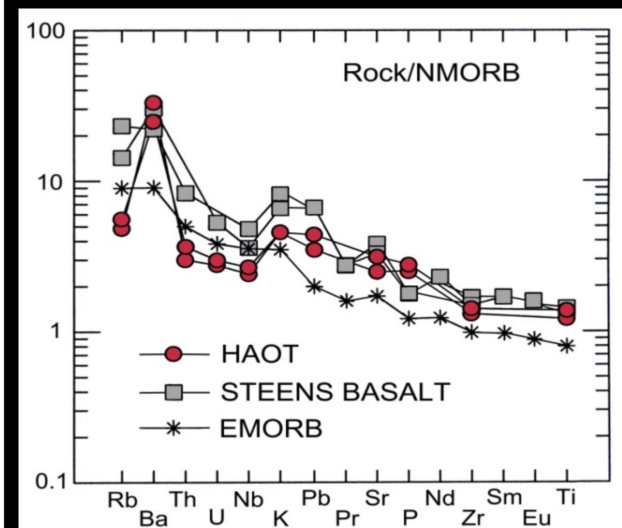

Down-track spreading of plumes can *entrain a significant amount of colder, depleted mantle,* with temperatures decreasing in the down-stream direction (e.g., Richards and Griffiths, 1989; Harp and White, 2001).

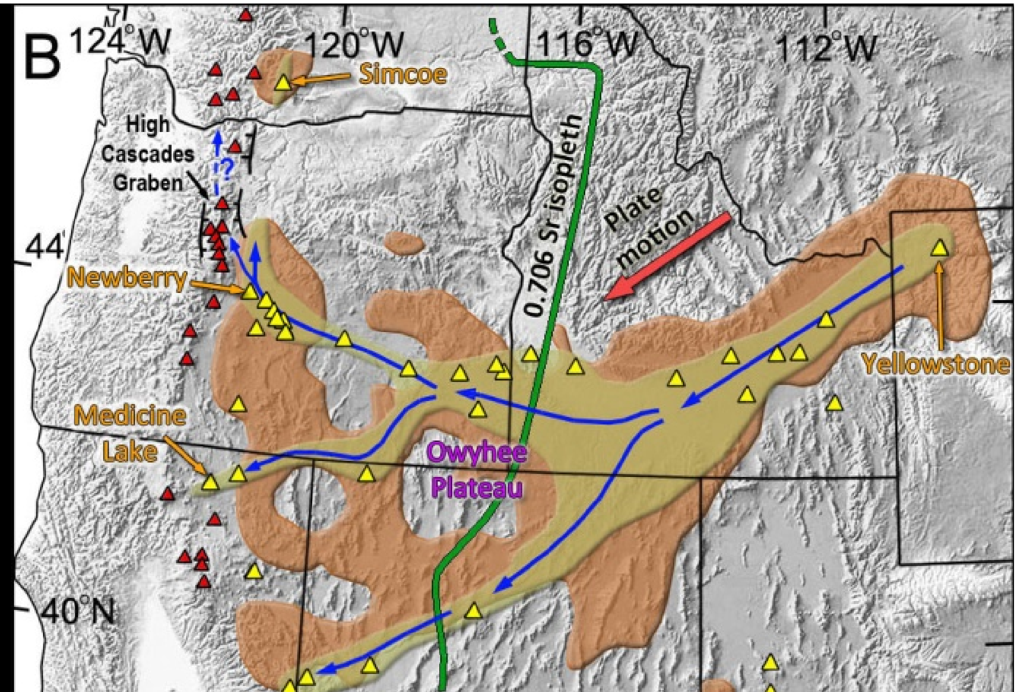



The progressive decrease in $^3He/^4He$ to the west is consistent with increasing entrainment of depleted mantle and dilution of a plume component.




HAOT trace-element pattern:
Similar to EMORB and Steens Basalt thought to be derived from plume-modified mantle.