A plume-triggered delamination origin for the Columbia River flood basalts

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After being overridden by N. America, the Yellowstone hotspot reemerged “on track” when the Columbia River flood Basalt (CRB) eruptions started in SE Oregon with the Steens basalts. Then, a set of strange things occurred: (Fig. A) CRB magmatism propagated rapidly northward, where the Grande Ronde erupted very volumes; (Fig. B) the isolated Wallowa batholith (age=120 Ma) uplifted 2 km, centered in an uplifted topographic bullseye; (Fig. C) a large high-velocity structure was left dangling vertically ~300 km beneath the Wallowa Mts.

To explain these features, we first note that the preceding tectonic/volcanic history suggests Farallon slab was at the base of NE Oregon prior to the CRB eruptions (details at poster). We attribute northward CRB propagation to a plume-triggered rollback-style of delamination of this Farallon lithosphere (see Fig. D for conceptual model), which today is imaged as the high-velocity structure still dangling beneath NE Oregon (Fig. C). This structure is too fast and large to be anything but ocean lithosphere. When delamination rollback reached the Wallowa batholith, its dense root foundered, exciting increased volcanism and causing Wallowa Mt uplift.

(A) Regional topography, showing the location and timing of CRB fissure eruptions. These started in the south with the Steens eruptions and propagated rapidly to the north. The Grande Ronde erupted 70% of the total CRB volume.
(B) Post-CRB uplift (left panel), derived from the now-warped CRB flow interfaces. The Wallowa batholith (and only the batholith) rose 2 km. Right panel shows the distribution of granites in the NE Oregon region.
(C) P-wave tomographic image of the upper mantle (and crustal structure and Moho depth, from Gao et al., 2011).
(D) Model of melt-enabled Farallon lithosphere delamination (green), followed by batholith foundering (purple).