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Constraining the origin of the Yellowstone-Snake River Plain volcanic province using seismic imaging

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Since the inception of the whole-mantle plume hypothesis, the Yellowstone-Snake River Plain (YSRP) volcanic track has been a candidate location for such a plume. Various alternative hypotheses have also been proposed including a propagating rift (e.g. Christiansen et al., 2002) and, more recently, polodial flow in response to slab rollback (e.g. James et al, 2011). We use seismic imaging techniques, in conjunction with other geological and geochemical constraints, in an attempt to distinguish between these various hypotheses. Our 3D seismic velocity model, DNA12, uses data from the Earthscope and ANSS regional networks, and integrates teleseismic body- and surface-waves with ambient noise constraints. The resulting P- and S-velocity models constrain the structure of the crust, lithosphere and mantle to a depth of ˜1000 km. The models have their best resolution beneath the western two thirds of the US. Beneath the YSRP we find the strongest low velocity anomaly found anywhere in the lithosphere. In the 50-250 km depth range the low velocities are elongated in a northeast-southwest direction along the Snake River Plain. Deeper, in the transition zone, the low velocity is more circular in shape and localized to the northwest of the Yellowstone Caldera with higher velocity anomalies surrounding it. In the deepest part of the model, down to 1000km, the low velocity anomaly becomes much broader again. While the propagating rift hypothesis is inconsistent with the tomographic images, the plume and polodial flow hypothesizes are consistent and complementary. A hybrid model consistent with the images has a deep to mid-mantle heat source (˜1000 km or greater depth) feeding a plume conduit that flows in response to surrounding mantle forces. The early phases, before the 17Ma eruption of the Columbia River Basalts (CRB), would include a plume head buoyantly supporting the flattened Farallon slab. Existing weaknesses in the slab would eventually lead to slab fragmentation allowing the plume head to erupt and form the CRB (Obreski et al., 2010). The flow of the plume tail would then be perturbed and forced to dip towards the northwest in the upper mantle (Smith et al., 2009) while the rollback of the shortened Juan de Fuca slab draws the residual material westward creating the Newberry Volcanic track of the High Lava Plains (Long et al., 2012).

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