Paleogene to Neogene alkaline lavas as a probe of the lithosphere-asthenosphere boundary (LAB) beneath western Canada

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The origin and evolution of high heat flow and a thin, hot lithosphere in the North American Cordillera in Canada is debated in geophysically-based models to have formed as either (a) ancient thinned lithosphere or (b) complete wholesale replacement followed by thickening and cooling in the past 5 - 25 Myr. We address this problem using published alkali olivine basalt and basanite lavas (n=128) hosting mantle xenoliths and erupted in the period 28 Ma to 8 ka over most of the region. We invert the bulk composition of the lavas for their P-T of origin using methods described in [1]. Using only mantle xenolith-bearing magmas confirms the lavas are least modified and most likely derived below the LAB. A range of possible H_2O, Fe^{3+}/total Fe and mantle olivine compositions (Fo_{88-90}) result in uncertainties of ±10 km and T of ±5%. Assuming a source mantle with 100 ppm H_2O, the depths of origin for the lava suites varies from 120 – 55 km with no obvious spatial variation. The oldest xenolith-bearing lavas have the shallowest depth of origin but host the hottest mantle xenolith suite. Extant limited age dating of lavas shows a possible increase in potential temperature (Tp) of ~ 100 C or increasing H_2O in the mantle source from 25 Ma to Holocene. The P-T of origin of the lavas is consistent with seismic receiver functions in the western USA that show a LAB at 65±10km underlain by slow wave speeds (attributed to partial melt) extending to ~ 150 km. The LAB is interpreted as the intersection of a <50 ppm H_2O mantle solidus with the Cordilleran geotherm and asthenosphere adiabat - all alkali basalts and basanites can be derived below this from wetter mantle with >100 ppm H_2O.

[1] Plank&Forsyth, 2016, G-cubed