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Implications of thermal disequilibrium during channelized melt-transport for the evolution of the lithosphere-asthenosphere boundary in intraplate settings

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This study explores how thermal disequilibrium during channelized melt-infiltration modifies the continental lithosphere from beneath. For this purpose, a 1D model of thermal disequilibrium between melt-rich channels and surrounding melt-poor material was developed, allowing us to estimate heat exchange across channel walls during melt transport at the lithosphere-asthenosphere boundary (LAB). For geologically-reasonable values of volume fraction of channels (φ), relative velocity across channel walls (v), channel spacing (d), and timescale of episodic melt-infiltration (τ), disequilibrium heating may contribute $>10^{-3}$ W/m^3 to the LAB heat budget. During episodic melt-infiltration, a thermal reworking zone (TRZ) associated with spatio-temporally varying disequilibrium heat exchange forms at the LAB. The TRZ grows by the transient migration of a disequilibrium-heating front at material-dependent velocity, reaching a maximum steady-state width δ□[$\varphi v d^{-2} \tau^2$]. The model results have implications for the Cenozoic evolution of the western US, specifically during the time period following the middle-Cenozoic ignimbrite flareup, and can be used to interpret a disparate set of previously published geophysical and geologic observations from the western US. The spatio-temporal scales associated with establishment of the TRZ in the models are found to be comparable with those inferred for the migration of the LAB based on geologic and petrologic observations within the Basin and Range province. More generally, the geochemistry of Cenozoic basalts across the region indicate a process in which melt-infiltration may have hastened the thinning and weakening of the lithosphere during and following the mid-Cenozoic ignimbrite flare-up, prior to Neogene extension.