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Evaluating the Effects of Spreading Rate and Melt Addition on the Closure Temperatures Recorded by Peridotite Thermometers

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The closure temperature recorded during peridotite cooling is a powerful tool to constrain the thermal history of uplift and exposure across various tectonic settings. The most widely applied thermometers (T_{BKN}, T_{REE}) require the coexistence of two pyroxenes, but other thermometers are necessary for clinopyroxene-poor lithologies. Olivine-spinel exchange thermometers are of particular interest as they can be applied to all peridotite lithologies. Here we apply and compare six thermometers to abyssal peridotites from fast and ultraslow spreading centers.

The temperature ranges recorded by the thermometers suggest different thermal histories when comparing individual sample suites. Among our 31 abyssal peridotites, temperatures recorded by pyroxene-based thermometers are relatively higher, with T_{REE} recording near-solidus temperatures (1100-1450˚C), followed by $T_{Ca\text{-}in\text{-}opx}$ (900-1300˚C) and T_{BKN}(800-1200˚C). In contrast $T_{ol\text{-}spl\ Fe\text{-}Mg}$, $T_{Al\text{-}in\text{-}ol}$, and $T_{Ca\text{-}in\text{-}ol}$ record lower closure temperatures (700-1000˚C), with $T_{Al\text{-}in\text{-}ol}$ being the lowest. The closure temperature differences recorded by the thermometers reflect the range of diffusivities of the exchanging species and the cooling rate. Harzburgites from the fast-spreading locality (Hess Deep) generally record higher temperatures compared to those from the ultraslow spreading ridges (Gakkel and Southwest Indian Ridge). Hess Deep temperatures for $T_{Al\text{-}in\text{-}ol}$ and $T_{Ca\text{-}in\text{-}ol}$ are 1000-1100˚C, $T_{ol\text{-}spl\ Fe\text{-}Mg}$ is 900 ˚C and $T_{Ca\text{-}in\text{-}opx}$ is 1300˚C. Gakkel and Southwest Indian Ridge peridotites have an average temperature for each thermometer that is 100-300˚C lower. The lower closure temperatures at the ultraslow spreading ridges are best explained by the slower emplacement rate.

Melt-veined peridotites have closure temperatures from the six thermometers that are relatively lower (800-900˚C) compared to nominally melt-free peridotites. Furthermore, among these melt-veined peridotites, T_{BKN}, $T_{ol\text{-}spl\ Fe\text{-}Mg}$, $T_{Al\text{-}in\text{-}ol}$, and $T_{Ca\text{-}in\text{-}ol}$ are generally in agreement with each other, suggesting that the presence of infiltrating melt facilitates thermal re-equilibrium. T_{REE} and $T_{Ca\text{-}in\text{-}opx}$ are only slightly lower than in melt-free peridotites, probably due to the sluggish diffusion of the respective species between two pyroxenes during cooling. Our results indicate that thermometers applicable to clinopyroxene-poor lithologies can also be compared to each other in a similar manner to the standard comparison of T_{BKN} and T_{REE} to reveal the cooling history of a peridotite.