Estimating crustal heat production from the petrochronology of lower crustal xenoliths

FRANCISCO APEN[1*], ROBERTA RUDNICK[1], JOHN COTTLE[1], DMITRI IONOV[2], JEAN-FRANÇOIS MOYEN[3], ALEXANDER GOLOVIN[4]

[1]Department of Earth Science, University of California, Santa Barbara, USA (*correspondance: apen@ucsb.edu)
[2]Géosciences Montpellier, Université de Montpellier, Montpellier, France
[3]Département de Géologie-Pétrologie-Géochimie, Université Jean-Monnet, Saint-Etienne, France
[4]Sobolev Institute of Geology& Mineralogy, Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia

Radiogenic heat production in the continental crust accounts for a significant portion of Earth's total heat budget. Past crustal heat production estimates have relied on surface heat flux and an assumed mantle heat flux. However, few direct constraints on mantle heat flow—and hence Moho temperature—exist. Here we constrain crustal heat production in the Tanzanian and Siberian cratons using combined U-Pb and trace-element petrochronology of accessory minerals from lower crustal xenoliths. We derive permissible Moho temperatures from titanite, rutile, and apatite in xenoliths erupted from Quaternary volcanoes in the Tanzanian craton and adjacent Mozambique belt and the Devonian Udachnaya kimberlite pipe in the Siberian craton.

Near-Moho depth xenoliths from Tanzania include a set of garnet two-pyroxene granulites that experienced peak pressures >1.6 GPa during Proterozoic continent collision. Titanite yields a range of U-Pb dates that, along with Sr, Nd, and Zr measurements, suggest prolonged recrystallization in the lower crust. Rutile and apatite do not contain measureable radiogenic Pb despite appreciable amounts of U. These data indicate that the Moho beneath the craton and belt is cooler than the Pb closure temperature of titanite, but hotter than that of rutile and apatite. Using regional surface heat fluxes, we obtain crustal heat production values <0.6 $\mu W/m^3$ for the craton and 0.4–1.1 $\mu W/m^3$ for the belt.

Preliminary analyses of rutile and apatite in amphibolite- and granulite-facies xenoliths from Udachnaya reveal complex age patterns that suggest prolonged residence below their respective Pb closure temperatures. Based on these data and available heat flow measurements, we infer a very low heat production for the Siberian craton (<<0.5 $\mu W/m^3$). Collectively, the data for both localities point to exceedingly low crustal heat production in these cratons, which lie at or below the lower limit previously estimated for Archean crust.