How continents form: insight from Pb isotopes measured on K-feldspar inclusions within zircons

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About 80% of the present day crust is generated in subduction settings, with the rest being mostly generated in intraplate settings. A major uncertainty in the rock archive is the balance between subduction and intraplate magmas in the generation of continental crust.

Intraplate-related and subduction-related magmas have different U/Pb ratios with median values of 0.33 and 0.09 respectively. The U/Pb ratio can therefore be used as a proxy for the tectonic settings in which the continental crust is generated. However since most crustal rocks have been derived from pre-existing crust, the initial composition of juvenile continental crust has remained difficult to determine.

This study presents a new way to see back to the composition of that new crust, based on ion probe analysis of Pb isotopes in K-feldspar and plagioclase inclusions within well-dated zircons. The Pb isotope data are used to calculate the time-integrated U/Pb ratios (i.e. $^{238}U/^{204}Pb = \mu$) for the period between the Hf model age and the U-Pb crystallization age of the zircons. Since the model age indicates when new crust was generated, the time-integrated U/Pb ratios reflect the geodynamical setting of the formation of new continental crust.

Two test samples with Proterozoic Hf model ages and Paleozoic crystallization ages have feldspar inclusions with Pb isotope ratios that overlap within analytical error for each sample. Sample Z7.3.1 from Antarctica has initial Pb isotope ratios ($^{206}Pb/^{204}Pb_{average}$ = 16.88 (±0.08σ)) that indicate it was derived from source rocks with low U/Pb ratios (~0.1), similar to those found in subduction-related settings. Sample TEMORA 2 from Australia has more radiogenic Pb isotope ratios ($^{206}Pb/^{204}Pb_{average}$ = 19.11 (±0.23σ)) indicative of a source with higher U/Pb ratios (~0.4) similar to magmas generated in intraplate settings.

The use of this method on magmatic and detrital zircons with a range of Hf model ages (e.g., 4.5–0 Ga) opens new avenues to our understanding of the formation and the evolution of the continental crust through time.