# Internal Zr isotope zoning in magmatic zircons revealing magmatic thermal history

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Zircons widely occur in magmatic rocks and often display internal zonation finely recording the magmatic history. The isotopes of its major component Zr could be another powerful, but only limited explored tracer. Here we present the in-situ Zr isotope compositions of magmatic zircons by laser ablation MC-ICP-MS with high-spatial-resolution (20 µm) and high-precision values (2SD <0.20‰ for $\delta^{94}$Zr, the permil deviation of the $^{94}$Zr/$^{90}$Zr from the IPGP-Zr standard). The studied zircons are from mafic-felsic calc-alkaline plutonic rocks of the juvenile Gangdese arc, southern Tibet. The results show large variations in $\delta^{94}$Zr from −0.86‰ to 0.41‰. Most individual zircon grains show well-developed internal zoning with low $\delta^{94}$Zr in the core and higher values toward the rim, clearly indicating the preferential incorporation of light Zr isotopes into zircon from evolving melts. The crystallization of zircon would drive the residual melt to heavier Zr isotope compositions. The zoning profiles in zircon grains are well explained by the Rayleigh distillation model, which yield fractionation factors α between zircon and melt of 0.99955-0.99995. The average α of each sample is well correlated to the median Ti-in-zircon temperature. Large Zr isotope variations are expected in more evolved magmas with lower temperatures. These results solve the fundamental issue on the fractionation behavior of Zr isotopes during magmatic differentiation [1, 2]. The results also demonstrate that in-situ Zr isotope profiles in zircons could provide key insights into the thermal history of magmatic systems. The stable Zr isotopes thus have very promising applications in deciphering magmatic differentiation history as well as the formation and evolution of continental crust through time.

[1] Inglis et al. (2019) *Geochim. Cosmochim. Acta* 250, 311–323; [2] Ibañez-Mejia and Tissot (2019) *Sci. Adv.* 5, eaax8648.