Zircons of the Bushveld Complex – When and how did they form?

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The Rustenburg Layered Suite (RLS) of the Bushveld Complex (BC) represents Earth's oldest large igneous province (>370 000 km^3), and contains the world's largest reserves of platinum-group elements, chromium and vanadium. However, its mode of formation, the exact timing and nature of magma emplacement, solidification and sub-solidus cooling history remain a matter of debate. In this paper we present new data from zircons recovered from nine (ultra)mafic rocks of different units throughout the ca. 8 km thick RLS. Our datasets comprise new results of high-precision U-Pb dating obtained by CA-ID-TIMS, detailed information about zircon compositions, textures, zoning, crystallization temperatures, and mineral/melt inclusions. These data in combination reveal that zircon throughout the RLS crystallised within 1.02 ± 0.63 Ma from highly fractionated intercumulus melts at temperatures between 940° and 670°C. Zircon in quenched Marginal Zone rocks crystallized at 2055.91 ± 0.26 Ma, and slightly later at 2054.89 ± 0.37 Ma in cumulus rocks in the centre of the RLS [1]. This timing is in agreement with field observations and the results of thermal modelling, which require rapid accumulation of magma at a flux rate of >5 km^3/year over less than 100 ka [2], followed by crystallization and cooling to below 700°C within 300 to 950 ka.

Zircon zoning patterns additionally indicate that zircon crystallisation in economically important units like the UG2 chromitite layer and Merensky reef occurred in "closed system", and/or "open system" intercumulus environments during cooling. Cooling is well supported by systematic decrease of Ti from zircon core to rim (formed in assemblage with quartz and rutile). Initially "closed system" zircon growth is indicated by a systematic decrase in U (from 150 to 10 ppm) at increasing Th/U (from 0.8 to 10), that can be explained by Rayleight fractionation, and subsequent open system zircon growth by late rims with high U (>150 ppm), and low Th/U and Ti.

[1] Zeh *et at.* (2015) *EPSL* **418**, 103-114. [2] Cawthorn & Walraven (1998) *J. Petrol.* **39**, 1669–1687.