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New temporal records for old magmatic systems: advances in high precision $^{207}Pb/^{206}Pb$ geochronology

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Zircon geochronology in older magmatic systems typically favours $^{207}Pb/^{206}Pb$ dates for 'age interpretation' over U/Pb isotope systems due to higher analytical precision and 'zero-age' open system effects within the minerals dated. With mixed double-spiked U-Pb tracers and the advent of low-noise detector technology, analytical $^{207}Pb/^{206}Pb$ precision can now routinely approach the levels needed to examine timescales of magmatic processes in the first half of Earth's history. However, these analytical uncertainties are minor relative to uncertainties arising from quantification of potential inter- or even intra- sample differences in $^{238}U/^{235}U$.

The geological implications of uncertainty derived from zircon $^{238}U/^{235}U$ are illustrated by examining contrasting emplacement models for Earth's largest resource of PGEs, the ca. 2.055 Ga Rustenberg layered Suite, Bushveld Igneous Complex, South Africa (e.g. [1,2,3]). Emplacement models have been built around high-precision zircon $^{207}Pb/^{206}Pb$ dates, yet we show that apparently significant temporal differences can be accounted for by variation in zircon $^{238}U/^{235}U$.

The single zircon $^{238}U/^{235}U$ measurement required to address this issue presents challenges due to the large dynamic ratio, limited ratio variation, and principally, the typical amounts of U available. Whilst single crystal measurement has been achieved by conventional MC-ICPMS approaches [4], significant improvements to measurement and uncertainty propagation are required for more general application to U-Pb geochronology. Here, we demonstrate how recent developments in instrumentation and analytical approach for $^{238}U/^{235}U$ measurement on small amounts of U can be implemented to meet the challenges. We explore the new boundaries permitted by coupled high-precision U-Pb ($^{207}Pb/^{206}Pb$) and $^{238}U/^{235}U$ measurements, and how these can refine temporal models of geologically old magmatic systems. We also highlight the potential of single zircon $^{238}U/^{235}U$ measurement as a proxy to shed new light on the evolution of magmatic systems.

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