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Amplifying Earth history: Zircon U-Pb geochronology by ID-TIMS at the 0.1 ‰ level using new 10^{13} ohm resistors

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Precise and accurate radiometric dating of volcanic ash beds in sedimentary successions is the backbone of the numerical calibration of Earth history. Uranium-lead geochronology by isotope dilution thermal ionization mass spectrometry (ID-TIMS) is the most precise and accurate dating technique and is applicable to most of Earth history from the Hadean to the Pleistocene. The accessory mineral zircon is the prime target material due to its commonly high U concentration, virtually no initial Pb and high daughter-product retentivity. However, complex crystallization histories as well as magmatic and sedimentary recycling of zircons require the analysis of single crystals resulting in small amounts of radiogenic Pb (Pb* usually <100 pg) available for mass spectrometry. Precise and accurate isotope ratio determinations on such small samples require highly sensitive ion detection systems making ion counting detectors such as secondary electron multipliers and Daly photomultipliers the most commonly employed detectors for the analysis of small Pb* ion beams. While these detector systems are highly sensitive they are limited by their restricted linear dynamic range and require dynamic peak hopping to collect multiple isotopes. We recently demonstrated the applicability of new 10^{13} ohm resistors in the Faraday cup amplifier feedback loop for the static multi-collection of all tracer and sample Pb isotopes with ^{202,205,206,207,208}Pb measured on Faraday cups and ^{204}Pb measured in the axial SEM of a Thermo Scientific TRITON Plus TIMS instrument [1]. These measurements take advantage of the superior stability of Faraday detectors, their significantly larger dynamic range and the multiple advantages of static multi collector analyses (longer counting on peak, simultaneous collection of all isotopes etc.).

Here, we document recent advances in our analytical protocols that further improve the precision, accuracy and reproducibility of U and Pb isotope ratio measurements of small samples using static multi-collection with 10^{13} ohm resistors. We present high-precision U-Pb data for standard zircons and samples covering an age range from 2 Ma to 2 Ga. With this data set we demonstrate the ability to obtain single crystal U-Pb and Pb-Pb dates with uncertainties <0.2 ‰ for high-Pb* zircons and weighted mean ages for populations of closed system zircons with uncertainties <0.1 ‰ . This level of temporal resolution will allow to better quantify the timing and durations of critical intervals in Earth history, evaluate causalities between different events such as flood basalt eruptions and mass extinctions, quantify rates of changes in biodiversity and assess the origin of cyclic patterns in the sedimentary records.

[1] von Quadt, A., Wotzlaw, J.F., Buret, Y., Large, S., Peytcheva, I., Trinquier, A., 2016, High-precision zircon U/Pb geochronology by ID-TIMS using new 10^{13} ohm resistors. J. Anal. At. Spectrom., DOI: 10.1039/C5JA00457H