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Implementation of U-Th-Pb apatite dating by LA-MC-ICP-MS at CPGeo-USP: reference material assessment and thermochronological constraints on the southern Ribeira Orogen

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Apatite U-Th-Pb thermochronology bridges the gap between high-temperature zircon geochronology and low-temperature fission-track methods, recording thermal events within a closure temperature window of ~350–550 °C that are otherwise poorly constrained. Despite its potential, routine apatite U-Th-Pb dating demands careful reference material selection and robust common lead (Pbc) correction strategies, particularly when working with common lead-rich matrices typical of most natural apatites.

We present the implementation and validation of a complete analytical routine for U-Th-Pb apatite dating by laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) at CPGeo-IGc-USP, São Paulo, Brazil. A hierarchical calibration scheme was established using MAD-1 Madagascar apatite (485.0 ± 1.7 Ma, ID-TIMS [1]) as the primary standard, selected for its isotopic homogeneity and low Pbc content (<8%). Two secondary standards were employed for quality control: Kovdor apatite (~378 Ma [2]), which monitors matrix effects in Th-rich compositions, and Wilberforce apatite (~931 Ma [3]), which allows extending the validation into the Precambrian. Instrumental mass bias of Pb isotopes was corrected using NIST 612 glass. Analyses reproduced reference ages within uncertainty (Kovdor: 377.6 ± 2.6 Ma; Wilberforce: 950 ± 11 Ma). A computational workflow in a Jupyter Notebook automates data reduction and Pbc correction via the two-stage model of Stacey and Kramers (1975), improving traceability and reproducibility. External validation was achieved by re-analyzing Cubatão Shear Zone apatites previously dated [4], yielding concordant ages with reduced uncertainties (601.6 ± 3.6 Ma vs. 603 ± 7 Ma; 619.9 ± 1.9 Ma vs. 610 ± 8 Ma; Figure 1). Application to thirteen igneous and metamorphic samples from the southern Ribeira Orogen (Figure 2), including the Mongaguá and Registro complexes and the Cubatão, Itariri and Serrinha shear zones [5], produced U-Th-Pb apatite ages spanning through 600–500 Ma. These results record distinct thermotectonic episodes during late-stage cooling associated with Western Gondwana assembly, demonstrating that the routine yields precise thermochronological data in complex orogenic settings.

1. Thomson et al. (2012), *Chem. Geol.* 332–333, 218–228.
2. Amelin & Zaitsev (2002), *Chem. Geol.* 182, 23–37.
3. Paul et al. (2021), *Geostand. Geoanal. Res.* 45, 457–473.
4. Cabrita et al. (2022), *Tectonics* 41, e2021TC007119.



