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Tracking the transition from subduction to continental collision using Ce and Eu anomaly in detrital zircons

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Zircon geochemistry provides critical info on the melt from which they form. Trace element compositions of large set of detrital zircons can thus serve as proxies to quantitatively study the evolution of Earth's lithospheric processes. Experimental petrology and empirical calibrations allows these proxies to be used as magmatic barometer, thermometer, and as an indicator of magma redox conditions and water content. As for Eu and Ce anomalies in zircon, both proxies are typically influenced by multiple factors (e.g., magmagenetic depth, magma hydration, oxidation, crystallization of plagioclase/apatite). Many studies misuse these proxies, specifically when dealing with Precambrian crustal evolution; focus on single proxies and interpretations, overextending the application frameworks or underestimating the effects of long-term geodynamic changes, variations in geotectonic settings, and/or the influence of magma composition on the saturation of co-crystallizing mineral phases.

We apply this approach to the Pan-African orogenic belt in the Moroccan Anti-Atlas. Its evolution, spanning from 1000 to 550 Ma, is relatively well constrained through whole-rock geochemistry and geochronology of igneous rocks and detailed tectonic and metamorphic surveys. A petrochronological analysis (U-Pb dating plus trace element signature) were performed on a large set of Neoproterozoic detrital zircons, extracted from meta-sandstones and meta-conglomerates, collected from twelve well distributed locations, spanning different tectonic domains and deposition age across the orogenic belt. The zircons were imaged by SEM-BSE and -CL, then analyzed by LA-HR-ICPMS for combined U-Pb and trace element compositions. A dataset of 827 Neoproterozoic zircons was statistically analyzed using bootstrap approach to produce chemical timeseries for both Eu and Ce anomalies. Our analysis reveals that major magmatic flare-ups in the Anti-Atlas orogenic belt coincide with the transition from oceanic subduction to continental collision. Periods of geotectonic settings transitions (e.g., from rifting to subduction to collision) are characterized by strong correlations between Ce and Eu anomalies timeseries, likely driven by significant changes in the geochemical composition of the magma sources rather than shifts in magmatic oxidation states. Conversely, intervals associated with variations in crustal thickness exhibit a clear decorrelation between the Eu and Ce time series.