

Transition from arc accretionary-type to collision-type orogenic events during the assembly of the Gondwana supercontinent from the integrated detrital zircon and monazite age spectra

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Supercontinent assembly plays an important role in crust generation and reworking and is associated with oceanic crust subduction zone and continental crust collision. In the later stage of supercontinent assembly, a continent-continent collision causes large-scale chemical and structural modification of lithosphere, even leading to the change in climate via enhancement of crustal erosion rate and relevant weathering. Hence, constraints on the timing of collision-type orogeny, which repeated several times over geologic history, are significant for the study of the Earth's history.

To constrain Precambrian orogenic events, a number of detrital zircon studies have been conducted (e.g., Kemp et al., 2006; Condie et al., 2009). Detrital zircon can retain the crystallization age reflecting their host rock, since they are highly robust to chemical and mechanical weathering. Although detrital zircon U–Pb dating is a powerful tool for ancient provenance study, detrital zircon cannot always record major tectonic events (Hietpas et al., 2010). Especially, the detrital zircon record mainly reflects granitic magmatism, but might miss the metamorphic events. In this study, we examined the utility of the combined use of detrital monazite and zircon data for constraints on the timescales and nature of major orogenic events including collision-type orogeny. Because monazite occurs in low-Ca granitic rocks and a wide range of metamorphic rocks, the high-precision single grain U–Pb dating of detrital monazite is expected to be a complimentary approach to detrital zircon dating.

Here, we show the U–Pb age spectra of detrital zircon and monazite from five African major rivers (Iizuka et al., 2013; Itano et al., 2016, Fig. 1) and highlight their correspondences and differences. [i] Both the detrital zircon and monazite show age peaks at 1200–900 Ma and 700–500 Ma; [ii] Age peak of 800 Ma is only observed in the zircon age spectra; [iii] Monazite age peaks are younger by 20–40 Ma than zircon age peaks during the Pan-African and Kuunga orogenies, forming the Gondwana supercontinent. [i] The two major age populations recorded by both of zircon and monazite correspond to the periods of Rodinia and Gondwana supercontinent assembly, respectively. The finding that Paleo- and Meso-proterozoic detrital monazite grains were scarce relative to zircon grains would be attributed to the more susceptibility of monazite to dissolution during metamorphism or sedimentary processes. [ii] The paucity of ~800 Ma monazite, in contrast, cannot be simply explained by the preservation bias, considering the abundance of older monazite grains. The detrital zircon grains dated at ~800 Ma are characterized by remarkably juvenile Hf and O isotope signatures. These isotopic signatures and the lack of monazite age population suggest a prevailing high-Ca granitic magmatism during this period, likely reflecting formation and accretion of island arcs in the Arabian–Nubian Shield. In other words, the detrital zircon and monazite records can preferentially reflect accretionary-type and collision-type orogenies, respectively. [iii] Taking a closer look at the period of Gondwana supercontinent assembly (Pan-African orogeny), detrital monazite peaks tend to be younger by 20–40 Myrs than detrital zircon peaks. Trace element compositions of the monazite grains further indicate that these peaks would mainly reflect the timings of metamorphic events based on trace element composition (Itano et al., 2016), whereas the detrital zircon age peaks reflect those of a wide range of felsic magmatism. Therefore, the age gaps of 20–40 Myr would reflect the transition between major felsic magmatism in pre-to syn-collisional stages and metamorphism in syn-to post-collisional stages during Pan-African orogenic events.

Keywords: zircon, monazite, Earth's history, continental crust

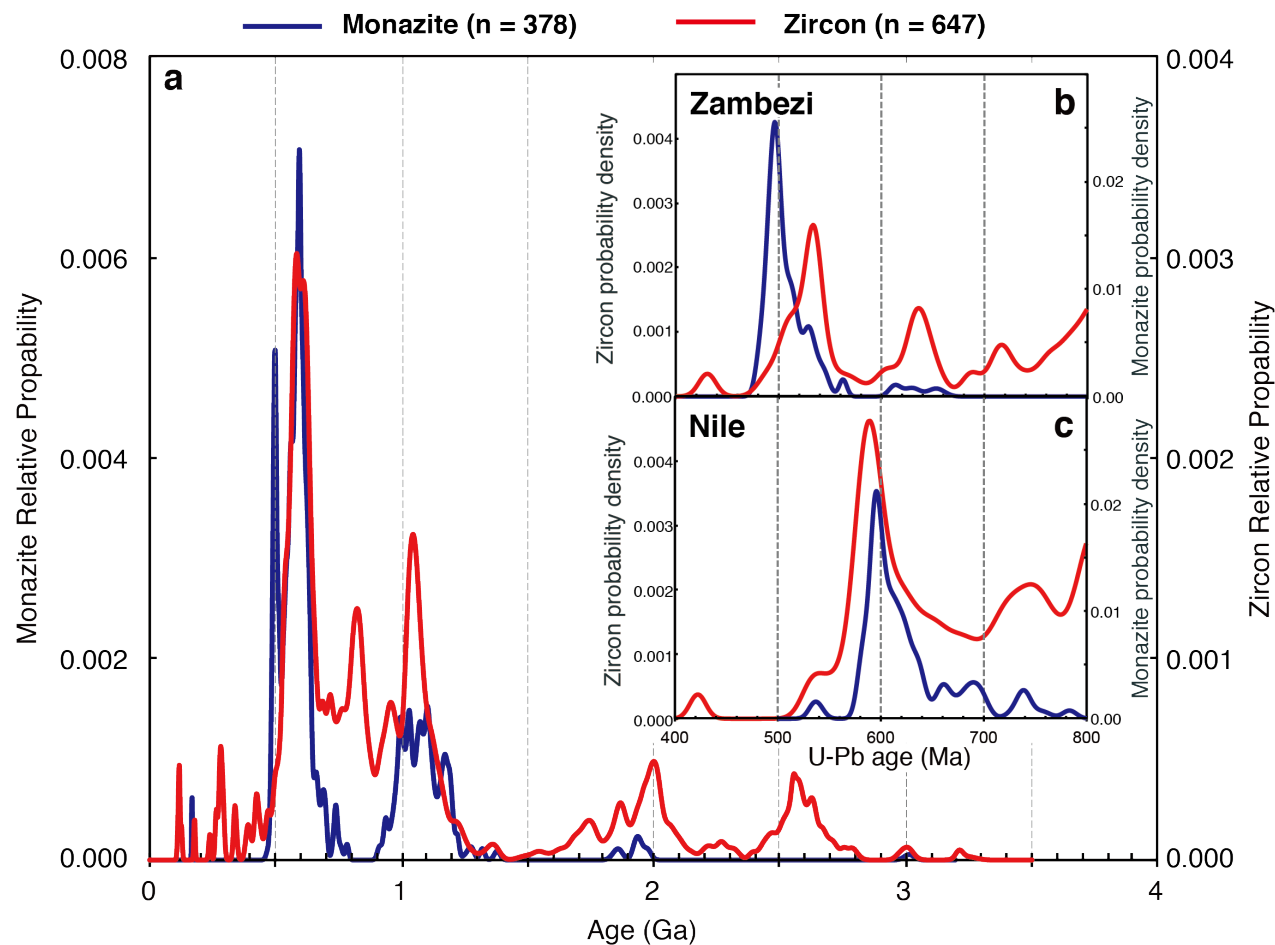


Figure 1 (a) Detrital zircon and monazite U-Pb age spectrum for detrital zircons and monazites from the five largest African rivers. (b) and (c) Age spectrum from 800 to 400 Ma, illustrated for the Zambezi and Nile Rivers, respectively.