Geophysical Research Abstracts
Vol. 17, EGU2015-3087-1, 2015
EGU General Assembly 2015

Development of the African continent deduced from U-Pb chronology and trace element chemistry of detrital monazites from major rivers

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To better understand the development of the African continent and, by implication, the Gondwana supercontinent, we present U-Pb age and trace element data for ca. 500 detrital monazite grains corrected from five African major rivers (the Nile, Niger, Congo, Zambezi and Orange Rivers). Monazite, a light-REE phosphate, occurs as an accessory mineral in low-Ca felsic rocks and middle- to high-grade metamorphic rocks. Because monazite has high U, Th and low common Pb contents, it is suitable for precise U-Pb chronology. In addition, its crystallization condition can be recorded by the trace element composition. Consequently, combination of U-Pb dating and trace element analysis of detrital monazites from large rivers would provide valuable insights into the timing and nature of orogeny resulting from supercontinent assembly. For this, we determined U-Pb ages and trace element compositions of the monazite grains by LA-SF-ICP-MS and LA-ICP-QMS, respectively.

Detrital monazite U-Pb age distributions of all studied rivers except for the Orange River indicate prominent age peaks between 700 and 480 Ma, corresponding to the period of the Gondwana supercontinent assembly. In detail, each river shows a different age distribution and peak(s) (Nile: 580-600 Ma, Niger: 560-600 Ma, Congo: 540-560 and 600-640 Ma, Zambezi: 480-500 Ma, Orange: 900-1200 Ma). Furthermore, detrital monazite grains show variable trace element signatures, especially in [Eu/Eu*]N, [Gd/Lu]N and [Th/U]N ratios. Given that these trace element signatures reflect the effects of co-existing minerals, such as feldspar, garnet and zircon (Rubatto et al., 2006), the trace element data allow us to interpret the geologic significance of the identified age peaks. By combining the U-Pb age and the trace element data, we obtained the following picture for the development of the African continent: metamorphic events took place in the drainage basin area of the Congo River during the orogeny correlated to collision between the Congo and Saharan Cratons at 600-640 Ma. Subsequent metamorphism in relation to the East African Orogeny after arc assembly-continental collision occurred at 580-600 Ma. In the drainage basin area of the Niger River, post-collisional magmatism and metamorphism took place at 560-600Ma. After the collision between the Kalahari and the Congo Cratons, metamorphic events occurred again in the drainage basin area of the Congo River at 540-560 Ma. Finally, the collision between the Congo-Kalahari Block and Madagascar-India Block resulted in high–grade metamorphism at 480-500 Ma.

We note that the detrital monazite age peaks from the Niger, Congo and Zambezi Rivers are younger by 20-40 mys than those of detrital zircon from the same rivers (Iizuka et al., 2013). Given that detrital zircon age peaks correspond to the timing of major magmatic events in the drainage basin areas, the age gaps of 20-40 mys may reflect the timescales of transition from magmatic stage to metamorphic stage in orogeny with supercontinent assembly.