Geophysical Research Abstracts
Vol. 15, EGU2013-6873-1, 2013
EGU General Assembly 2013

Evolution of the continental crust as recorded in accessory minerals

Tsuyoshi Iizuka
Department of Earth and Planetary Science, University of Tokyo (iizuka@eps.s.u-tokyo.ac.jp)

Recent developments in precise in situ isotopic analysis by LA-ICPMS and SIMS allow correlating multiple isotopic systems within single grains of accessory minerals such as zircon and monazite. The combined isotope systematics have provided valuable insights into the evolution of the continental crust.
Zircon, a common accessory phase in granitoids, can be precisely dated by the U-Pb system. Zircon Lu-Hf isotopic composition is a function of crustal residence time of the magmatic protolith, whereas the O isotopic composition is a sensitive record of reworking of mature sediments such as pelite. An integration of U-Pb, Lu-Hf and O isotopic data for detrital zircons from modern large rivers indicates that: (1) the preserved continental crust dominantly formed between 3.6 and 1.0 Ga, (2) the major mode of crustal development would change during the supercontinent cycle, i.e. the generation of juvenile crust during supercontinent fragmentation versus the stabilization of the generated crust via crustal remelting during supercontinent fragmentation, and (3) reworking of mature sediments increased abruptly at ca. 2.1 Ga.
No granitoids are known to have survived since 4.03 Ga. Yet evidence of an even older evolved crust is provided by detrital zircons with ages up to 4.4 Ga from Mt. Narryer and Jack Hills metasedimentary rocks in the Yilgarn Craton, Western Australia. Recently, such Hadean zircons have been found from outside the Yilgarn Craton, indicating that the young Earth had widespread granitoid crust. In addition, another accessory phase, monazite, in the Mt. Narryer and Jack Hills metasedimentary rocks offers an unique opportunity to advance our knowledge of early crustal evolution.
Monazite, a light rare earth element phosphate mineral, occurs as an igneous accessory phase particularly in low-Ca granitoids, in contrast to the occurrence of igneous zircon in a wide range of granitoids. U-Pb and Sm-Nd isotope systematic of monazite are analogous to U-Pb and Lu-Hf isotope systematics of zircon in that they define the timing of the crystallization and magmatic protolith formation (model age), respectively. The lack of monazites having >3.6 Ga crystallization ages as well as >4.0 Ga Nd model ages in the Mt. Narryer and Jack Hills metasedimentary rocks suggests that the source rocks of the Hadean detrital zircons are not low-Ca granitoids and therefore contained few monazites. Given that low-Ca granitoid magmas generated mainly by melting of pre-existing mid-lower crust, this finding may indicate minor intra-crustal melting and, by extension, crustal stabilization until ca. 3.6 Ga. This is consistent with the picture portrayed by the detrital zircons from modern rivers. Presumably, the hotter and rheologically weaker lithospheric mantle fostered many small plates and island arcs early in Earth's history, and the young arc crust was efficiently returned to the mantle via subduction. Accordingly, net growth of continental crust was essentially minor in early Earth's history despite high rates of crust generation.