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Growth curve of continental crust on the surface of the Earth

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The growth curve of continental crust through the Earth's history has been estimated by many methods, which include geologic-geophysical-, and geochemistry-based. Many studies through geophysical and geochemical modeling indicate that there was rapid formation of continental crust during the early part of the history of the Earth. The geological record shows, however, that less than 20% of continental crust before 2.6 Ga remains and an absense Hadean geological body. The difference between the formation of continental crust, indicated by modeling to be more extensive than what is observed in the geological record has been thought to be effect of crustal recycling or subduction of crustal material into the mantle. Recently, the importance of arc subduction (Yamamoto et al., 2009) and large scale subduction erosion around circum-Pacific active subduction zones has been revealed through geologic investigation of the Japanese islands (Isozaki et al.,2010; Suzuki et al., 2010). The crustal material subducts into the mantle transition zone and forms a second continent (Kawai et al.,2009;2013). It is the aim of this study to delineate the growth history of continental crust which takes into account the subduction of continental crustal material into the mantle global scale.

River sand zircon method is one of the most powerful methods to determine the age frequency distribution of the continental crust (Rino et al.,2004;2008). In this study, the global unconformities are regarded to be past continental margins, with river sand in clastic rocks occuring above them. The age frequency distributions of detrital zircons at given global unconformities with ages of 2.6, 1.0 and 0.6 Ga were determined in this study. This included analyzing detrital zircons separated from sedimentary rocks which occur above global uncconformities with surfaces covering the Pilbara, Kaapvaal, Zimbabwe and Wyoming cratons, with U-Pb ages determined through the LA-ICP-MS at Hirata Laboratory in Kyoto University. In addition, in oreder to make this more of a global study, published data was also were used to determine the age frequency distribution of continental crust at 2.6, 1.0 and 0.6 Ga.

The growth history of continental crust is discussed by showing the compilations of age frequency distribution of detrital zircons at 2.6, 1.0, 0.6 Ga (this study) and at present (Rino et al., 2008). The shape of these curves indicates that there was rapid formation of continental crust with large scale subduction of crustal materials into the mantle during a time range of 4.5 to 2.6 Ga, and that during 1.0 Ga to present, continental crust on the Earth's surface has been declining due to subduction erosion being more dominant than crustal formation. In addition, the growth history of continental crust was estimated in this study by using the evolution of oceanic Sr isotope ratio recorded in carbonate rocks (Shields and Veizer, 2002). In this study, the Sr flux estimated from the carbonates is assumed to be proportional to the volume of the continents.

Based on these works, a model of growth history of the continental crust is proposed here. From the Hadean through the Archean to the early part of the Proterozoic, there was rapid formation of granitic crust as most oceanic island arcs were subducted into the mantle with only a limited number of them colliding and contributing to the growth of continental crust of the surface of the Earth. At 2.6 Ga, the amount of continental crust was 75% of that at present. Subsequently, magmatism at subduction zones was superior to subduction erosion with about 150% continental crust at 1.0 Ga compared to that at present. Since about 1.0 Ga, the continental crust has been reducing in volume due to subduction erosion being superior to growth at subductions zones.

Keywords: U-Pb age, detrital zircon, global unconformity, growth of continental crust