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True Continental growth

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Continental crust is very important for evolution of life because most bioessential elements are supplied from continent to ocean. In addition, the distribution of continent affects climate because continents have much higher albedo than ocean, equivalent to cloud. Conventional views suggest that continental crust is gradually growing through the geologic time and that most continental crust was formed in the Phanerozoic and late Proterozoic. However, the thermal evolution of the earth implies that much amounts of continental crust should be formed in the early Earth. This is Continental crust paradox.

Continental crust comprises granitoid, accretionary complex, sedimentary and metamorphic rocks. The latter three components originate from erosion of continental crust because the accretionary and metamorphic complexes mainly consist of clastic materials with minor basaltic oceanic crust. Granitoid has two components: juvenile component through slab-melting and recycling component by remelting of continental materials. Namely, only the juvenile component of granitoids contributes to net continental growth. The remains originate from recycling of continental crust. The estimate of continental growth is highly varied. Thermal history implied the rapid growth in the early Earth, whereas their present distribution suggests the slow growth. Mantle composition suggests the moderate increase in the Proterozoic to Phanerozoic. The former regards continental recycling as important whereas the latter regarded as insignificant. Continental recycling has three components: intracrustal recycling, crustal reworking, and crust-mantle recycling.

We calculate true continental growth including continental formation and recycling. We changed a recycling rate, and find an answer to satisfy five conditions: its present distribution (no continental recycling), geochronology of zircons (intra-continental recycling, redistribution of continental materials or formation of accretionary complex), Hf isotope ratios of zircons (remelting of continental materials), isotope evolution of upper mantle (return of continental materials to the mantle) and secular change of mantle temperature.

Subduction geotherm depends on the mantle temperature because thickness, size and life-span of oceanic plates are controlled by mantle temperature. Increase of mantle temperature leads to their short life-spans due to the smaller sizes, and results in hot subduction geotherm; thus, hotter mantle temperature allows more granitoid formation through subduction of thicker and younger oceanic crusts. The amounts of intra-continental recycling, redistribution of continental materials and deposition of clastic sediments in trenches depends on amounts of continental crusts. Especially, amounts of continental crusts and lengths of subduction zones control amounts of clastic sediments. More continental crusts lead to more sediment. Longer subduction zone leads to more sediments in trenches. Because the length of subduction zone depends on mantle temperature, high mantle temperature results in high crustal formation and deconstruction. We changed erosion rate of continental crust and calculated secular changes of continental formation and destruction to fit the five types of estimates of continental growth curves. The calculation shows the following. (1) The distribution of continental crust 2.7 Ga is equivalent to the modern amounts. (2) Especially, the distribution of continental crust from 2.7 to 1.6 Ga is much larger than at present, and the size around 2.4 Ga became maximum and decreases since then. More continental crusts were formed during the high mantle temperature at 2.7, 1.9 and 0.8 Ga, and more amounts were destructed after then. As a result, 2.4 Ga continental crust apparently became minor, and few Archean continental crust remained. The timing of large distribution of continental crust corresponds to the timing of icehouse, namely 2.4, 1.6 and 0.8 Ga in Precambrian.

Keywords: Continental growth, evolution of Earth's surface, continental recycle, Archean, early Earth, mantle overturn