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Growth rate curve of continental crust through time-An estimate from the river mouth zircons

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Growth curve of the continental crust of the Earth was estimated by the U-Pb ages of river mouth zircons collected over the world. 16 major rivers were investigated. Combining Cathode-luminescence and Laser ICP-MS, the original magmatic zircons were selected to be dated extensively to obtain the igneous crystallization age.

After the statistical examination of river mouth zircons collected from Mississippi River, North America, South America, Central and East Asia, Africa, and Russia were studied. The coverage of the world all continents as drainage region reaches to 27%. The obtained curve was then corrected by comparison with uncovered continents on the geologic maps. Moreover, the sub-surface geology of continental shelf, and uncovered active circum-Pacific margin, and the western Pacific juvenile island arcs were considered to improve the curve. The following conclusions were led.

(1) Relative frequency of zircon age clearly reflects the regional geology of each continent. Both South and North America reflects the much older continental crust formed mainly in the latest Archean and Early Proterozoic. Africa was formed during Grenvillian and Pan-African times in the Late Proterozoic. Central and East Asia were formed mainly in the latest Proterozoic and Paleozoic times.

(2) Formation of continental crust was not continuous but episodic with four strong peak ages, 2.8-2.5Ga, 2.3-2.0Ga, 1.2-1.0Ga and 0.8-0.5Ga.

(3) The least formation age is 2.5-2.3Ga and 0.15Ga compared to that of the highest peaks of above four, suggesting the least activity of plate tectonics on the Earth.

(4) The obtained growth curve indicates that the continent has grown only 20% by the end of Archean, reached 50% by 1.5Ga, and completed 90% by the onset of Phanerozoic.

Lesson in the modern western Pacific where ca.70% island arcs are present, indicates clearly ubiquitous arc subduction into deep mantle, if it subducts obliquely, presumably due to small buoyancy. Archean geology infers common occurrence of intra-oceanic arcs more than 400 reflecting double-layered mantle convection, and hence common phenomena of arc subduction into mantle, presumably 6.5MEc (total mass of present-day upper continental crust). On the other hand, tectosphere is seen only below the cratons older than 2.0Ga, and rich in orthopyroxene, i.e., SiO2 enriched metasomatized mantle. Arc subduction promoted to develop tectosphere under the high geothermal gradients in the Archean. Considering the excess SiO2 (2-10 wt%) in tectosphere, we can estimate the Archean production of CA magma, as much as 1 mass of the present upper continental crust.

Assuming the present rate of TTG production in the western Pacific which occupies the 4% of the Earth's surface, to be same as in the Archean, the first 2.0Ga history would have produced 6.0 VEc, because total surface of the Archean Earth was assumed to be covered completely by oceanic microplates. After 2.0Ga, micropate region was assumed to be 4% same as today, and those continental crusts are assumed to be subducted into deep mantle, 0.5VEc subducted into deep mantle.

Thus, totally 6.5VEc moved down to the deep mantle, and 1 VEc remained on the surface. Among the total 7.5VEc of TTG on the surface, 0.3VEc was spent to make tectosphere in the upper mantle, and thus 6.2 VEc should have subducted in the lower mantle at 100GPa (2300km) depth. Those TTG enriched in stishovite in the upper and mid-lower mantle is denser than the surrounding mantle, but turns to be buoyant at 100GPa, because of density cross-over beyond the PREM density curve at 100GPa. Thus, TTG cannot reach to the CMB. Around 2300km depth, 6.2 VEc if it turns to be a density-stratified layer, it should have a thickness of ca.80km.