专题 27：早期地球的形成与演化

The Birth, Growth and Aging of the Subcratonic Mantle – A Case Study of the Kaapvaal Craton, South Africa

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The classic Kaapvaal craton and its underlying mantle is one of the best studied Archean entity in the world. Despite that, discussion is still vivid on important aspects. A major debate over the last few decades is the depth of melting that generated the mantle nuclei of cratons. Our new evaluation of melting parameters in peridotite residues shows that the Cr_2O_3/Al_2O_3 ratio is the most useful pressure sensitive melting barometer. It irrevocably constrains the pressure of partial melting to less than 2GPa with olivine, orthopyroxene and spinel as residual phases. Garnet grows at increasing pressure during lithosphere thickening and subduction via the reaction of orthopyroxene + spinel → garnet + olivine.

The time of partial melting is constrained by Re-Depletion model ages (T_{RD}) mainly to the Archean. However, only 3% of the ages are older than 3.1Ga while crustal ages lie mainly between 3.7Ga to 2.8Ga. Such discrepancy can be explained that many T_{RD} ages are probably falsified by metasomatism and the main partial melting period was older than 3.1Ga. Also, the early-middle Archean age of peridotitic lithologies is also recorded via the model ages of the Nd and Hf isotope systematics (from 3.2Ga to 3.6Ga). Meanwhile, the extremely negative εNd (−40) and εHf values (−65) in these two isotope systems signal the presence of subducted crustal components in these old mantle portions. Subducted components diversify the mantle in its chemistry and thermal structure. Adjustment towards a stable configuration occurs by fluid transfer, metasomatism, partial melting and heat transfer. Major metasomatic events occurred in the subcratonic mantle were mainly in the Archean recorded via the Lu-Hf isotope system (3.2Ga, 2.9Ga and 2.6Ga) which is also coinciding with the collision of cratonic blocks, the growth of diamonds, metamorphism of eclogites and enormous Ventersdoorp magmatism. Finally, the cratonic lithosphere was stabilized thermally by the end of the Archean and cooled since then with a rate of 0.07°C/Ma.

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