



## **Re-Os isotope evidence for orthopyroxene addition to the Kaapvaal cratonic mantle in (Archaean) subduction zones**

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Considerable progress has been made in the understanding of craton formation and evolution in southern Africa in recent years, thanks to newly available geophysical and geochemical data. Recent tomographic studies and Re-Os analyses of on- and off-craton mantle xenoliths have clearly shown that the Kaapvaal craton is underlain by a cold, depleted lithosphere at least 200 km thick that was stabilized in the Archaean.

Several important questions regarding the consolidation and modification of the lithosphere, however, remain unanswered or highly debated. Firstly, the origin of the unusually low Mg/Si and associated high orthopyroxene contents in Kaapvaal low-temperature (low-T) peridotites compared to most other lithospheric peridotites worldwide is still unclear. Resolution of this issue is critical to understanding the mechanism of lithosphere formation. Secondly, the mean whole rock Re depletion age for the Kaapvaal craton mantle is 2.7 – 2.9 Ga, which is significantly younger than many ages from the overlying crust.

Here we report new whole rock Re-Os isotope data from 26 well-characterized low-T peridotites from Kimberley, with a range of orthopyroxene contents. The suite shows

that there is a strong correlation between the amount of orthopyroxene and the Os isotopic composition in peridotite xenoliths. This indicates that the process that led to the unusual orthopyroxene enrichment in the Kaapvaal mantle also introduced more radiogenic Os, resulting in younger (i.e. late Archaean, in contrast to middle Archaean ages of the overlying crust) apparent Re-Os ages for the mantle xenoliths.

In order to obtain more information on the nature and timing of orthopyroxene addition to the Kaapvaal mantle we performed simple 2-component mixing calculations between strongly depleted mantle and various potential metasomatic agents. The correlation between whole rock  $\text{SiO}_2$  content and Os isotope composition observed for the typical low-T peridotites can only be reproduced by mixing with a slab derived hydrous fluid, a silicic melt (TTG) or an orthopyroxene cumulate. Mixing with a kimberlitic or carbonatitic would significantly lower, instead of increase, the Si-content of the peridotites. Interaction of mantle previously enriched in  $\text{SiO}_2$  with kimberlitic or carbonatitic melts, however, might be responsible for the elevated  $\gamma_{Os}$  in some more fertile samples. In summary, relatively low Re and Os contents, unlike those of normal basaltic melts (MORB, OIB) in the metasomatizing agent are crucial to maintain the generally unradiogenic Os isotope composition in the Kimberley lithosphere with time, especially if the metasomatism happened significantly before kimberlite eruption.

The results from this study, together with those from whole rock and mineral major and trace element analyses and garnet and clinopyroxene Sr-Nd-Hf isotope systematics, are most consistent with introduction of orthopyroxene to the Kaapvaal mantle via slab-derived melts and fluids in an Archaean subduction zone. These findings strengthen the hypothesis that Archaean cratons formed by collision and amalgamation of smaller terrains through processes similar to modern orogenic events, rather than in major plumes or via underplating and accretion of material from below.