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Hydration of Archean lithosphere: A chemico-physical case study of the lherzolitic upper mantle below the Kaapvaal Craton

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Since its formation in the Archean the subcratonic upper mantle of the Kaapvaal in southern Africa has undergone several processes of modification. Detailed analysis of Kaapvaal xenoliths from kimberlites show clear differences in age, origin, mineralogy, fertility and degree and type of alteration illustrating a period of complex interaction between asthenospheric and lithospheric mantle domains. The evolution of the cratonic lithosphere through time involved several metasomatic events leading to chemical and thermal anomalies. Global and regional 3-D shear wave velocity models are imaging a low velocity zone for the lower Kaapvaal lithosphere. However, regardless the resolution and significance of the lithospheric low velocity zone its origin is a matter of debate and is discussed to be either of thermal or chemical nature. Petrological evidences point to a rather chemical origin caused by refertilization and/or hydration of lithospheric mantle by metasomatizig fluids.

Here we present a chemico-physical study of the lherzolitic lithosphere below South Africa using a recalculated bulk composition based on analyses of the rock forming minerals from lherzolithes from the Roberts Victor Mine. The thermo-chemical calculations were done for a water saturated lherzolite representative of published compositions of garnet lherzolites from the Kaapvaal Craton in order to estimate the distribution of hydrous phases and the combined influence on physical properties as density and P- and S-wave velocities. Our results confirm the existence of a zone with slightly lower S-wave velocities and are supporting the idea of chemically layered lherzolitic mantle that has been repeatedly hydrated by slab released volatiles in a two sided subduction model.

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