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Eclogites and garnet pyroxenites from the mantle: their age and ageing-two point isochrons, Sm-Nd and Lu-Hf closure temperatures, model ages

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Eclogites and garnet pyroxenites from kimberlites which erupted through Archean crust, show a wide variability in mineral chemical and isotopic composition. The heterogeneity is the result of multiple origins of their protoliths and potential chemical changes before and after eclogitisation. Tantalizing questions are the nature of the protoliths, their age and the age of eclogitisation. We have studied eclogites and garnet pyroxenites from the Bellsbank diamond mine on the Kaapvaal craton. They represent subducted oceanic crust (kyanite eclogites = plagioclase rich cumulates and garnet pyroxenites = clinopyroxene-rich cumulates) and metamorphosed, primary high pressure garnet+clinopyroxene precipitates. These lithologies may or may not have equilibrated later with metasomatic agents. Our focus is the meaning of garnet + clinopyroxene Sm-Nd and Lu-Hf two-point isochron ages, the derivation of closure temperatures for these isotopic systems and the meaning of model ages.

Two-point isochron ages in mantle samples from underneath old Archean crust can be either i) cooling ages (samples stem from shallower parts of the mantle which are colder than the closure temperature), or ii) eruption ages (continuous isotopic exchange at temperatures above the closure temperature) or iii) meaningless old ages due to a selective disturbance of clinopyroxene at a time or at temperatures not sufficient for reequilibration. We have estimated P,T-conditions of last equilibration for our and literature samples by an iterative process from the comparison of temperatures calculated with Krogh (1988) at continuously adjusted pressures with those on a 40 mW/m2 conductive geotherm. We plotted these temperatures against the ages of the two-point isochrones and found an envelope of age values which decrease in a curvilinear fashion with increasing temperature up to an inflection point with the age of the eruption of the kimberlites. The age remains the same from then on. The inflection points are taken as the closure temperatures which are at around 850°C for the Sm-Nd system and 1000°C for Lu-Hf. Oldest closure ages for Lu-Hf at the lowest temperatures are almost 2 Ga and 1.4 Ga for Sm-Nd. Some samples with temperatures above the closure temperature give even older ages but these are "aged" and meaningless by a selective disturbance of clinopyroxene.

Model age calculations will give minima for garnet and maximum ages for bulk rocks. They potentially give the age of the protoliths, provided that there was no chemical change since its origin and that a primitive mantle is the correct bench mark. The ages rejuvinate dramatically, if a phase like rutile is also present. Its presence may be seen from negative Ti anomalies. Several of our samples have no Ti-anomaly. They are also those which we had attributed to a subduction origin because of positive Eu-anomalies and low and flat HREE patterns. The Sm-Nd and Lu-Hf isotopes give identical model ages for garnets of around 3.2 $\pm$ 0.3 Ga. We interpret these results as unequivocal evidence for the existence of Wilson cycles at the beginning of the crust generation of the W-block of the Kaapvaal craton.