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Water in the cratonic mantle lithosphere

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The fact that Archean and Proterozoic cratons are underlain by the thickest (>200 km) lithosphere on Earth has always puzzled scientists because the dynamic convection of the surrounding asthenosphere would be expected to delaminate and erode these mantle lithospheric "keels" over time. Although density and temperature of the cratonic lithosphere certainly play a role in its strength and longevity [1,2], the role of water has only been recently addressed with data on actual mantle samples. Water in mantle lithologies (primarily peridotites and pyroxenites) is mainly stored in nominally anhydrous minerals (olivine, pyroxene, garnet) where it is incorporated as hydrogen bonded to structural oxygen in lattice defects [3]. The property of hydrolytic weakening of olivine [4] has generated the hypothesis that olivine, the main mineral of the upper mantle, may be dehydrated in cratonic mantle lithospheres, contributing to its strength [2]. This presentation will review the distribution of water concentrations in four cratonic lithospheres.

The distribution of water contents in olivine from peridotite xenoliths found in kimberlites is different in each craton (Figure 1). The range of water contents of olivine, pyroxene and garnet at each xenolith location appears linked to local metasomatic events, some of which occurred later then the Archean and Proterozoic when these peridotites initially formed via melting [5-8]. Although the low olivine water contents (<10 ppm wt H_2O) at > 6 GPa at the base of the Kaapvaal cratonic lithosphere may contribute to its strength, and prevent its delamination [9], the wide range of those from Siberian xenoliths is not compatible with providing a high enough viscosity contrast with the asthenophere [6]. The water content in olivine inclusions from Siberian diamonds, on the other hand, have systematically low water contents (<20 ppm wt H_2O, [10,11]).

The xenoliths may represent a biased sample of the cratonic lithosphere with an over-abundance of metasomatized peridotites with high water contents. The olivine inclusions, however, may have been protected from metasomatism by their host diamond and record the overall low olivine water content of the cratonic lithosphere. Water may thus still play a role in cratonic keel longevity.

Olivine H_2O (ppm wt)

Figure 1: Olivine water contents in minerals

0"
100"
200"
300"

from cratonic xenoliths and inclusions in

1"

Kaapvaal&xenoliths&

Slave&xenoliths&Lac&de&Gras&
diamonds versus pressure of equilibration. Data

Siberian&xenoliths&Udachnaya&
from [6,9-13] & unpublished by Peslier.

Siberian&diamond&inclusions&

Tanzanian&xenoliths&Labait&

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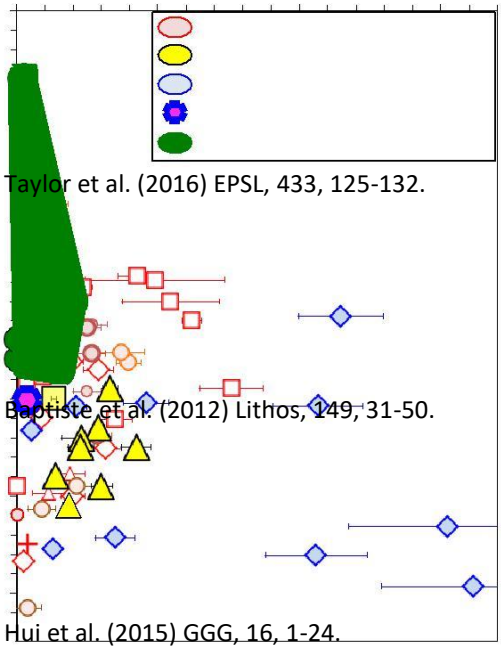

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