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The thermal history of Archean lithosphere. Constraints from FTIR studies of zoning in diamonds.

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The Murowa kimberlites [1] are located near the southern edge of the Zimbabwe craton. The few available measured ages suggest that the xenoliths and diamonds in the kimberlites date to 3.2 Ga and the kimberlite exhumation dates to 0.5 Ga, giving a mantle residence time for the diamonds of 2.7 Ga [2].
In this study we have performed detailed FTIR maps and linescans of Murowa diamonds using doubly polished sections and an infrared beam focussed to a diameter of 20 microns. Most of the diamonds display complex distributions of nitrogen, nitrogen aggregation, hydrogen and degree of platelet degradation that provide a rich source of information on the thermal history of the lithosphere. While some Murowa diamonds are relatively homogeneous, many show an overgrowth with a step in nitrogen concentration and aggregation near the rim. One interesting, and previously unreported, feature is a large maximum in the intensity of the 3107 cm-1 peak (related to hydrogen) at the transition from core to rim. This hydrogen may reflect the ingress of a new aqueous fluid into the diamond-containing region of the mantle. It is not possible to determine a unique temperature history for the diamonds without independent ages for the different stages of growth, but some constraints can be obtained by forward modelling of the nitrogen aggregation state, given the measured nitrogen concentrations and assumptions about the dates of the different periods of growth. Most reasonable scenarios suggest a drop in temperature of around 30-50°C between growth of the cores (typically 1160°C) and rims (typically 1120°C).
There are numerous possible explanations for the temperature reduction and a second diamond growth event within the framework of different published models for the evolution of the Kalahari craton. One possibility that will be discussed is initial growth of peridotitic diamonds at 3.2 Ga, subduction-related thickening of the lithosphere at 2.9 Ga (leading to cooling) and secondary growth of the diamonds at 1.9 Ga, possibly resulting from mobilisation of fluids by the Bushveld intrusion [3].

[1] Smith C.B. et al. (2004) Lithos 76 219-232. [2] Smith C.B. et al. (2009) Lithos 112S, 1120-1132. [3] Shirey (2004) Lithos 77, 923- 944.