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Kimberlite magmatism and lithospheric structure

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Kimberlite-type magmatism is typical of stable continental lithosphere of Precambrian cratons. This is paradoxical since “stable” regions are not expected to be subject to any tectono-magmatic events at all.

Geodynamic origin of kimberlite-type magmatism remains speculative and the proposed models range from plate tectonics processes to plume-lithosphere interaction. No matter the origin, kimberlite magmatism should lead to a significant modification of the cratonic lithosphere, which otherwise is expected to have a unique thickness (>200 km) and unique composition (dry and depleted in basaltic components). Magmatic reworking of the Precambrian lithosphere may include magmatic underplating at the base of the crust, thermal thinning, and metasomatism of the lithospheric mantle. These processes are clearly reflected in the thermal, density, and seismic velocity structure of the cratonic lithosphere.

Based on a joint interpretation of geophysical data, such as thermal, seismic tomography, and gravity data, I demonstrate a significant lateral and vertical heterogeneity in the structure of the crust and the lithospheric mantle of cratons worldwide. This heterogeneity reflects the extent of the lithosphere reworking by both a large-scale (e.g. Siberian LIP) and kimberlite-type magmatism. The results (compared to petrological studies of mantle-derived xenoliths) indicate that kimberlite regions have different composition of the lithospheric mantle than the “intact” cratons. There are no significant differences in lithospheric thickness between kimberlite regions and intact cratonic lithosphere. Therefore, lithosphere modification is caused primarily by mantle metasomatism, and kimberlites of different ages (e.g. Group I and II kimberlites in Kaapvaal) may sample mantle of a significantly different composition. The results may provide a new strategy for diamond prospecting, since statistically, diamondiferous kimberlites tend to erupt through a low-density, depleted lithosphere, while non-diamondiferous kimberlites are more typical of a highly metasomatised cratonic mantle.