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The Proterozoic Ladoga rift (SE Baltic shield): Linking mantle dynamics to supercontinent cycle and regional tectonics

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Mesoproterozoic mafic magmatism at the southern part of the Baltic Shield (the Lake Ladoga region) is conventionally ascribed to epicratonic rifting. The region hosts a series of mafic dykes and sills of Mesoproterozoic ages, including a ca. 1.53-1.46 Ga sheet-like gabbro-dolerite sills and the Salmi plateau-basalts from the Lake Ladoga region. Based on chiefly geochemical data, the region is conventionally interpreted as an intracratonic Ladoga rift (graben). We question the validity of this geodynamic interpretation by analyzing regional geophysical data (crustal structure, heat flow, Bouguer gravity anomalies, magnetic anomalies, and mantle Vs velocities).

Our analysis of characteristics of continental rifts demonstrates that:
1. the topography of the region lacks a linear horst-graben structure typical of modern rifts, however this feature might have been lost by surface erosion;
2. the crust has neither shallow Moho, nor magmatic high-velocity underplated material, and thus is not typical of continental rifts;
3. weakly negative Bouguer gravity anomalies, especially by comparison with adjacent “background” anomalies suggest the presence of high-density material at shallow, near-Moho depths; however, the shape of the anomaly is rounded rather than linear, and may not attest to the paleorifting event;
4. seismic velocities in the upper mantle show a possible weak low-Pn anomaly near Lake Ladoga, and strong positive (+5+7%) Vs anomaly at 75-125 km depth to the NE of the lake, but not in the region of Mesoproterozoic mafic magmatism;
5. no thermal anomaly or lithosphere thickness anomaly is currently present in the lithosphere of the region, which instead is marked by extremely low heat flow; however, given the age of magmatism any thermal anomaly may have long ceased and thus its absence does not disprove rifting origin of magmatism;
6. the absence of linear magnetic anomalies which are preserved in other paleorifts provides strong evidence that this region has not been affected by rifting.

We conclude that a mechanism other than rifting is responsible for Mesoproterozoic mafic magmatism at the southern part of the Baltic Shield and propose that magma intrusion associated with deformation along the margins of Nuna (Columbia) supercontinent, and its transformation to eclogite facies, locally speeded by fluids, produced a highly heterogeneous density structure of the lithosphere.