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Delamination of eclogitized lower crust: control on the crust-mantle boundary in the area of deep Moho in the Fennoscandian shield

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The crustal structure of the central part of the Fennoscandian shield is dominated by a high velocity lower crust (HVLC) (V_P 7.3-7.5 km/s, at the depth of 40-63 km in an area of ca. 400 km x 600 km) formed in the Palaeoproterozoic Svecofennian orogen at $\sim$1.91-1.87 Ga. In the area of the HVLC the Moho is deeper than 50 km and attains depths of up to 63 km in eastern Finland at the Archaean-Proterozoic boundary zone. We study the processes which controlled the formation of thick crust and suggest that the present Moho dates back to late Svecofennian time and was determined by delamination of high-density eclogitized lower crust after tectonic collisional thickening of crust. Densities deduced from seismic and gravity data suggest a very small or completely lacking density contrast between lower crust and uppermost mantle. New geological evidence from kimberlite-hosted garnet xenocrysts supports the presence of a garnet population with compositions in agreement with crustal eclogitic garnets. Therefore, the presence of eclogites in the high velocity lower crust is implied, although the eclogite proportion as estimated from seismic velocity data is only a few percent in the present HVLC. With results on near-incidence and wide-angle seismic studies and geological and geochemical data on heat producing elements we modeled the Svecofennian collision and the thermal evolution of the crust to provide temperature constraints for the delamination model. The constructed thermal model simulates

the genesis of Svecofennian synkinematic (at 1.89-1.88 Ga) and post-kinematic (1.88-1.87 Ga) granitoids, as well as the general metamorphic grade of the surface rocks and lower crustal xenoliths. Moreover, the narrow distribution of the ages of the Svecofennian mafic-ultramafic magmatism (ca. 1.89-1.87 Ga) dispersed around the HVLC area is also explained by the model. The conditions of lower crustal delamination were estimated with a Rayleigh-Taylor convective instability model constrained with lower crustal and upper mantle rheological data. Delamination of a lower crustal eclogite layer 5-30 km thick takes place in about 6-37 Ma if the rock dynamic viscosity is $\leq 1 \cdot 10^{21}$ Pas. It requires temperatures of $\geq 1000^{\circ}$C in the lower crust and upper mantle. In the Svecofennian crust, such temperatures were attained at about 1860-1850 Ma, i.e. after the orogenic peak. We conclude that the Moho of the HVLC area was controlled by delamination of a ca. 5-10 km thick layer of high-density lowermost crust into the mantle. Such a density-controlled process may have controlled the Moho depth also in other Proterozoic shield areas.