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Seismicity and depth of faulting in the Archean Kuusamo region based on relocation of earthquakes with new velocity models

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New crustal velocity models and synthetic waveform modelling are used to constrain the depth distribution of earthquakes in Kuusamo and surrounding Archean areas of north-eastern Fennoscandia. In the Kuusamo block, the seismogenic layer extends from about 8 km below the surface down to a depth of about 30 km, i.e. close to the basement of the middle crust. Clear decrease in activity at about 20 km depth may be related to lithological contrast between the upper and middle crust. The upper cut-off in seismicity is attributed to the excess of strong mafic material in the uppermost crust. Comparison with the rheological profiles of the lithosphere, calculated at nearby locations, indicates that the base of the seismogenic layer correlates best with the onset of brittle to ductile transition at about 30 km depth.

In the surrounding Archean areas, two-thirds of the earthquakes occur in the upper crust between 1 and 13 km depth, and a sharp drop in seismicity level happens at 14 km. The lower cut-off depth of 38 km is solely attributed to the deep microseismic activity in the Norrbotten tectonic province of northern Sweden. The limited data set available for this study shows no evidence on movements in the lower crust beneath the Archean Karelian bedrock of northern Finland and Russian Karelia.

The new 2-D crustal velocity models and a Moho depth map of the area were derived by integrating waveform data recorded by the Kuusamo temporary network with previous data sets. The results indicate that the Karelian upper crust is 12-20 km thick and associated with P wave velocities of 6.1-6.4 km/s. The relatively high velocities are related to layered mafic intrusive and volcanic rocks. The middle crust – lower crust boundary is located at depths between 28 and 38 km. In the middle crust, lower crust, and uppermost mantle P wave velocities range from 6.5 to 6.8 km/s, 6.9 to 7.3 km/s and 7.9 to 8.2 km/s, respectively. The average Vp/Vs ratio increases from 1.71 in the upper crust to 1.76 in the lower crust.