Observations on Intraplate Seismicity in Central Fennoscandia

Korja, A.[1], Uski, M.[1], Lund, B.[2], Grigull, S.[3], Nironen, M.[4], E., Högdahl, K.[2]

[1]University of Helsinki, Institute of Seismology, Helsinki, Finland, annakaisa.korja@helsinki.fi
[2]University of Uppsala, Uppsala, Sweden
[3]Geological Survey of Sweden, Uppsala, Sweden
[4]Geological Survey of Finland, Espoo, Finland

Fennoscandian Shield is situated in a seismically quiet intraplate setting in northern Europe. Intraplate seismicity has been attributed to ridge-push from the North Mid-Atlantic Ridge, post-glacial rebound stresses and to local gravitational potential energy differences associated with compositional differences and crustal thickness variations.

Based on a subset of the most recent earthquake data (2000-2012), most of the earthquakes (80%) occur in the upper crust down to 17 km in depth, a minority (19%) in the middle crust (17-31 km) and only a few in the lower crust 31-45 km (1%) [1]. The seismogenic layer is less than 30 km in depth. The layer seems to be rather uniform across Fennoscandia. We suggest that the middle to lower crustal boundary may add compositional and rheological constraints to the depth extent of the seismogenic zone in the study area.

The orientation of the overall maximum horizontal stress field in northern Europe is WNW–ESE to NW–SE. Pre-existing deformation zones that are optimally oriented in the present stress field can potentially be reactivated. The deformation zones were analysed for their length and azimuth and they were assigned a potential reactivation type (reverse, normal or strike slip) based solely on their azimuth. The earthquakes in the seismically most active area, close to Skellefteå, Sweden along the western coast of the Gulf of Bothnia and its north-easterly continuation, appear to cluster around the shoreline and along post-glacial faults, which are mostly oriented optimally for reverse or strike slip faulting. The seismically active Kuusamo area in Finland is transacted by wealth of deformation zones all trending in directions optimal for reactivation.

The seismically active areas are located in areas where the crust is less than 50 km thick. Where the crustal thickness gradient trends in a NE–SW direction, e.g. along the faulted western margin of the Bothnian Sea and along the Auho-Kandalaksha fault zone in the Kuusamo area, the gradient seems to be associated with a zone of increased seismicity. In these areas, the crustal thickness gradients are optimally oriented for reactivation. Because the spatial distribution of the registered earthquakes exhibits little to no correlation with the an existing ellipsoidal rebound model or Glacial Isostatic Adjustment (GIA) model [2], and the still active post-glacial faults do not occur parallel to the isolines of the rebound ellipsoid, it is concluded that there is no clear evidence that the rebound stress is the main source for triggering seismicity in Fennoscandia today. However, during late- and post-glacial times, glacially-induced isostatic rebound was probably much more important for the generation of earthquakes.

Reference:

[1] Korja, A. and Kosonen, E. M. (eds.) 2015. Seismotectonic framework and seismic source area models in Fennoscandia, Northern Europe. Univ. Helsinki, Instit. Seismology, Report S-63, 284 p. http://www.seismo.helsinki.fi/pdf/Seismotectonic_S63_Korja_Kosonen.pdf

[2] Nørbech, T., Engsager, K., Jivall, L., Knudsen, O., Koivula, H., Lidberg, M., Ollikainen, M. & Weber, M., 2008. Transformation from a common Nordic reference frame to ETRS89 in Denmark, Finland, Norway, and Sweden – status

report. Technical Report No. 1, 2008, DTU Space National Space Institute.