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Neotectonics and strandflat formation in Nordland, northern Norway

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Ranafjorden, in northern Norway, is a region with increased seismic activity relative to the other parts of Fennoscandia. A six-station seismic network detected in a two-year period c. 300 earthquakes in the area, often occurring as swarms. Fault plane solutions indicate E-W extensional faulting. The outer Ranafjorden district is also the location for the largest earthquake recorded in Fennoscandia in historical times, i.e. the c. 5.8 magnitude in 1819. Liquefaction structures in the postglacial overburden points to the likely occurrence of large, prehistoric earthquakes in this area. Three measurements of uplift of acorn barnacle and bladder wrack marks on the islands of Hugla and Tomma in the outer Ranafjorden area show anomalous low land uplift from 1894 to 1990 (0.0-0.07m) compared with the uplift recorded to the north and south (0.23-0.30 m). An irregular relative subsidence pattern in the order of 1-2 mm/year is also observed on INSAR permanent scatterer data in the same area. The relatively low seismicity occurring at a depth of 2-12 km could, therefore, create the observed irregular subsidence pattern at the surface. We have established a Global Positioning System (GPS) network to measure the active geological strain in the Ranafjorden area. Three 15-20 km-long profiles were located across outer, central and inner Ranafjorden. The GPS stations along the western profile seem during the period from 1999 to 2008 to have moved c. 1 mm/year to the NW relative to the stations along the two eastern profiles.

Plio-Pleistocene sedimentary wedges on oceanic crust in the Lofoten and Norway basins are co-located with seismic activity. Along the coast of northern Norway there is a parallel and shallow zone of increased seismicity, which largely reflects extensional stress conditions. Considering that the Plio-Pleistocene loading of the relatively stiff oceanic crust causes seismicity in the Norwegian Sea, it is also likely that a comparable unloading of the coastal areas in western and northern Norway may induce extension and accompanying earthquake activity. Some of the earthquake clusters in the Hugla and Sjona area are located along N-S trending fracture zones with escarpments facing to the west. They are most likely formed by glacial plucking of the bedrock along the fractures by the moving inland ice. Ice-plucking features may, however, be indirectly related to neotectonics. Moving glaciers in the Canadian Cordillera tend to pluck bedrock along extensional fractures parallel to the direction of maximum horizontal stress. The Pleistocene glaciers could, in a similar way, cause a higher degree of bedrock plucking by basal glacier shear along favourably oriented fractures in areas with highly anisotropic rock stress.

It is highly likely that the deeply weathered basement rocks as we find on either side of Vestfjorden today extended farther south along the Nordland coast prior to the exhumation in the Plio-Pleistocene. The unloading of the crust in these coastal areas could have resulted in flexuring and accompanying fracture extension. The deeply weathered and fractured basement rocks could have facilitated effective glacial erosion during the c. 40 glaciations during the Pleistocene. Freezing and thawing combined with abrasion by ocean waves during non-glaciated periods would have assisted in the formation of a relatively wide strandflat along the Nordland coast.