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Neotectonic stresses in Fennoscandia: field observations and modelling

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The present-day stress state of Fennoscandia is traditionally viewed as the combination of far field sources and residual glacial loading stresses. Investigations were conducted in different regions of Norway with the purpose of detecting and measuring stress-relief features and to derive from them valuable information on the crustal stress state. Stress-relief features are induced by blasting and sudden rock unloading in road construction and quarrying operations and are common in Norway and very likely in other regions of Fennoscandia. Stress relief at the Earth's surface is diagnostic of anomalously high stress levels at shallow depths in the crust and appears to be a characteristic of the formerly glaciated Baltic and Canadian Precambrian shields. The studied stress-relief features are, in general, indicative of NW-SE compression, suggesting ridge-push as the main source of stress. Our derived stress directions are also in excellent agreement with the ones derived from other kinds of stress indicators, including focal mechanisms from deep earthquakes, demonstrating that stress-relief features are valuable for neotectonic research.
As a second step we applied numerical modelling techniques to simulate the neotectonic stress field in Fennoscandia with particular emphasis to southern Norway. A numerical method was used to reconstruct the structure of the Fennoscandian lithosphere. The numerical method involves classical steady-state heat equations to derive lithosphere thickness, geotherm and density distribution and, in addition, requires the studied lithosphere to be isostatically compensated at its base. The a priori crustal structure was derived from previous geophysical studies. Undulations of the geoid were used to calibrate the models. Once the density structure of the Fennoscandian lithosphere is reconstructed it is straightforward to quantify its stress state and compare modelling results with existing stress indicators. The modelling suggests that present-day stress magnitudes are far to be uniform in Scandinavia. For example the modelling predicts that the topography of the southern Norwegian Mountains creates Gravitational Potential Energy (GPE) levels higher than the ones characterising the surrounding regions. This results in significant buoyancy forces competing locally with the regional ridge-push. GPE decreases almost gradually towards the Gulf of Bothnia where strong compressive stresses are predicted.
A local departure from the regional NW-SE trend for the maximum horizontal stress axes is simulated in Trøndelag, Norway. This local stress deviation is supported by stress-relief observations and in situ stress measurements. Our modelling suggests that it results from the combined effects of the weak rheology of the Møre-Trøndelag Fault Complex and topographic stresses associated with the southern Norwegian Scandes mountains.