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Intraplate seismicity of postglacial faults: The ICDP DAFNE proposal

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We recently submitted a full ICDP drilling proposal entitled Drilling Active Faults in Northern Europe (DAFNE). The drilling target is a postglacial fault (PGF) system in North Sweden, the Pärvie fault system (PFS). The PFS is 155 km long, with an apparent throw of up to 25 m (bedrock and soil thickness). The PFS ruptured at the final stage of the Weichselian glaciation, about 10 ka BP, most probably in a great earthquake (Mw=8.0±0.4) triggered by the rapid uplift of Fennoscandia due to relaxation of accumulated stress under the disappearing ice sheet. The PFS is still seismically active; from 2003-2013, 1046 microseismic events were recorded down to ∼35 km depth along the fault system.

We have identified two drill sites located c. 30 km west of the city of Kiruna. This part of the PFS has been proposed to reflect a flower structure. To understand this complex structure, multiple boreholes, logging, in situ testing and monitoring are required. Two sites, with two boreholes at each site are proposed. The two sites aim at penetrating the east-dipping main fault and the west-dipping subsidiary fault, respectively. Ongoing seismicity is related to both structures.

DAFNE has the following scientific objectives:
1. To improve insight in both how large intraplate earthquakes are triggered and why seismicity persists for very long time periods in areas of previous large ruptures;
2. To reach a better understanding of accumulation and release of strain along a postglacial intraplate fault zone, as well as revealing the consequences of seismicity, brittle deformation and stress on the thermal and hydrogeological regimes and the deep biosphere;
3. To improve the understanding of glacial isostatic adjustment (GIA). We anticipate that new data and results from drilling and numerical analyses will support prediction of new postglacial-type seismicity that is expected due to shrinking of ice sheets during current climatic warming at high latitudes (e.g. Greenland, Antarctica, Iceland, Alaska, and major mountain chains); and
4. To study the distal effect of the passive margin development along the western Fennoscandian Shield by extending the 3D modelling of temperature, stress and strain in the Nordland area of Norway eastwards to cover the PFS.

The PGFs in general and PFS in particular represent a type of intraplate seismicity that is still poorly understood. The project also has high societal relevance regarding assessment of seismic hazard for hydropower- and tailing dams, storage of nuclear waste, and mining. With the aid of scientific drilling, we aim at a comprehensive study of the geology, fault properties, tectonic history, stress field, seismicity, hydrogeology, subsurface life and geothermics of the PFS to address the scientific objectives of the project.