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The Stress Pattern of Iceland

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Iceland is one of the few places on earth where an active spreading can be observed onshore, yet the contemporary crustal stress state has not been investigated intensively. We compiled the first comprehensive stress map of Iceland from different stress indicators and analysed data from 57 Icelandic geothermal boreholes. In total we interpreted approx. 37 km of acoustic image logs for stress indicators, i.e. borehole breakouts and drilling induced tensile fractures. Furthermore we revised the 38 data records for Iceland from the World Stress Map 2008 and conducted an extensive literature research to compile all available focal mechanism solutions and geological stress indicators.

The new stress compilation consists of 495 data records for the orientation of the maximum horizontal stress (S_{Hmax}) in and around Iceland with 318 data records of A-D qualities according to the World Stress Map ranking scheme. Most of the data records are derived from focal mechanism solutions (35%) and geological fault inversions (26%). Borehole related indicators (breakouts, drilling induced fractures, hydro-fractures) have a share of 20%. Minor contributions to the dataset are provided by the alignment of volcanic vents and fissures and overcoring measurements.

The mean orientation of S_{Hmax} is $17^\circ \pm 39^\circ$ for all A-D quality data. A closer look at subregions reveals four different provinces with fairly consistent S_{Hmax} orientation. They are in the Capital area and Southern Lowlands (mean $S_{Hmax} = 38^\circ \pm 29^\circ$), the eastern Highlands and Eastfjords (mean $S_{Hmax} = 8^\circ \pm 25^\circ$), the Tjörnes Fracture Zone and Akureyri (mean $S_{Hmax} = 151^\circ \pm 21^\circ$), and the Westfjords (mean $S_{Hmax} = 137^\circ \pm 17^\circ$).

This distribution of S_{Hmax} orientations is in agreement with the prevailing tectonic structure. At the spreading ridges Reykjanes and Kolbeinsey in the South and North respectively an orientation of S_{Hmax} parallel to the plate boundary is observed. The same is observed in the Northern and Eastern Volcanic Zones and it is also indicated by the few indicators associated with the Western Volcanic Zone. In the transform South Iceland Seismic Zone and Tjörnes Fracture Zone which produce Iceland's largest earthquakes, S_{Hmax} is at an angle of approximately 20° to 60° to the transform faults which define the plate boundary. A rotation from ridge parallel to the general intraplate ridge normal S_{Hmax} is expected at some distance from the plate boundary. Such a rotation is observed in the Westfjords, NW-Iceland.