Past and Potential Future Earthquakes in North Iceland

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The knowledge about past and potential future earthquakes in North Iceland has been significantly improved through various research efforts during the past couple of decades. North Iceland is one of the two seismically most active areas in Iceland with earthquakes of magnitudes up to 7. The area is a mid-ocean transform zone, linking the active rift system in northern Iceland to the offshore ridge to the north of the island. However, this transform zone does not consist of a single transform fault, like are common at mid-ocean ridges, but of two parallel and roughly 100-km long seismically active lineaments, the Grímsey Oblique Rift (GOR) and the Húsavík Flatey Fault (HFF). Together these lineaments have been referred to as the Tjörnes Fracture Zone.

Among ongoing research activities that we are involved in are geodetic observations of the plate-boundary deformation, revision of historical accounts to search for previously unidentified information on historical earthquakes in the region, installation of a strong-motion network to study local site and relative amplification effects within the town of Húsavík, multi-beam bathymetric surveys to better determine the location and structure of the HFF, and core-drilling into lake sediments in search for turbidites or other information on pre-historic earthquakes.

Campaign and Continuous GPS observations, as well as InSAR data, have been used to characterize the deformation of the plate boundary. The InSAR data have helped to identify and model several volcanic deformation sources in the rift zone in northern Iceland and the results used to correct GPS station velocities to isolate the steady plate-boundary deformation. The GPS velocities and modeling show that both transform structures in the TFZ actively accommodate the ~2 cm/year relative motion between the ridge segments to the south and to the north. About 2/3 of the transform motion seems to be taken up by the GOR, but only 1/3 by the HFF, which corresponds to ~6.8 mm/year slip-rate for the HFF. The results also indicate that the locking depth on the HFF is surprisingly shallow, or only ~6.2 km, which is likely a consequence of the high temperature gradient in the area. Despite the shallow locking depth and slower slip-rate, the accumulated slip-deficit of the HFF since the last large earthquakes in 1872 is equivalent to a magnitude 6.8 earthquake.

A possible large future earthquake on the HFF is of significant concern for the town of Húsavík, which is located directly on the fault. The estimetated potential, however, is based on several assumptions, e.g. that the 1872 earthquakes completely relieved the fault of accumulated stresses, that the stressing rate has been uniform since 1872, that the locking depth is uniform along the entire fault, and that all the accumulated moment would be released in a single earthquake. To learn more about these assumptions, we are improving the GPS measurement network along the fault and investigating more thoroughly the influence of the Krafla rifting episode (1975-1984) on the accumulated stress on the HFF.