

The Seismogenic Fracture Systems of the Tjörnes Fracture Zone

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The Tjörnes Fracture Zone is a seismically active transform zone connecting the southern end of the Kolbeinsey Ridge to the Northern Volcanic Zone of Iceland. This zone is comprised of a series of interconnecting, tectonic and volcano-tectonic zones, or branches, that together take up the transform motion between the two divergent segments of the mid-Atlantic plate boundary (Fig. 1; Einarsson, 1991; 2008). Understanding the characteristic activity of each branch, and how they interact, is essential for a meaningful estimate of seismic risk in this region. At its southern end the submarine Kolbeinsey Ridge bifurcates into the Eyjafjarðaráll Rift that continues southwards, and the Grímsey Oblique Rift that extends to the SE. The Eyjafjarðaráll Rift is characterised by extensive normal faulting but no indications of Holocene volcanism can be found. The Grímsey Oblique Rift, on the other hand, is composed of several active volcanic systems with N-S trending fissure swarms. Evidence for Holocene volcanism is abundant. At its SE end the GOR connects to the Krafla fissure swarm of the Northern Volcanic Zone (Hjartardóttir et al., 2012). Large earthquakes along this branch are mostly caused by strike slip faulting, often on transverse faults, by bookshelf-type kinematics (Rögnvaldsson et al., 1998). The Húsavík-Flatey Zone, is about 40 km south of and sub-parallel to the GOR. It is well defined by the distribution of seismicity from the southern end of the ER and can be traced on the ocean bottom to the coast in the Húsavík town (Sæmundsson, 1974). It then continues on land into the Northern Volcanic Zone, where it merges into the Theistareykir fissure swarm (e.g., Tibaldi et al., 2016). The HFZ consists of several splay faults that are parallel to the zone itself, sometimes arranged slightly en echelon. The type of faulting is strike-slip with a small component of normal faulting. The HFZ is divided into two main branches where it crosses the Skjálfandi Bay, separated by a 70 m high N-S aligned, normally magnetised hyaloclastic ridge. Several smaller WNW-trending faults are located sub-parallel with the main HFZ within the bay. The main faults have a vertical displacement of 0-15 m, increasing westwards. Four pull-apart basins occur along the fault zone, the largest at the intersection with Eyjafjarðaráll Rift, the southward but magma-starved, continuation of the KR.

The HFZ is seismically active with significant earthquake sequences in 1867–1868, 1872 and 1884-1885, causing considerable structural damage at Húsavík and surrounding farms (Thoroddsen, 1905).

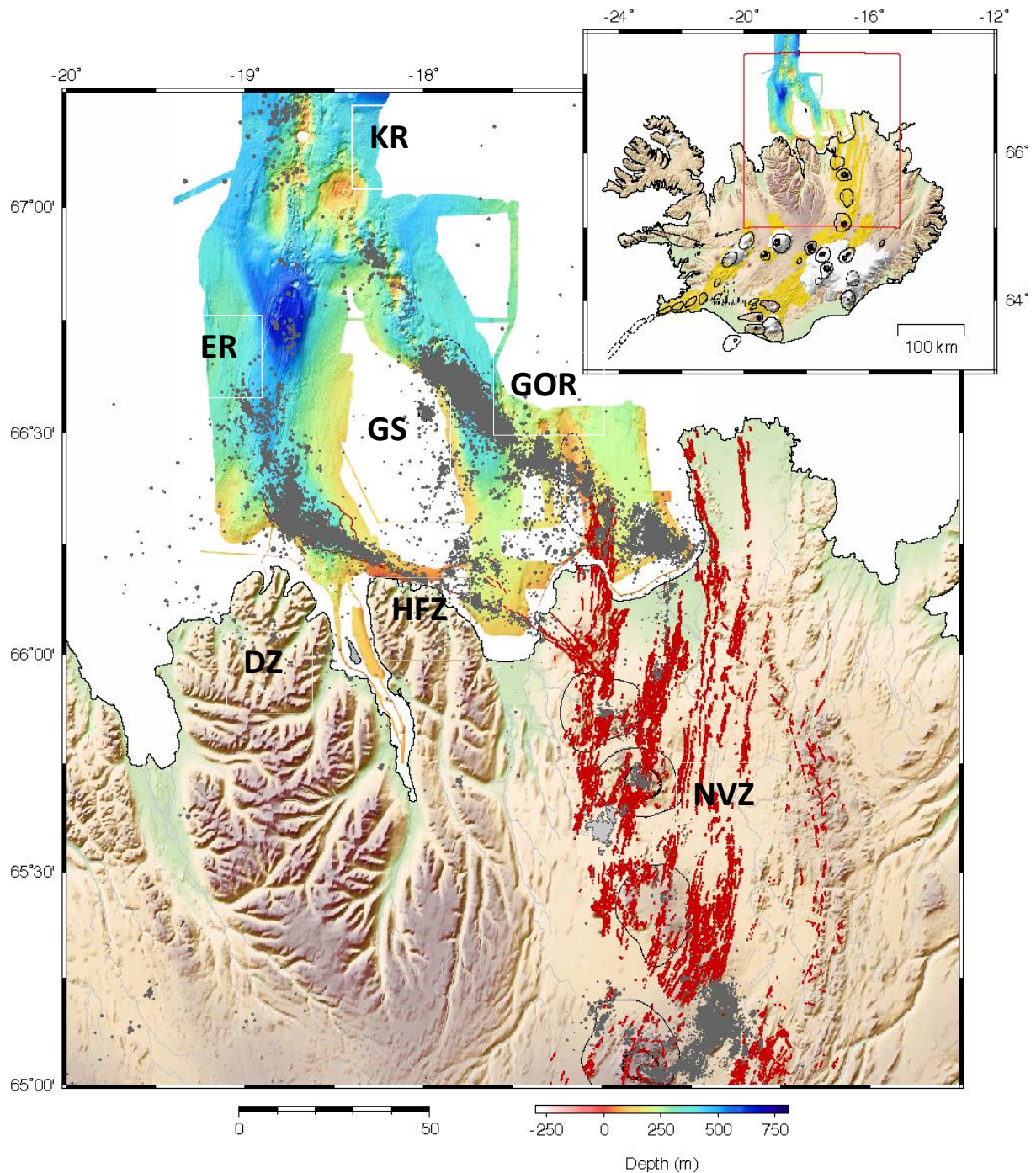


Fig. 1. Overview map of the offshore Tjörnes Fracture Zone and the Northern Volcanic Zone of Iceland, showing the different branches of the plate boundary, The Kolbeinsey Ridge (KR), Eyjafjarðaráll Rift (ER), the Grímsey Oblique Rift (GOR), the Húsavík-Flatey Zone (HFZ), the Dalvík Zone (DZ) and the Northern Volcanic Zone (NVZ). GS shows the Grímsey shoal. Inset map of Iceland shows the volcanic systems (Einarsson and Sæmundsson, 1987) and the study area. Holocene fractures and faults are shown in red (from Hjartardóttir et al., 2015), earthquake epicenters of the last 5 years with black dots (from the Icelandic Meteorological Office). The submarine topography is from Magnúsdóttir et al. (2015).

The crustal block demarcated by the GOR, ER, HFZ, and NVZ, in some way acts independently of the two major lithospheric plate, North America and Eurasia Plates. This Grímsey Block may be too small to be a candidate for a microplate. There is a hint of a N-S

trending zone of seismicity connecting the GOR and the HFZ along the eastern edge of the Grímsey shoal and dividing the Grímsey Block in two. This zone appears to consist of 3-4 NNE-striking faults. There is indication of a third major shear zone about 30 km south of the HFZ, the enigmatic Dalvík Zone. Large historic earthquakes have occurred in this zone, most recently in 1963 and 1934 (Einarsson, 1976; Halldórsson, 2005; Stefánsson et al., 2008), but recent GPS measurements have failed to show significant movements along it (Metzger et al., 2013). Bookshelf-type tectonism has been suggested and is supported by the distribution of epicenters in the last decades.

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