Seismic activity in North Iceland since 2011 with a special focus on the past three years

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Following two major earthquake sequences in the Tjörnes Fracture Zone – 2012 in Eyjafjarðaráll and the western Húsavík-Flatey-Fault, as well as 2013 in Skjálfandadjúp on the Grímsey-Oblique-Rift – several smaller earthquake swarms have been detected in the fault zone since. The most prominent one occurred in autumn of 2013 on the Húsavík-Flatey-Fault, filling up the gap between the two cluster that were active in 2012. Another significant swarm occurred in Öxarfjörður beginning of 2016. However, strongest events in these sequences did not exceed M_{lw}4.

This presentation gives an overview on seismic activity from 2011 until now. After a short summary of the 2012 and 2013 major sequences, the main focus of the talk will be on earthquake sequences during the past three years. Figure 1 gives an annual overview of earthquake activity in North Iceland for each year since 2011, including focal mechanisms of events M_{lw}>3. Seismic activity developed throughout the past six years as follows:

Following a comparably calm year 2011 with around 2,100 detected events, the largest up to M_{lw}3.2, seismic activity significantly increased in mid September 2012, when an earthquake swarm occurred in the Eyjafjarðaráll graben, about 25-27 km NNE of the town of Siglufjörður. Strongest earthquakes reached M_{lw}4.5 and a total of around 500 events could be located. On 20 October 2012 seismic activity picked up again about 4-5 km SW of the previous swarm location, rapidly developing into a major earthquake sequence with a total of more than 3,000 locatable events until the end of the year. The two strongest events reached M_{w}5.6 and M_{w}5.3 shortly past midnight on 21 October, both being widely felt in N-Iceland. Several further events exceeded M_{w}4 during the first hours of the sequence. Focal mechanisms of major earthquakes in the graben show N-S striking normal faulting (GCMT catalogue, Ekström et al., 2012). During the following days, seismic activity migrated towards the SE, into the western segment of the Húsavík-Flatey-Fault. Focal mechanisms in this area based on P-wave polarities as well as P- and SV-wave amplitudes (Slunga, 1981) show strike-slip movements, most likely right-lateral and striking in direction of the main fault. Aftershock activity decreased throughout the next weeks and into the beginning of the year 2013.

Another major earthquake swarm began on 30 March 2013 in the Skjálfandadjúp graben on the Grímsey-Oblique-Rift, about 15 km east of the island of Grímsey. Magnitudes increased steadily for the next days, culminating in a M_{w}5.5 earthquake shortly after midnight on 2 April. Several earthquakes of M_{w}4.0-4.7 followed within the next two days, first on a fault about 7-8 km NW of the main shock, but later also on faults about 15-20 km SE of it. Activity jumped between these three clusters for the next weeks and gradually decreased. Focal mechanisms of almost all larger events suggest that they are located on NNE-striking left-lateral faults.
Both the 2012 and 2013 major earthquake sequences caused an immediate response of the Icelandic Civil Defence and the scientific community. Alert levels in the region were raised to “uncertainty” during both crises in view of a potential $M_W 6.5-7.0$ earthquake (Stefánsson et al., 2008; Metzger et al., 2011) – and the first Húsavík workshop on seismic activity in North Iceland was held in June 2013.

Fig. 1: Overview of seismic activity in the Tjörnes Fracture Zone for each year since 2011. Red dots mark earthquakes occurring during the respective year, grey dots in the following panels mark old events since 2011. Beach balls give focal mechanisms of earthquakes $M_{lw} >3$. Offshore structures and faults are given as black lines, onshore faults are red. Seismometers of the permanent SIL network (Böðvarsson et al., 1999) are shown as black triangles, arrows give the direction of plate movement.
During the past three years, the Tjörnes Fracture Zone remained rather active, although none of the earthquake sequences that have followed since spring 2013 reached similar levels of intensity and number of events.

The offset between both clusters of the 2012 – an approximately 10 km long gap between the southern end of the Eyjafjarðaráll graben and the western Húsavík-Flatey-Fault – remained an area of major concern. This gap was filled up with an earthquake swarm in late September and early October 2013, with a total of around 2,000 earthquakes. Focal mechanisms revealed typical strike-slip movements as expected on that fault segment, but none of them exceeded $M_{lw}3.5$. A minor sequence on the same segment followed in February 2014 with magnitudes up to $M_{lw}3.2$. Since then, activity in Eyjafjarðaráll and on the western Húsavík-Flatey-Fault has been gradually decreasing throughout the years 2014-2015. Only minor and short-living sequences or single events have been detected since, none of them reaching $M_{lw}3$.

At the same time, seismicity on the Grímsey-Oblique-Rift was rather low in 2014. Activity steadily increased again in 2015 with two N-S striking normal faulting events of $M_{lw}3.8$ and $M_{lw}3.5$ east of Grimsey during a swarm end of October. Another prominent and longer living earthquake sequence occurred in January 2016 in Öxarfjörður at the SE-end of the Grímsey-Oblique-Rift. A total of around 1,800 events has been detected there between mid January and mid February, the strongest of which reached $M_{lw}3.7$ on 21. January and showed almost pure strike-slip movements, most likely left-lateral NNE-SSW striking.

Summarising, the Tjörnes Fracture Zone has remained seismically quite active since the last Húsavík workshop in 2013. Although no event has exceeded Mw4 since the April 2013 earthquake sequences east of Grimsey, several smaller swarms were observed on both the Húsavík-Flatey-Fault and the Grímsey-Oblique-Rift.

References:


