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Dynamics of the Askja caldera landslide, July 2014, from seismic signal analysis

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A voluminous landslide occurred at the Askja caldera in the Icelandic highlands on July 21st, 2014. The next day, flood marks of at least ten tsunami waves, that had reached the northern shore of the caldera lake, could be mapped out. The highest flood marks were found up to 60 m above the lake level close to famous tourist spots underlining the high hazard potential of the area.

Since the landslide happened at night, no direct observations of the mass movement nor of the subsequent tsunami waves in the caldera lake were made. We present the analysis of seismic data from a network of 58 seismic stations that recorded data during the event. The seismic data give valuable information on the triggering, initiation, timing, and propagation of the landslide, with additional details on precursory signals before and oscillation waves in the caldera lake after the main landslide. From the set of seismic wave forms, characteristic features were extracted that could be used for early warning proposes.

The seismic data reveals that the main slope failure along the southeastern caldera wall was a large, single event starting at 23.24 UTC. The main part of the energy was released in the first two minutes followed by smaller events, before the background noise level was re-established some 40 minutes after the main failure. Subsequent mass movements, much lower in amplitude, occurred during the following hours.

About 20 minutes before the main failure, the background noise level started to rise. Ground velocities were up to three times higher that the background level with dominant frequencies between 2-4 Hz. The increase in background noise level is visible in stations up to 30 km away from the landslide area. This velocity increase is followed by a prominent velocity drop five minutes before the main failure. The spatial distribution of the velocity decrease with its centre at the detachment area of the landslide has an elliptical outline with a long axis oriented NE-SW. This orientation mimics the general structural trend at the Askja volcanic system. The information about the characteristic increase and decrease in ground velocities before the main landslide could be one of the elements to be implemented in a monitoring and early warning system of the caldera walls.