



## **Seismic events induced by a landslide: what can they tell about the landslide?**

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The characteristics of seismic signals generated by the mass movement are considered to reflect the physical properties of the movement, and the use of seismic data for landslide studies has recently attracted increased attention. Some landslides produce very small earthquakes associated with slip initiation, which can be observed by nearby seismic stations. The 2015 Rausu landslide in Japan and the 2016 Nuugaatsiaq landslide in Greenland showed repeating small earthquakes before the catastrophic failure. The small earthquakes have very similar waveforms with different amplitudes and time intervals. The events continued for about 10-20 hours followed by the large deformation of the landslide.

These seismic sequences are considered to be evidence of stick-slip movement of the landslide before the large failure occurs. The nearly identical waveforms suggest that the source locations and mechanisms are very similar in the sequence, which indicate that the seismic events are generated at a particular small area. The amplitudes and time intervals of the events may reflect the physical properties of the slip surface. Larger amplitudes and/or shorter time intervals of the seismic events suggests an increase of the shear stress accumulation during the precursory creeping stage.

Similar apparent stick-slip behavior has also been observed during movement of glaciers and ice sheets at the contact between ice and bedrock. These observations suggest that the heterogeneous structure, such as asperities on the slip surface plays an important role in controlling the movement of landslides, and adds a new aspect to the conventional understanding of mechanisms that control the mass movement.