



## **4.5 years of monitoring the very active Veslemannen rockslide, Romsdalen, Western Norway**

Lene Kristensen, Gudrun Majala, and Lars Harald Blikra  
Norwegian Water Resources and Energy Directorate, Oslo, Norway

Veslemannen is a small part of the large unstable rockslide Mannen, which moves 50-400 times faster than the rest of Mannen. Every late summer and autumn, it undergoes increased displacements and stages of acceleration in relation to precipitation events. In 2017 and 2018 the rates of movement more than doubled every year, causing concern both from evacuated people and local and state agencies responsible for population safety, railroad etc.

Mannen is a large unstable rock slope (10-15 mill m<sup>3</sup>) located in the steep glacial valley Romsdalen, Western Norway. Mannen is classified as a high-risk object, under continuous monitoring since 2009 by NVE (The Norwegian Water Resources and Energy Directorate). The 120-180.000 m<sup>3</sup> large unstable part was discovered by GB InSAR measurements in 2014, and) is developed in a steep anti-dip slope in gneiss from the Caledonian orogeny. The upper parts are loose boulders while the middle parts (inaccessible) are crushed rock, but the inherent foliation is still visible. The lower parts are less fractured bedrock and appear to hold back the moving rock mass. The runout from a failure of Veslemannen may affect a few houses, a farm and a railroad. Inhabitants are therefore evacuated and the railroad is closed when red (highest) hazard level is issued.

Movement in Veslemannen starts every year during snowmelt and increase progressively in late summers and autumn. The acceleration periods relates to heavy rain events or in some cases melting of early snow. In the years 2014 to 2016, the upper parts of Veslemannen moved less than 1 m and the lower parts about 10 cm. The movement increased significantly in 2017, with 2.6 m displacement in the upper part and 30 cm in the lower part. Some of the 2017 increase was caused by an attempt to trigger the rockslide by pumping water to the uppermost parts. However, no large failure occurred, and the experiment has not continued. A more dramatic increase occurred in 2018, with movements of 6-8 meters in the upper part, and 1 meter in the lower part. Velocities during the crisis have increased in a similar way, from a daily maximum of about 4 cm in 2014-2016 to 24 cm in 2017 and 70 cm in 2018. The number of annual crisis (red hazard level) has likewise increased, from one each year from 2014 to 2016, two in 2017, and finally six in 2018.

Veslemannen appears to undergo a progressive development towards failure. Movements, velocities and number of evacuations have increased significantly the last years and in particular in 2018. At the same time, rockfall activity is high during the acceleration events – the largest in 2018 being around 1.500 m<sup>3</sup>. This progressive development might also to have been influenced by the yearly different snow accumulation and subsurface temperature-regime conditions. It is possible that the rock mass will fail in smaller fractions without reaching inhabited areas. NVE will continue monitoring the Veslemannen rockslide.