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Using geophysics on a terminal moraine damming a glacial lake: the Flatbre debris flow case, Western Norway.

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The 2004 debris flow in Fjærland, Western Norway, developed from a failure of a glacial moraine ridge, causing sudden drainage of the lake behind and possibly also a lake trapped within the Flatbre glacier. The mass flow itself included 250 000 m^3 and ended in a fan of boulders 3 km downstream, while the finer material inundated fields and nearby areas. The initial volume at the moraine is estimated to 25 000 m^3, showing a significant bulking as the masses cascaded down the valley.

Early drainage from the glacier and blockage of the normal drainage routes combined with a weakening of the moraine ridge may have triggered the event in the first place. In a warming climate, a likely scenario in many high mountain glacial regions is melting ice cores and internal erosion of moraines damming glacial lakes, and eventually dam ridge failure when high drainage is experienced. To check whether geophysics could be useful for investigation of the inner structure of the moraine, a geophysical campaign was performed in September 2006, consisting of resistivity, GPR and seismics. A new type of rough terrain antenna was used for the GPR.

All techniques worked well, providing useful information, despite a very blocky moraine material. There is, for example, no evidence of ice, at least at the penetrated depths (20-30 m). On the contrary, the moraine is quite wet, characterized by low resistivity in opposition to icy material closer to the glacier, seismic velocities typical of water-saturated material, and GPR shows clear water tables. The good quality of the seismic data, usually poor on such moraine material, is an additional indication of

high water content. Both resistivity and GPR are very efficient techniques, providing results directly in the field. Seismic is more difficult to use, but its results, when combined with those of the two previous techniques, give a more complete image of the moraine. A zone of apparently higher water content was identified and may require a continuous monitoring to better assess the water flow inside the moraine.