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Towards the prediction of thermally driven landslides

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The problem of a creeping landslide which is accompanied by heat production due to friction on its base (i.e. a thermally driven slide) is studied. The landslide is modeled using a rigid block that slides on a zone of finite width. The model is applied in the infamous catastrophic landslide of the Vaiont valley (Northern Italy) which was preceded by 2-3 years of creep. The slide ended with the final collapse of the rock mass slipping at about 30 m/s in an artificial lake at the foot of the slide. Creep and final slip were localized in a clay-rich water-saturated layer. We propose shear heating as the primary mechanism for the long-term phase of creep and for the final collapse of the landslide. We model the creeping slide with a rigid block moving over a thin zone of intense shear. Introducing a thermal softening and velocity strengthening law, we reformulate the governing equations of a water-saturated porous material, obtaining an estimate for the collapse time of the slide. Our model is calibrated upon real velocity measurements from the Vaiont landslide and provides a good representation of the total history of the slide velocity. We also show that $\sim$ 21 days before the collapse the stability of the slide changed, since shear-heating started localizing in the clay-rich layer, inducing a tendency for slip localization and thermal runaway instability in a plane. The last minute acceleration of the slide is explained by the onset of thermal pressurization, triggered by the temperature rise within the clay-rich layer. Thermal pressurization leads to total loss of strength of the gouge and to movement on a frictionless base.

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Reference

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