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Rheological behaviour of Trièves clay, and applications to landslide dynamics

Guénolé Mainsant (1), Guillaume Chambon (2), Denis Jongmans (1), Laurent Baillet (1), Eric Larose (1), and Grégory Bièvre (3)

(1) UJF, ISTerre, Saint Martin d'Heres, France (guenole.mainsant@ujf-grenoble.fr), (2) Cemagref, UR ETGR, Grenoble, France, (3) Centre d'Etudes Techniques de l'Equipement de Lyon, Laboratoire Régional d'Autun, France

Clayey landslides are common worldwide. In the Trièves area (south of Grenoble, French Alps), which is mainly covered by a thick Quaternary clay layer, several landslides with different dynamics are continuouly monitored (L'Harmalière landslide, Avignonet landslide, etc.). The velocity of these slides can vary dramatically (from cm/y to m/s), with earthslides evolving to earthflows, depending on the meteorological conditions (rainfall, snowmelt), water infiltration in the mass, slope and geometry of the substratum. These factors may change the stress state applied to the sliding mass and define its evolution with time. However, in such a dynamic context, the geotechnical properties of the material, such as Atterberg limits, are not sufficient to define the behavior of clay slides. Knowledge of the full rheological behaviour of the clay, ie of the relationships between stresses, strains, and strain rates, is required. To that purpose, we performed laboratory rheometric parallel-plate tests on samples of Trièves clay (taken from a gully close to L'Harmalière landslide) with different water contents and different times of rest (after a preshear).

Trièves clay was identified as a viscoplastic material with a highly pronounced viscosity bifurcation. Below a yield stress τ_c, the material behaves as a solid. Above the yield stress, on the contrary, the material abruptly starts flowing, with a relatively high critical shear rate ($\dot{\gamma_c} = 1 - 2.10^{-1}s^{-1}$). The value of the yield stress τ_c strongly depends on the gravimetric water content (GWC) of the material: 160Pa for $GWC = 68\%$, 210Pa for $GWC = 62\%$, 400Pa for $GWC = 55\%$. The yield stress also varies with the time of rest. On the contrary, the value of the critical shear rate $\dot{\gamma_c}$ appears essentially independent of these parameters. Trièves clay also displays a clear thixotropic behaviour: above the yield stress, the fluidization of the material may be delayed by several tens of seconds after the application of stress, indicating that the destructuration of the material does not only depend on the mechanical solicitation but also on the time during which this solicitation is applied.All these rheological properties could potentially play a key role in the slide-to-flow transition observed in the Trièves lanslides, explaining how dramatic and sudden fluidization can occur, and highlighting the influence of time on this process.