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Accounting for pore water pressure and confined aquifers in assessing the stability of slopes: a Limit Equilibrium analysis carried out through the Minimum Lithostatic Deviation method

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The model we introduce is an implementation of the Minimum Lithostatic Deviation (MLD) method, developed by Tinti and Manucci (Tinti and Manucci 2006; 2008), that makes use of the limit equilibrium (LE) theory to estimate the stability of a slope. The main purpose here is to analyse the role of a confined aquifer on the value of the Safety Factor (F), the parameter that in the LE is used to determine if a slope is stable or unstable.

The classical LE methods treat unconfined aquifers by including the water pore pressure in the Mohr-Coulomb failure formula: since the water decreases the friction shear strength, the soil above the sliding surface turns out to be more prone to instability. In case of a confined aquifer, however, due to a presence of impermeable layers, the water is not free to flow into the matrix of the overlying soil. We consider here the assumption of a permeable soil sliding over an impermeable layer, which is an occurrence that is found in several known landslide cases (e.g. Person, 2008; Strout and Tjeltja, 2008; Morgan et al., 2010 for offshore slides; and Palladino and Peck, 1972; Miller and Sias, 1998; Jiao et al. 2005; Paparo et al., 2013 for slopes in proximity of artificial or natural water basins) where clay beds form the potential sliding surface: the water, confined below, pushes along these layers and acts on the sliding body as an external bottom load.

We modify the MLD method equations in order to take into account the load due to a confined aquifer and apply the new model to the Vajont case, where many have hypothesised the contribution of a confined aquifer to the failure. Our calculations show that the rain load i) infiltrating directly into the soil body and ii) penetrating into the confined aquifer below the clay layers, in addition with the lowering of the reservoir level, were key factors of destabilization of the Mt Toc flank and caused the disastrous landslide.