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Creep: An underrated type of mass movement on gently dipping hill slopes - examples from the Eastern Alpine foreland

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Creep, as a very slow type of mass movement was first described by Terzahgi (1950) und Haefeli (1954, 1967). Terzaghi (1950) pointed out that creep represents an own type of mass movement cannot be compared with other types, such as slides, as creep occurs without rupture. According to him other mechanical laws than those that typically apply for mass movements, have to be determined for creep. In a more recent classification of mass movements, creep is described as slow earthflow within the flow type of movement (Highland & Bobrowsky, 2008). Aside from different ways of categorization of landslides, a very slow, imperceptible rate of movement is still considered characteristic for creep.

Recent geological and geomorphological investigations of all kind of mass movements in the Eastern Alpine foreland in Austria (Eastern part of the Styrian basin, Oberpullendorf basin, Eisenstadt basin) showed that creep is not only widespread, but is in fact the most common type of mass movement in the Neogene sediments of the basins. More than 180 previously unrecognized zones of creep have been classified. Statistical analysis indicates that in some of the investigated areas creep occurs typically on slopes with gradients between only 10-35°. Movement rates are very low, inclinometer and other measurements show displacement rates in the range of a few centimeters per year. Therefore these mass movements have previously remained unnoticed by the population, local authorities and engineers. As a result there have been misjudgments in the land use-, building- and infrastructure planning which have caused a number of damages.

Aside from the immediate implications creep has even more severe and longer term consequences. As a land-forming process creep acts very constant over a very long period of time. Already Haefeli (1967) realized that creep occurs at a much lower rate of shear stress than the shear strength of the soil material. The rate of shear stress where creep starts to occur is called critical shear stress or boundary of creep (Prinz & Strauß, 2006). If the critical shear stress impacts the slope material over a long period of time (decades or centuries) the displaced slope material will react by reducing its shear strength. That causes a reduction of the original shear strength in the displaced mass up to the residual shear strength of the former unaffected mass.

In case of heavy precipitation, water acts among other effects as an additional weight-component in the displaced mass. Zones of creep with their reduced shear strength are in this case much more vulnerable to form fast moving slides and flows than slopes without creep.

This relationship became very obvious during extremely heavy rains in the study area in June/July 2009, causing floods and hundreds of fast mass movements. The induced slides and flows caused severe damages on buildings and infrastructure. Many of these slides and flows occurred in areas that have been affected by creep before.

In summary the present investigation shows that creep acts in two different time scales: The short-term effects caused directly by the slow but continuous movement of a slope, and the long-term effects causing reduced stability of the slope related to lowered shear strength. As a result the areas of creep are more vulnerable for fast and much more dangerous mass movements.

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