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Macroscopic Brittleness: A Poorly Understood Initiation Mechanism for Extremely-Rapid, Flowlike Landslides in Fine Grained Colluvium

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Extremely-rapid, flowlike landslides can impact people and property far from their source, and predicting the initiation and runout of these events remains a challenging task. The ongoing risk analysis of the Schlucher Landslide, located near the town of Malbun, Liechtenstein, highlights the uncertainties associated with this type of analysis. This landslide, composed of clayey sand and clayey gravel, has accumulated 10s of meters of displacement in the last 3 years. Managing the risk posed by this unstable colluvial mass requires addressing the following questions: Can the Schlucher Landslide transition into an extremely-rapid flowlike landslide? If such a transition were to occur, what would be the consequence for the community located at the outflow of the Schlucher Catchment?

Addressing these questions requires an understanding of potential mechanisms that can lead to catastrophic failure of the unstable mass. A number of mechanisms, including static and dynamic liquefaction, loss of true and/or apparent cohesion and shearing to residual strength have been well documented in literature, and can be identified by routine geotechnical analyses. The focus of this work is on macroscopic brittleness, a poorly understood mechanism that may have governed the failure of a number of well documented case histories that were composed of fine grained colluvium, similar to the Schlucher Landslide.

Here we present detailed field observations and 3D numerical runout modelling of three extremely-rapid, flowlike landslides that occurred in fine grained colluvium: The 2014 Oso Flowslide, the 2012 Johnsons Landing Landslide and the 1973 Attachie Slide. These analyses reveal that the catastrophic runout of all three cases can be explained by the landslide debris undergoing a large, undrained strength loss. The potential for this mechanism to occur at these sites would have been difficult to identify by conventional geotechnical analyses. We then compare surface and subsurface data obtained for the Schlucher Landslide to these three cases to qualitatively assess the potential that this landslide could experience a similar undrained strength loss. The results of this work have significant implications for understanding catastrophic failure potential of fine grained colluvium, and highlight the need for further research on the mechanism of macroscopic brittleness.