Geophysical Research Abstracts
Vol. 20, EGU2018-9765, 2018
EGU General Assembly 2018
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Potential and limitations of physical laboratory modelling for the analysis of rock avalanche dynamics: insights from field and experimental observations

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Rock avalanches are extremely rapid, massive flow-like movements resulting from the detachment of large volumes of rock that dynamically disaggregate during the motion. This type of phenomena typically occurs in extremely steep, remote areas that are difficult to access: for these reasons, eyewitness observations are rare, and then an accurate analysis of the deposit texture becomes of great importance for the comprehension of the behaviour of the avalanche. However, in the last years several authors have tried to analyze the dynamic behavior of rock avalanches also by means of laboratory experiments with specific flume test apparatuses. But, considering the rock volumes typically involved in such events, these experiments are highly affected by the scaling problem. Another drawback of laboratory experiments is the difficulty to properly simulate the fragmentation process due to the low energy involved. Nevertheless, evidences from small scale laboratory tests can provide useful information about the dynamics of rock avalanches, particularly as regards the formation of sedimentary structures within the landslide body. From this point of view, experimental tests allow to examine the propagation and deposition of the material, that is instead very difficult to be observed during real events.
Therefore, this work aims at better understanding the sedimentary features of real rock avalanche deposits by clarifying the deposition mechanisms through flume laboratory experiments. In this sense, specific focus will be given to the mechanism of inverse grading (or inverse sorting), in which the average clast size progressively increases towards the top of the deposit. This feature is typical of numerous rock avalanche deposits: for this reason, we first describe in detail the sedimentary structures of two rock avalanche deposits located in Central Apennines (Central Italy). Then, we provide the results deriving from laboratory tests performed using two different flume test apparatuses: the objective of these tests is to identify potential similarities between the tested material and the real rock avalanche deposit. Finally, we examine the whole problem from a theoretical point of view, by introducing simple rheological models in order to describe the inverse grading phenomenon at different scales, then defining limitations of applicability of laboratory modelling to real events.