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## An International Perspective I or II: Dynamic Modeling of Submarine Slide Run-Out/Submarine Mass Movements—Where Do We Stand, and What Are the Main Challenges?

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### Abstract

Submarine mass flows show a wide variety of flow behavior not all of which are understood yet. Some submarine slides show extreme long runout distances with runout ratios, i.e. the ration between drop height,  $H$ , and horizontal travel distance,  $L$ ,  $H/L \sim 0.01$  or even less. These low runout ratios are not explainable with simple rheological models based on in-situ soil properties. Those slides do not have a subaerial resemblance. On the other hand, runout ratios of submarine rockslides fit very well into the line of subaerial ones, except that their dimensions are larger.

Hydroplaning, which was first discovered in laboratory flows and later suggested to occur also in submarine debris flows, is probably a prime mechanism for explaining the extremely long runout distances observed in some natural debris flows even of overconsolidated clay materials.

Recent experimental and theoretical work on the dynamics of submarine flows will be summarized. We give a brief review on field data, experimental results gained with subaqueous flows of various compositions, and focus on recent approaches for the numerical simulations of submarine debris flows based on those observations. Distinction is given to the different behavior of clay-rich and the more sandy flows.

### Introduction

Submarine debris-flows, mudflows, rockslide, and turbidity currents are important mass wasting processes along the continental margin causing the transport of sediments into the deep sea. These submarine gravity mass flows have been recognized to have transported sediment over several hundreds of kilometers on slopes of less than one degree. For example, one of the largest known slide, the Storegga Slide in front of

western Norway extended its flow over approximately 800 km about 8000 years ago (Bryn et al. 1998). The more recent Grand Banks event in 1926 extended more than 1000 km (Locat and Lee, 2002).

Furthermore, those flows constitute geohazards, as they endanger offshore constructions like oilrigs, pipelines, or communication lines. They can cause tsunamis and so endanger costal towns and onshore sides. This hazardous component is a major reason for the great interest in their dynamical behavior and the ability to predict their runout lengths, impact forces, and their potential of triggering a tsunami wave.

Recent reviews on submarine slide processes are given, e.g., by Locat and Lee (2005) and Elverhøi et al. (2005).

Field observation and laboratory experiments form the basis for the development of numerical tools for the prediction of runout length and impact pressure calculations. For that reason, we start with a brief overview on field observations and laboratory experiments. Then we present some activities on numerical modeling and challenges involved.

### Field observations

Figure 1 sketches the distribution of the runout ratio  $H/L$  for various types of subaqueous and subaerial landslides. Low runout ratios imply a long runout and low frictional effects. Obvious is the decreasing of the runout ratio with increasing slide volume, except for so-called outrunner blocks, which show a different trend. Subaqueous debris flows tend to have smaller runout ratios having similar volumes than their subaerial counterparts, whereas rock avalanches, on the other hand, seem to behave similar in water as well as subaerial. This similarity between subaerial and subaqueous rock avalanches suggests similar flow behavior (rheology). This is not the case for debris flows. Here, distinctive differences can be observed; subaerial are less mobile than submarine once. Issler et al. (2005) investigated the scaling behavior of clay-rich submarine debris flows and concluded that scaling behavior is close to that for visco-plastic flow models. However, a closer look revealed also a progressive deviation for large flow masses.