A seismological study of gravitational mass movements based on lab-scale experiments

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I hereby certify that the work presented in this thesis has been composed independently without use of any sources or auxiliary means other than mentioned.

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Abstract

Seismological monitoring of gravitational mass movements is considered an emerging field in earth and environmental sciences, allowing for the remote detection and quantification of slope processes by distant seismometers (Burtin et al. (2013); Petley (2013)). The method includes the possibility to invert seismic signals for a suite of aspects of event dynamics and for details of the fragmentation process. For a sound interpretation of these ground movement signals in nature, knowledge of the seismic source and of the energy transfer to the detector is paramount. Since most events however lack direct observations by other methods (e.g. cameras), the source–signal relationship often remains obscure. In order to shed light on the source–signal relationship in the context of monitoring gravitational rock movements, we started controlled laboratory experiments using analogue models. The idea of applying seismological monitoring techniques on a lab–scale opens for new and perhaps improved ways of characterizing natural events by their corresponding seismograms. Initial benchmark tests are carried out involving a controlled source i.e. a ballistic steel ball vertically impacting a horizontal glass base. These tests intend to calibrate and verify the monitoring method by relating a set of seismic metrics to the energy released during impact and deriving the respective scaling laws. Subsequently, the method is applied to models of dynamically fragmenting gravitational rock movements (Haug et al. (2014)). For this purpose a material was developed that fails in a brittle manner at lab–scale conditions. Experiments are performed by releasing the material down a slope and monitoring with a digital camera at a frequency of 50 and 250 Hz. The results from previous experiments illustrate the dynamic propertied of samples as a function of shear strength or cohesion (Haug et al. (2014)). By application of the scaling law to the experimental data, we attempt to estimate the impact energy during analogue experiments, potentially allowing for qualitative and quantita-
tive information about the underlying mechanisms and the energy budget of the system. We find that the degree of fragmentation of a sample not only influences the mobility of experiments, but also their corresponding seismic signals and that the amount of energy consumed by fragmentation plays a more significant role in the energy budget of gravitational mass movements than has previously been assumed.
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# Contents

1 Introduction

1.1 Motivation and Outline .................. 14
1.2 Thesis Structure ........................ 16

2 Literature Overview ....................... 17
2.1 Dynamics of Gravitational Rock Movements .................. 17
2.2 Seismic Monitoring in Nature .................. 18
2.3 Experimental Approach .................. 20
2.4 Wave Propagation ........................ 24

3 Monitoring techniques and setups .......... 26
3.1 Seismological Monitoring .................. 26
3.2 Optical Monitoring .................. 27
3.3 Benchmark Setup .................. 28
3.4 Experimental Setup .................. 30

4 Methodology ................................ 32
4.1 Material Preparation .................. 32
4.2 Sensor Calibration .................. 33
4.3 Data Processing .................. 33
4.3.1 Event Detection .................. 34
4.3.2 Hilbert Transform and Analytic Signal .................. 35
4.3.3 Seismic metrics .................. 38
4.3.4 Spectral Analysis .................. 38

5 Results ................................ 40
5.1 Bouncing ball benchmark .................. 40
CONTENTS

5.1.1 Observational results ........................................... 41
5.1.2 Quantitative results ............................................. 45
5.1.3 Physical Meaning ................................................ 53
5.1.4 Scaling to Nature ................................................ 54
5.2 Analogue Experiments .............................................. 57
  5.2.1 Observational Results .......................................... 57
  5.2.2 Quantitative Results .......................................... 59
  5.2.3 Application of the Scaling Law and Inferred Energy ..... 65
  5.2.4 Limitations of the Approach .................................. 68

6 Discussion .................................................................... 71
  6.1 Signal Analysis ..................................................... 71
  6.2 Validation of the Scaling Law .................................... 77
  6.3 Possibilities and Limitations in the Lab ....................... 80
  6.4 Application to Nature ............................................. 81

7 Summary ...................................................................... 83

Bibliography ................................................................ 87