

Introduction to the Physics of Landslides

Fabio Vittorio De Blasio

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Lecture Notes on the Dynamics
of Mass Wasting

 Springer

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Preface

A book like this should certainly start emphasizing the death toll and destruction potential of landslides and the consequent need for a better understanding of these geohazards. Nevertheless, the interesting and inspiring aspect of natural catastrophes should also be stressed. Much physics, mathematics, engineering, technology, and even chemistry and biology form the foundation of the study of natural hazards. It is a subject that will become more physically oriented in the near future, and from which the motivated researcher will enjoy material for study, research, and discovery.

There are numerous books, reports, and Internet documents about landslides, and no scientist knows even a small fraction of them. This book is not an attempt to review the field of landslides, as this would be an impossible task for one person, an effort which besides would soon go outdated. During my teaching at the University of Oslo I have realized the need for better understanding of the basic physics necessary for understanding landslides, and the geological phenomena in general. Sometimes students, investigators, and practitioners who use conceptual and numerical models in the study of landslides pay little attention to the basic physical laws, and ignore the mathematics necessary to describe it. The understanding of physical processes may become fuzzy; formulas and computer programs are arcane and their range of validity is not tested. One of the negative consequences of the rapid progress in science is the extreme specialization, which entails a deep knowledge of a narrow subject, limited understanding of a close topic, and complete ignorance of distant disciplines. Although pigeonholing scientific knowledge is useful for learning, it must be reminded that cultural compartments are fictitious. Strengthening the basis of a certain subject appears as an appropriate treatment to reduce this problem.

Quantitative methods in the study of landslides are not novel. However, geotechnics and geological engineering mostly deal with problems of slope stability. Apart from Erismann and Abele's book only dealing with rock avalanches, I am not aware of any book on this subject at the introductory level, although it is possible that some books do exist in language other than English like my own short introduction in Italian. Although this is also a topic on which many contributions continuously appear on specialized journals, the field of landslide dynamics is still

far from a state of maturity. Perhaps this is reflected by the lack of a name defining the subject of landslide dynamics like seismology is for the science of earthquakes (probably a name like “ruinology” could be appropriate, from ruina=landslide in Latin).

This book will especially deal with the physics and dynamics of landslides. In short, the book aims at: (1) Informing about the physical basis of the mass wasting phenomena. (2) Stand as a reference of some basic physics needed for working with landslide modeling. (3) Help to work out physical models of landslides. (4) Influence the students to become more curious than erudite.

It is easier to list what the book is not about. It is not intended as an updated report packed with references. Nor does it treat the subject in a systematic and thorough way. The emphasis is instead on simple models rather than up-to-date complex analytical and numerical techniques. The book does not try to be comprehensive and updated; it rather aims at promoting physical reasoning. Important subjects have been left out for different reasons: because too complicated, too novel, very far from the author’s expertise (a good number of books represent a more personal view than the author would admit), or simply for lack of space. To cite only one of the several missing topic: a systematic treatment of numerical simulations of landslides. I anticipate that many scientists who contributed a great deal to the field will be disappointed to see their contribution underrepresented.

A list of the subjects treated is the following.

Chapter 1 is an introduction to the subject of landslides. The reader will not find much novel information but rather an ordering of the subject useful for later use.

Chapter 2 opens with the laws of friction and cohesion. It then introduces very shortly some problems of slope stability. The chapter is perhaps the least novel in the book, as the subject is treated in a more thorough way in several other textbooks, but an introduction to slope stability appeared to be necessary.

Chapter 3 is an introduction to fluid mechanics useful for landslide studies. Some basic concepts of fluids are initially brought in heuristically. In a second step, the laws of fluid mechanics are introduced in the proper conceptual framework.

Chapter 4 initially introduces the subject of non-Newtonian fluids. In the second part, the chapter deals with rheological flows such as mudflows, lahars, and debris flows.

Chapter 5 is a general introduction to the physics of granular media, both dry and wet. It forms the bases for Chap. 6 and for part of Chap. 9.

Chapter 6 is the longest of the book. It deals with granular flows and rock avalanches. It is partly descriptive, with a tendency to become more quantitative in some particular topics. Special subjects such as rocks generated by frictional heat or vapor lubrication are also discussed.

Chapter 7 considers landslides in peculiar environments: water reservoirs, glaciers, and mass wasting on the surface of other planets.

Chapter 8 is a plain introduction to rock falls, which are single falling boulders. Even if much smaller in volume than rock avalanches, they are a very common threat in mountain environment.

Chapter 9 is a primer to the physics of submarine landslides. The contact forces with water become important, and thus the subject strongly builds on concepts developed in Chap. 3.

Chapter 10 considers a number of gravity mass flows, not necessarily landslides, and draws a comparison to other landslides examined in the book. The reader will also be able to appreciate how previous knowledge can be applied to other forms of hazardous phenomena.

To help (or even to encourage) the reader jumping from different parts of the book, the reference to other parts of the book are signaled with arrows. A right pointing arrow (\rightarrow Sect. 3.2.1) indicates that particular concept will be developed in a later part of the book, in this case in section 3.2.1. A left-pointing arrow (\leftarrow Sect. 1.2.3) signals that the subject has been treated earlier.

Boxes are scattered throughout the book. Some are introductive of concepts that not all readers may have (they are termed “one step back”). The more advanced ones or the ones not central to the discussion but interesting or even enjoyable have been labeled as “one step forward.” Both can be skipped in a first reading, for opposite reasons. Other boxes are very short introductions to some famous landslides and gather basic information. They are called “brief case study.” Another kind of box is “external link,” dealing with disciplines other than ruinology but in which landslides play an interesting role. A few boxes of the series “simple views” illustrate easy theoretical schemes or uncomplicated experiments to make a particular subject clearer. Finally, other boxes are not categorized.

Three appendices complete the book: a mathematical appendix, also called *MathApp* throughout the book, a Geological appendix called *GeoApp*, and a physical appendix *PhysApp*. These can be useful as quick look-up reference for some data or equations. Most of the photographs are original and unpublished.

For providing comments, diagrams, articles, or figures, the following persons deserve my gratitude: Stein Bondevik, Hedda Breien, Giovanni Battista Crosta, Graziella Devoli, Anders Elverhøi, Birgitte Freiesleben De Blasio, Ulrik Domaas, Peter Gauer, Lisetta Giacomelli, Carl Harbitz, Kaare Høeg, Dieter Issler, Ole Mejlhede Jensen, Paolo Mazzanti, Marco Pilotti, Roberto Scandone, May-Britt Sæter, Maarten Venneste, Hassan Shaharivar, Alessandro Simoni, Roger Urgeles, and the numerous students who during these years have been the test subjects of the lecture notes this book grew from. Needless to say, the author is the sole responsible for any misconception or inaccuracy that plagues every book, and this probably more than others.

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