GEOPHYSICAL INVESTIGATION INTO THE INTERNAL DYNAMICS OF MOVING LAHARS

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Frontispiece. *Aerial view downstream overlooking the Tangiwai rail (foreground) and road (backgound) bridges during the Crater Lake-breakout lahar from Mt. Ruapehu, New Zealand, on 18th March 2007. The inundated memorial to the 151 people who died in the 1953 Tangiwai Disaster, caused by a similar style lahar, is located between the two bridges. (Photograph courtesy of H.J.R. Keys.)*

Abstract

Lahars and other mass flows are highly hazardous phenomena that can pose great risk to areas in their path. Due to their often unpredictable onsets, scientific observations are limited. In addition, the erosive capabilities of a lahar mean that the most commonly used monitoring and sampling methods, such as load cells and bedload traps, are often damaged early in the flow. The cost of repair and maintenance of these instrumentation prohibits comprehensive coverage of each channel that might be at risk from lahars. The development of seismic sensors as an alternative monitoring method could prove effective as they do not require contact with a flow and are therefore less at risk from damage. The complex behaviour of a lahar can be witnessed in the geophysical record of its passage which, in combination with more traditional monitoring methods, can be used to record the detailed evolution of a flow. The three-dimensional analysis of seismometer recordings can provide an approximation of the frontal velocity that may differ from maximum velocity estimates made using super-elevation calculations. Comparisons of the seismic records of different mass flow types illustrate that it is possible to differentiate between them. Frequency analysis allows for the distinction of the flow mechanisms, particle interactions, and dominant rheology of a lahar. Low frequencies are more indicative of bedload frictional motion, while higher frequencies reflect the collisional impacts of particles, either between themselves or with the substrate. Detailed records of a flow at a single site provide a comprehensive understanding of the temporal variations that occur within the duration of a lahar, while comparative analyses of numerous sites along a channel highlight its downstream evolution. While initial onset signals can be recorded at local-to-source sites, they are attenuated too quickly to be observed further downstream. The records at proximal sites can, however, reflect the stages, or packets, involved during the main bulk of lahar initiation. At more distal sites, observations show that a lahar transitions to a [minimal] 4-phase behaviour. This consists of a frontal bow wave of ambient streamwater that increases

in volume with distance from source, and immediately precedes the lahar proper. The following phases are defined by variations in sediment concentration, velocity, stage, and, in the case of Crater Lake-originating lahars, water chemistry. The understanding of the variable behaviour possible during a lahar, as well as the identification of the specific flow type recorded, is fundamental to modelling approximations of flow volumes, sediment concentrations, likely inundation areas, and probable damage by the flow. It is essential for the development of future warning systems that the variations that can occur within a single lahar are better understood, as lahars represent a serious threat to the slopes of many volcanoes worldwide.

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Author's Declaration

I declare that the work in this thesis was carried out in accordance with the Regulations of Massey University. The work is original except where indicated by special reference in the text and no part of the dissertation has been submitted for any other degree. Any views expressed in the thesis are those of the author and do not necessarily represent those of Massey University. The thesis has not been presented to any other university for examination either in New Zealand or overseas.

Susan Elizabeth Cole

Date:

Viva Examination: 24th August 2011

For my Mum and Daddy.

Contents

List of Tables

List of Figures