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# **Towards Improving Volcanic Mass Flow Hazard Assessment at New Zealand Stratovolcanoes**

**A thesis presented in partial fulfilment of the  
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## Abstract

The most common hazards for communities surrounding mountain-forming stratovolcanoes are mass flows of a range of types. Determining their frequency, characteristics and distribution is a major focus of hazard mapping efforts. Recent improvements in computer power and numerical models have meant that simulation of mass flow scenarios is a new tool available for hazard analysis. Its application to hazard mapping, land use planning and emergency management awaits robust evaluation of the conditions under which simulation tools are effective. This study focuses on this question in attempting to improve mass-flow hazard assessments at the typical stratovolcanoes of Mts. Taranaki and Ruapehu in New Zealand. On Mt. Ruapehu, Titan2D modelling was applied to forecast behaviour of non-cohesive lahars in the Whangaehu River, primarily produced by Crater Lake break-outs, such as on 18 March 2007. The simulations were accurate in predicting inundation area, bifurcation, super-elevation, hydraulic ponding, velocity and travel times of the lahar to 9-10 km. A  $6 \times 10^6 \text{ m}^3$  simulated granular flow had a minimum discharge of 1800-2100  $\text{m}^3/\text{s}$  at the apex of the Whangaehu Fan, 9-10 km from source, comparable to all historic information. The modelling implied that it was highly unlikely for a flow of this nature to overtop a lahar training dyke (bund) at the fan-apex location and avulse northward into a more vulnerable catchment. Beyond this point, the model could not cope with the rapid and complex changes in rheology of these non-cohesive lahars. At Mt. Taranaki chronostratigraphic grouping of mapped past lahar deposits often clouds the actual series of landscape forming processes and hence variations in hazard that occurred over time. Here, patterns of mass flows following emplacement of a  $7 \text{ km}^3$  debris avalanche deposit were examined from field geology and Titan2D modelling to define a three-stage recovery process, where lahars of different types and sources were focused initially beside and later on top of the debris avalanche deposit for up to 10 000 years. Results from Titan2D were used to identify source areas of mass flows at different stages and their probable rheologies. Debris avalanche emplacement at Mt. Taranaki was investigated on the c. 7 ka B.P. Opua Formation with the help of Titan2D

simulations to identify initial collapse parameters and major flow paths. Once again, the simulations were reliable in proximal reaches, but could not reproduce the rheological transformations from an initial collapsing/sliding pile through to a cohesive clay-rich flow with long runout. In a further example, past block-and-ash flows (BAFs) and dense pyroclastic flow deposits northwest of the current crater were analysed to define the range of realistic model parameters for Titan2D simulations. These could be incorporated inside a Geographic Information System to produce a gradational map of relative probabilities of inundation by future BAF events that took both modelling and geological variability into account. This study highlights that computational models are now reaching the stage where a holistic approach can be taken to hazard analysis that combines both geological mapping and simulation of mass flow scenarios in a probabilistic framework to provide better tools for decision makers and land-use planners.

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