Contrasting the morphology and internal structure of hummocky mounds in two landslide deposits, North Island, New Zealand

THE UNIVERSITY OF AUCKLAND
FACULTY OF SCIENCE
School of Environment

Tamzin Linnell (1), Marc-André Brideau (1), Jonathan N. Procter (2)

(1) School of Environment, University of Auckland, Auckland, New Zealand (tlin072@aucklanduni.ac.nz), (2) Volcanic Risk Solutions, Institute of Natural Resources, Massey University, Palmerston North, New Zealand

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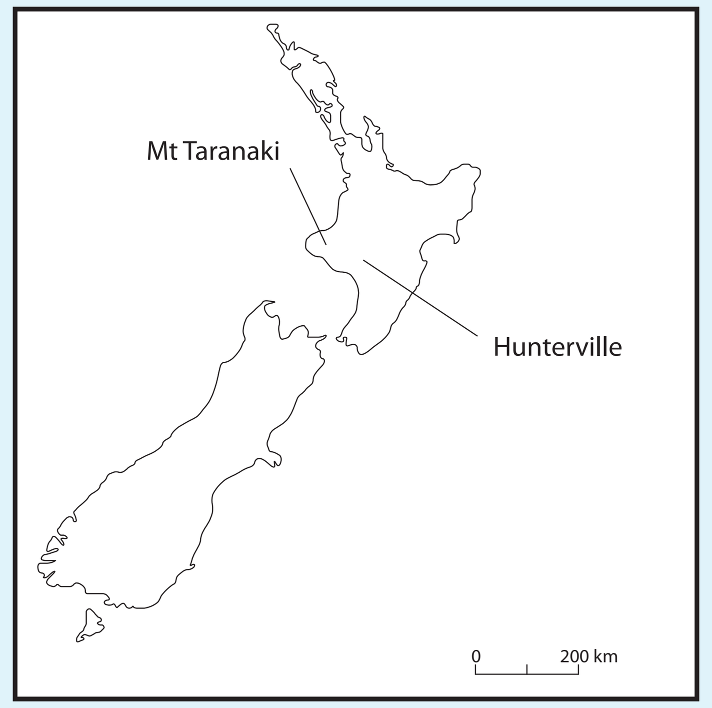

Figure 1 Map of New Zealand with each of the landslide sites studied indicated.

Introduction

The existence of hummocky mounds has been reported in large landslide deposits around the world and is particularly common in association with slope failures of volcanic edifices. A wide range of mechanisms has been proposed to explain their formation. Recent proposed mechanisms concentrate on the transport/deposition dynamics of debris and rock avalanche and the post-depositional landscape responses. Two case studies are examined: the Pungarehu and Opua volcanic edifice collapses from Mt Taranaki; and a smaller landslide in weak sedimentary rocks near Hunterville, on the North Island of New Zealand (see Figure 1 for locations). Aspects of their internal structure and morphology are compared and various emplacement mechanisms are explored in order to investigate the formation of each landscape.

Site 1 - Mt Taranaki

- Deposits of two major landslides studied:
  - Pungarehu Formation (western Taranaki; ~20 000 yrs old)
  - Opua Formation (south-western Taranaki; ~6000 yrs old)
- Mounds consist of loose poorly sorted volcanic debris with occasional evidence of shattered clasts.
- Each produced thousands of mounds across ~ 15 sq. km.
- Mounds average 5m in height, maximum 50m high.
- General decrease in mound height with distance from source.
- Mounds lack definable internal structure, evidence of dewatering, and large anchoring boulders.

Figure 2) Overview of Mt. Taranaki and the hummocky deposits

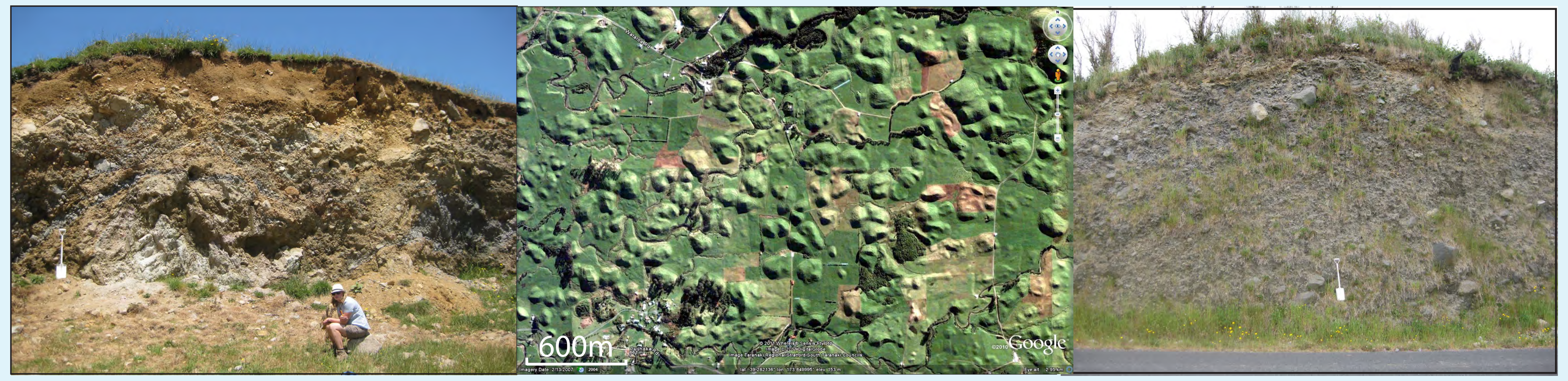

Figure 3) Aerial photograph of a portion of mound deposits in western Taranaki (centre) and variable internal structure of mounds (left and right).

Site 2 - Ongo Road

- Pre-historic landslide in weak sedimentary rock.
- The geology in the headscarp area consists of interbeds of weak to very weak beige siltstone and moderately strong beige sandy coquina units.
- Landslide produced over 100 mounds across 300,000 sq. m.
- Mounds average around 4m in height, maximum 7m high.
- General concentric alignment of mounds from source.
- Mounds lack evidence of dewatering structures or large anchoring boulders.
- No shattered clasts and mounds often consist of large (<7m high) single clasts with primary sedimentary structures preserved.

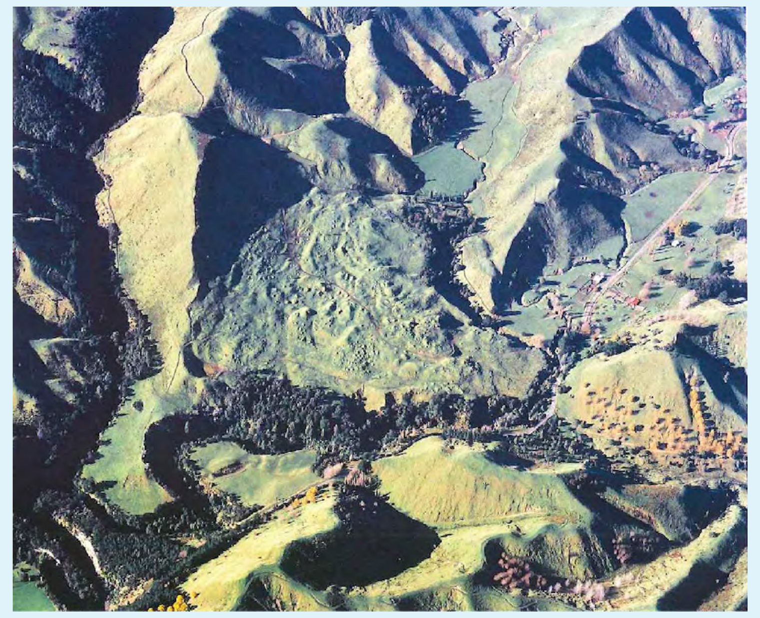

Figure 4) Overview of the Ongo Road landslide deposit (photo from GNS Science)

Figure 5) North-facing image of the Ongo Road headscarp with mounds (centre). Siltstone (left) and limestone (right) mound internal lithology also shown.

Grain Size Analysis

Two samples were taken from the Ongo Road landslide (one siltstone sample and one limestone sample) and two samples were taken from the Pungarehu landslide in Taranaki. Results (shown in Figure 6) illustrate the more gravel-rich Taranaki deposit, contrasted with the finer groundmass of the Ongo Road lithologies.

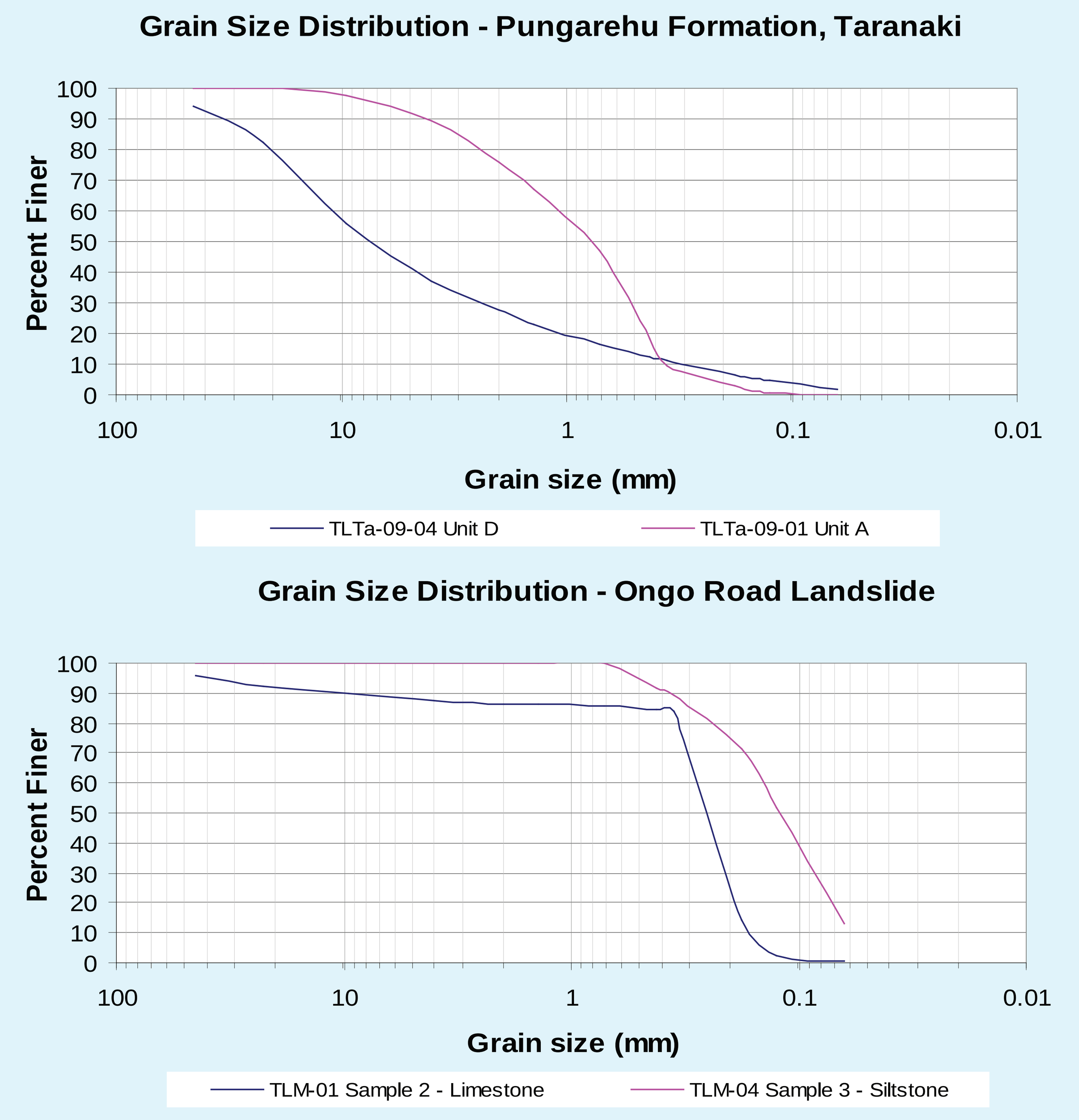

Figure 6) Particle size distribution from Pungarehu Formation and Ongo Road

Mechanisms

A wide range of mechanisms has been put forward to explain mound formation. Recent proposed mechanisms regarding the genesis of these landforms concentrate on the transport/deposition dynamics of debris and rock avalanche and the post-depositional landscape responses.

Laboratory analogues have been applied to study vibratory movement concurrent with landslide events which can create hummocky mounds by segregation of clasts within the deposit, resulting in the concentration of coarse clasts in a mound (Cassie et al., 1988).

Others have suggested that deposition of one or several large boulders can act as an anchor leading to the accumulation of mound-forming debris around it.

Dufresne and Davies (2009) suggest hummocks in landslide deposits may represent the remnants of longitudinal ridges that once ran sub-parallel to the landslide flow direction. Specifically, they suggest that ridges have eroded into individual hummocks over time but evidence of their origin can be seen in mound alignment.

Discussion

Comparatively, the mounds seen in Taranaki are more variable in their composition – often consisting of poorly sorted gravels and pebbles, and showing no clear structural patterns. While the effects of vibratory sediment sorting may apply to the Taranaki mounds, no clear coarsening of clast size was seen within the mounds, when compared to surrounding landslide debris clast size distribution. However, the apparent lack of relative coarseness within mounds may have been a sampling error in that low-lying deposits were less likely to be examined and field study focussed on the internal composition and structure of the mounds themselves. It is possible that the formation and erosion of linear ridges contributed in part to the emplacement of hummocks, however, close spatial analysis of mound alignment and distribution would be required in order to conclusively apply the works of Dufresne and Davies (2009).

Figure 7) Shattered clast within a Taranaki mound.

The Ongo Road landslide shows mounds which are composed of a single large boulder, sourced from the initiation zone (see figure 5). This, it is possible to attribute mounds in this setting to the deposition and subsequent weathering of large intact blocks. This is especially clear in the limestone blocks, which largely retained their angularity. The emplacement mechanism of the siltstone mounds was more difficult to assess. More homogeneous in composition and more rounded in their overall shape, it is possible that they formed by similar mechanisms (i.e. the deposition of a single large block), however, the finer and less resistant material was more easily weathered, forming the smaller, more rounded and homogeneous siltstone mounds seen today.

Conclusion

Based on the observations from the two case studies, the mechanism for the formation of hummocky terrain was different at each site.

The landslide near Hunterville shows hummocky mounds composed of single weathered large boulder. It thus suggests that the transport, deposition, and subsequent weathering of large intact blocks from the initiation zone have controlled the distribution of hummocky mounds.

The origin of the mounds associated with the edifice collapses of Mount Taranaki is more difficult to conclusively assign to a particular mechanism. At this point it can only be suggested that the features observed in the field are consistent with a very dynamic mixing environment during transport that might have been caused by acoustic vibration. In-depth spatial analysis and closer investigation of particle size distribution within and among hummocks throughout the landslide deposits will assist in attribution of hummock emplacement mechanisms in the Taranaki area.

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References

Cassie, J.W., Van Gassen, W. & Cruden, D.M. 1988. Laboratory analogue of the formation of molards, cones of rock-avalanche debris. Geology 16: 735-738.
Dufresne, A. & Davies, T.R. 2009. Longitudinal ridges in mass movement deposits. Geomorphology 105: 171-181.