Mt Wellington Rockfall 2014

Tasmanian
Government

The Mount Wellington rock fall event of 8 July 2014 described; with implications for MRT rock fall modelling methodology

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Synopsis

On 8 July 2014, a 65 tonne dolerite boulder on Mount Wellington was released from its precarious position to form a 170m long rock fall swath. The boulder initially toppled forward (end over end), rolled and bounced (along its long axis) across a boulder talus field, then travelled through stunted (sub-alpine) eucalyptus forest to its eventual resting place. It may have reached a maximum velocity of 40km/hr, easily smashing its way through the forest in its path.

This is one of many examples of "precarious" rocks of similar dimensions with unfavourable joint orientation that are capable of forming rock falls on Mount Wellington and many other dolerite mountains in Tasmania. However, events of this size are not commonly reported, which makes it difficult to estimate the likelihood of future events.

While the preparatory causal factors of the rock fall are well understood, there does not appear to have been a dramatic triggering event such as a rain storm. Rather, the boulder is interpreted to have been gradually detaching from its neighbouring columns and the restraining forces were eventually reduced to a point that the boulder was released. This implies that the many other precarious rocks on the mountain can fail without warning and at any time.

The rock fall has originated in an area that was not predicted by previous regional scale modelling by Mineral Resources Tasmania (MRT) and travelled further than what had been predicted. The non-prediction of the source area is due to the poor quality digital elevation model (DEM) used in the previous modelling and this can be corrected by using currently available LiDAR data. However, the fact that the rock fall has travelled further than previous modelling would indicate gives cause to consider adjusting the parameters for limiting runout and to review alternative modelling software packages.

Introduction

On 28 September the authors inspected a rock fall on Mount Wellington, first reported in the *Mercury* newspaper of 9 July 2014 and subsequently on 10 July 2014. According to the *Mercury*, the rock fall was heard by walkers on 8 July 2014 who reported it to authorities; fortunately there were no casualties. The rock fall has crossed a popular walking track, the Pinnacle Track, within Wellington Park. The initial *Mercury* report incorrectly stated that it had come close to the Pinnacle Road but this was corrected in the second article to say that it crossed the Pinnacle Track and "destroyed it". Our investigation indicates that the track was damaged but not destroyed. The second *Mercury* article reported that the rock fall stopped short of a steepened section of the mountainside, and had it gone further "would have sent it down onto the Pinnacle Rd". The accuracy of this statement is called into question below.

Shortly after the event Hobart City Council commissioned geotechnical consultants to provide an immediate assessment of the risk to the public. While we have informally discussed the event with one of the consultants, our report and conclusions are independent of their work and have different objectives.

The summit of kunanyi / Mount Wellington (Figure 1) is one of Tasmania's most popular tourist destinations, approximately 20 km by road from the Hobart CBD. The principle access is by the Pinnacle Road through Wellington Park. In addition to traffic related to sightseers, the park is an important recreation area for bush walkers, rock climbers and mountain bikers. For many decades there have been sporadic accounts of rock fall events on the mountain, with most of them affecting the Pinnacle Road. Fortunately there have not been any reported fatalities. Almost all of the records known to MRT are of insufficient quality to accurately locate where they occurred and to determine other associated factors necessary for rock fall hazard and risk assessment. For these reasons only six rock fall records for Mount Wellington are contained in MRT's landslide database (Figure 1). A newspaper report by the *Mercury* (10 September 1998) cites a commissioned report by a local consultancy

that most rock falls affecting the Pinnacle Road are related to road cuts (estimated at 3-4 per year) and the remaining are from "rogue rocks some distance from the road, often near the Organ Pipes" (up to 3 per year).

In general, rock fall events in Tasmania are rarely reported to MRT. We therefore have little data from which we can forensically analyse and answer important questions relating to the location, causal factors (preparatory and triggering factors), runout path, boulder dimensions and shape, and ground conditions along the path of typical rock fall events. Such information is important to establish parameters to underpin rock fall susceptibility modelling undertaken by MRT in recent years. Given the relative ease of access, and the large size of the boulder, for this recent rock fall we considered this to be an important site to visit while the evidence was still fresh on the ground. Furthermore, this provides us an opportunity to review our rock fall modelling methodology ten years after it was first implemented.

Location

The rock fall is located on the flanks of Mount Wellington (Figure 1) and is accessed via a walking track, Pinnacle Track, from the Upper Springs Carpark; approximately 1.3 km in distance, and a steady 30 minute walk. The junction with the Organ Pipes and Zig Zag tracks is a further 80 m on from where the boulder crossed Pinnacle Track. The path of the rock fall is currently very obvious given that it has created an approximately 5 m wide strip where the vegetation has been completely flattened above and below the track. The boulder responsible is visible from the track (approximately 20 m distant). The source location is almost visible from Pinnacle Track, partly obscured by vegetation, about 140 m up from the track (plan distance) and is reasonably easy to access on foot. The final resting place of the boulder is about 300 m in plan distance upslope of the vehicular road, Pinnacle Road.

Mapping method and relevant data sources

The entire rock fall event area has been inspected on foot. We used an iPad mini™ tablet as our mapping hardware and the FieldMove Clino Pro™ app software as a trial of this mapping system. The internal GPS in the device accesses both the American GPS and Russian GLONASS satellite constellations with expected accuracy better than 5 m horizontal (in ideal conditions). The field data has been imported into a GIS environment in the office (using Python scripts developed by C. Mazengarb) and visualised and analysed by overlaying on the 2011 Mount Wellington LiDAR and orthophoto imagery, partly sponsored by MRT from a Natural Disaster Mitigation Programme (NDMP) grant.

We consider that the accuracy of most of the GPS points was probably within the 5m expected as reported by the software, with some outside of this range by an unspecified amount. At the scale we were working this has required adjustment of our interpretive features within this range.

The location of all observations, photographs and notes is stored in digital form attached to the rock fall record in the MRT landslide database. Figure 2 shows Location numbers referred to in the following text.
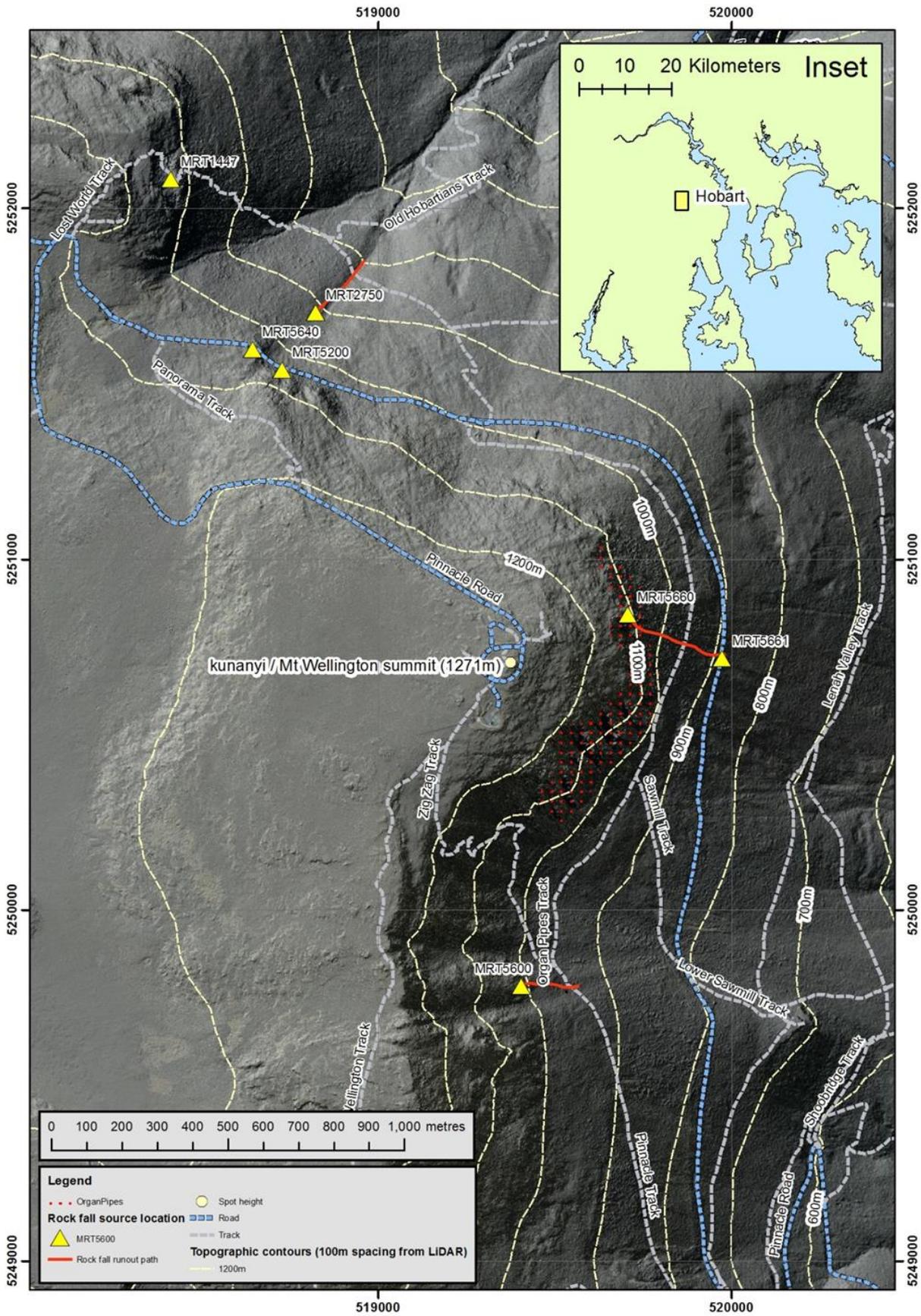
Figure 1. Location map of the 2014 rock fall (MRT 5600). All rock falls and topples in the MRT landslide database are shown and except for MRT1447 are recent features. MRT are aware of other incidences of rock fall along the Pinnacle Road but their locations are not known
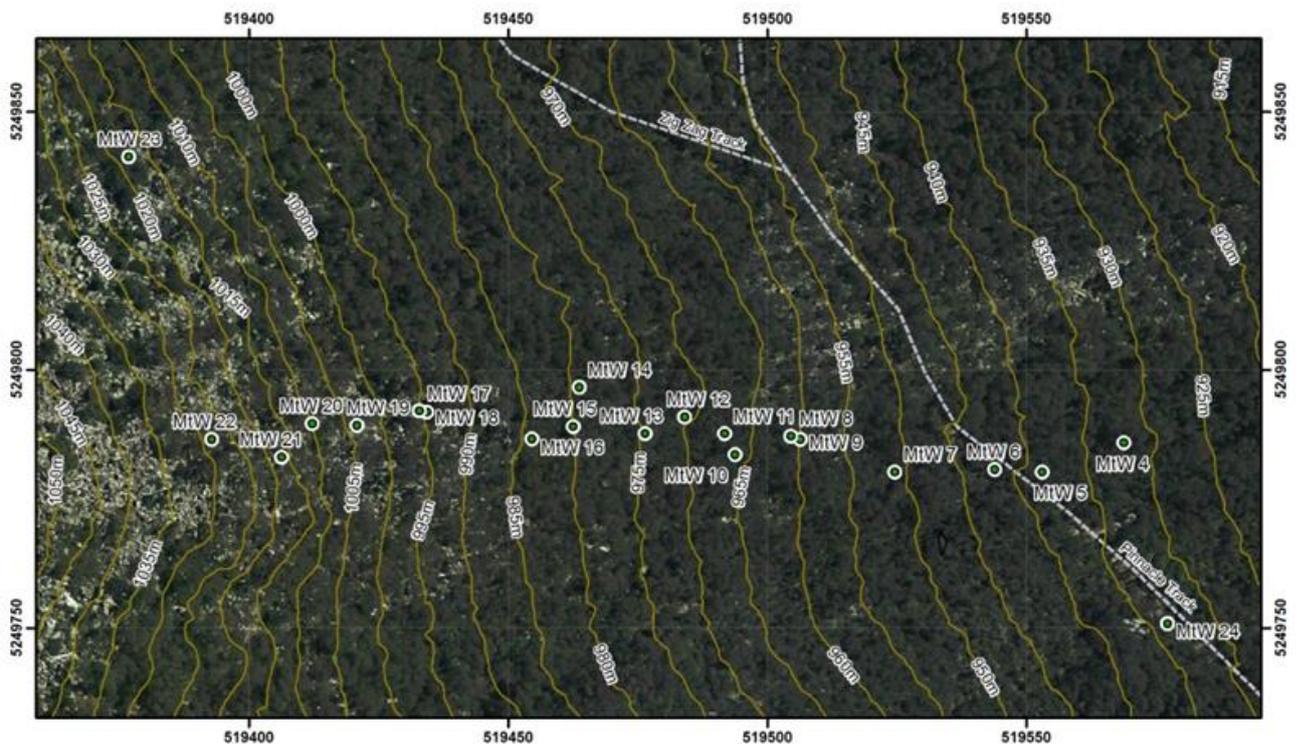
Figure 2. GPS derived observation points for the investigation. Additional information includes 2011 Mount Wellington orthophoto, LiDAR derived contours (5m intervals) and tracks (source: LIST). Map grid in MGA zone 55 (GDA94).

Figure 3 Plan of the rock fall path. The orange overlay indicates areas of slope ≥ 42 degrees where, in the experience of MRT staff, most rock falls originate. Map grid in MGA zone 55 (GDA94).

Description of the rock fall

The following description of the rock fall event is subdivided into descriptions of the boulder, the source and the path. Figure 3 provides an interpretation of the major features.

Rock fall boulder

A large dolerite boulder has come to rest about 15m downslope of the Pinnacle Track (Location MtW4, Figure 4). The sides of the boulder are generally planar with dimensions of approximately 3.75 m x 3 m x 2 m (22.5 m³); although it is somewhat rounded and narrower at one end, giving it a slightly eccentric shape. From the general shape of the boulder it appears to be part of a dolerite column with the long axis as shown in Figure 4, and with a fracture where a smaller fragment has been flaked off. We have identified a fragment that is likely to be the flake about halfway along the runout path (Figures 3 and 9), which has dimensions 1.7 x 1.9 x 0.6 m (~2 m³). The column segment is rectangular and four-sided, with the basal joint (depicted) at about 15 degrees from normal to the column axis. The overall shape of the boulder is classified as Columnar (one dimension considerably larger than the other two) according to the CRSP classification (Andrew, *et al.*, 2012). Assuming a volume of 22.5 m³ and a density of 2.88 tonnes/m³, the boulder has a mass of about 65 tonnes.

The boulder has come to rest against some much smaller rocks that appear to be only slightly displaced from their original positions.

Figure 2. View of boulder showing planar surfaces with person for scale. Location MtW4.

Description of source area

The source area is clearly identified in the field (Location MtW21, Figure 5), consisting of a cavity between two forward tilted dolerite columns (2.1 – 2.47 m wide) where a column once existed. In fact, we were able to match the dimensions of the cavity with the main displaced boulder and match the original contact surfaces with adjacent columns; allowing the original orientation of the boulder and basal joint to be determined. The remaining dolerite columns form a small bluff about 6m high and local slope of over 50 degrees. The released boulder would appear to have detached from the constraining forces of the adjacent columns and, by virtue of a joint across the column, toppled forward over a drop of about 2 m height, hit the ground below, and then started rolling downhill, initially end over end (Figure 6).

The remaining columns appear stable and we confidently walked over them. However, on geological time scales these columns will also ultimately fail. One of the adjacent columns has a joint across it at a similar angle to the original basal joint for the rock fall boulder (refer to Figure 19).

Figure 3. Rock fall source in cavity to right of person. Note the precarious rocks above the cavity. Location MtW21.

Runout Path

The runout path of the rock fall is easily mapped out as it forms a cleared swath about 170 m long (plan distance) and 5 m wide through stunted sub-alpine forest (Figures 10,12). However, not all of the path is in forest as the upper most part (above Location MtW15) is only lightly vegetated bouldery talus (Figures 6, 8).

The vegetation transitions down slope into eucalypt dominated scrub, of fairly uniform dimensions; about 5m high and trunks 7-10cm diameter (measured at 2m above base). The largest diameter measured was 13 cm. We estimated a tree density of about one tree per $2m^2$. It is possible that this stand has regenerated since the 1967 bushfires. All trees in the path of the boulder have been completely flattened and in places crushed and splintered (Figures 10, 11, 12).

The ground surface ranges from a boulder talus in the upper part to moist intermediate soils in the lower part, based on the CRSP classification (Andrew, *et al.*, 2012). With decreasing ground surface hardness from the release point along the runout path, the coefficient of restitution would be expected to decrease (i.e. absorb more kinetic energy) during the boulder's journey. Further, the kinetic energy of the boulder would have also been absorbed by the trees, which in combination eventually stopped the boulder's movement.

As a general rule, rock fall motion is a combination of falling, rolling and bouncing. In this case we will demonstrate that the fall component is probably very minimal and therefore the motion is either rolling or

bouncing. Our observations suggest that an initial topple movement from the release point is likely, dropping the boulder onto its end as it impacted the ground and setting up a rotational movement normal to the long axis (i.e. the boulder rotates end over end). We observed a number of impact structures along the length of the runout path, spaced between 5-10 m apart. The uppermost impacts (Figures 3, 6, 7) have fractured underlying boulders and were associated with the initial end over end motion of the boulder.

Figure 4. View of runout path as observed from the release point facing downslope. Fresh fractured boulders can be seen in middle ground attesting to the impact. The boulder travelled end over end between the two light-coloured tree trunks and further down turned and began rolling lengthwise.

A broad groove in the upper talus segment of the slope suggests that the boulder was in contact with the ground at all times during this part of the journey (Location MtW17, Figure 8).

Therefore, after a few end over end rotations, the axis of rotation would have shifted to be aligned with the longest dimension of the boulder, which from then onwards approximates the width of the swath. This alignment would be the most conducive for rolling.

Further impact structures were observed around the middle of the runout path (Figure 3) near where a substantial fragment of the original boulder appears to have flaked off (Location MtW13, Figure 9). These lower impact structures appear to be associated with bouncing over an area where low, in-situ rocks have provided launching points. The generally flattened vegetation and tree damage on the edge of the swath, measured in a few places at up to 3 m above ground (Figure 10), suggests that the bounce height may not have been particularly great.

From the bouldery talus onwards, once the boulder was travelling in a lengthwise rolling motion, the boulder followed a relatively straight path until the last 50 m or so, where it then zig-zagged slightly (Figure 12). Presumably the momentum of the boulder had decreased to a point where it's slightly eccentric shape began to affect its travel. This suggests that the boulder had significantly decreased in velocity before it reached the Pinnacle Track and before it came to rest against some smaller rocks – refer to the later discussion on velocity estimates and Figure 17.

Figure 5. The two people are standing on impact structures (Locations MtW19 and MtW20) approximately 10 m apart in the upper part of the rock fall swath, where the boulder rotated end over end.

Figure 6. Upper part of runout swath showing groove facing uphill, showing a broad groove in the talus. The source area is partly obscured behind trees above and right of the person. Location MtW17.

Figure 7. Likely fragment of the dolerite boulder deposited on the runout path at Location MtW13.

Figure 8. Damage to tree approximately 3m above the ground. Location MtW9.

Figure 9. Splintered tree trunk on the runout path. Location MtW8.

Figure 10. View of rock fall swath facing uphill from the Pinnacle Track.

Geological and geomorphic setting

The source of the rock fall is located very near the base of the Jurassic Tasmanian Dolerite (Veevers and Evans, 1975) escarpment capping Mount Wellington, and appears to be a displaced toppled block of dolerite, consisting of several columns, that has detached from the main dolerite sill. The basal contact of the sill and the underlying bedrock geology was not observed at the source as it is covered by a boulder field of dolerite talus (decimetre to metre sized blocks). However, lower down the runout path, the surficial material is finer consisting of colluvial material resting on clay. At the intersection with Pinnacle Track, white highly plastic clay is exposed under the colluvium that is probably derived from in-situ highly weathered Parmeener Supergroup sedimentary rocks (Banks, 1973).

The dolerite capping Mount Wellington forms a prominent escarpment, as it does in many other localities at similar elevations in the State. The escarpment has a generally steeper slope than the underlying Parmeener Supergroup (Figure 14).

Where intact outcrops are obvious, such as the Organ Pipes (Figure 1), the columns are in general near vertical. In detail though, the flanks of the escarpment contain many examples of inclined dolerite columns and boulder fields, as described by P.C. Stevenson (1980) and shown in Figure 13. The widespread forward toppling process is seen particularly well in stereo-imagery, ranging from vertical columns with progressive rotation ending with columns that lie entirely on their sides on the hillslope facing downhill, having rotated over 90 degrees from their original position. The toppling process has been accompanied by fragmentation of the columns to form boulder fields. In some cases detachment and block sliding of dolerite masses containing multiple columns has also occurred.

Bouldery surficial deposits of doleritic material occur widely on the dolerite escarpment and below. However, the origin of these deposits may be complex. While rock fall processes are undoubtedly one of the causes of accumulation of talus-like material in the present day, at this altitude there are many features indicative of periglacial activity during colder climates than the present. In detail the escarpment has a number of structurally controlled chutes where
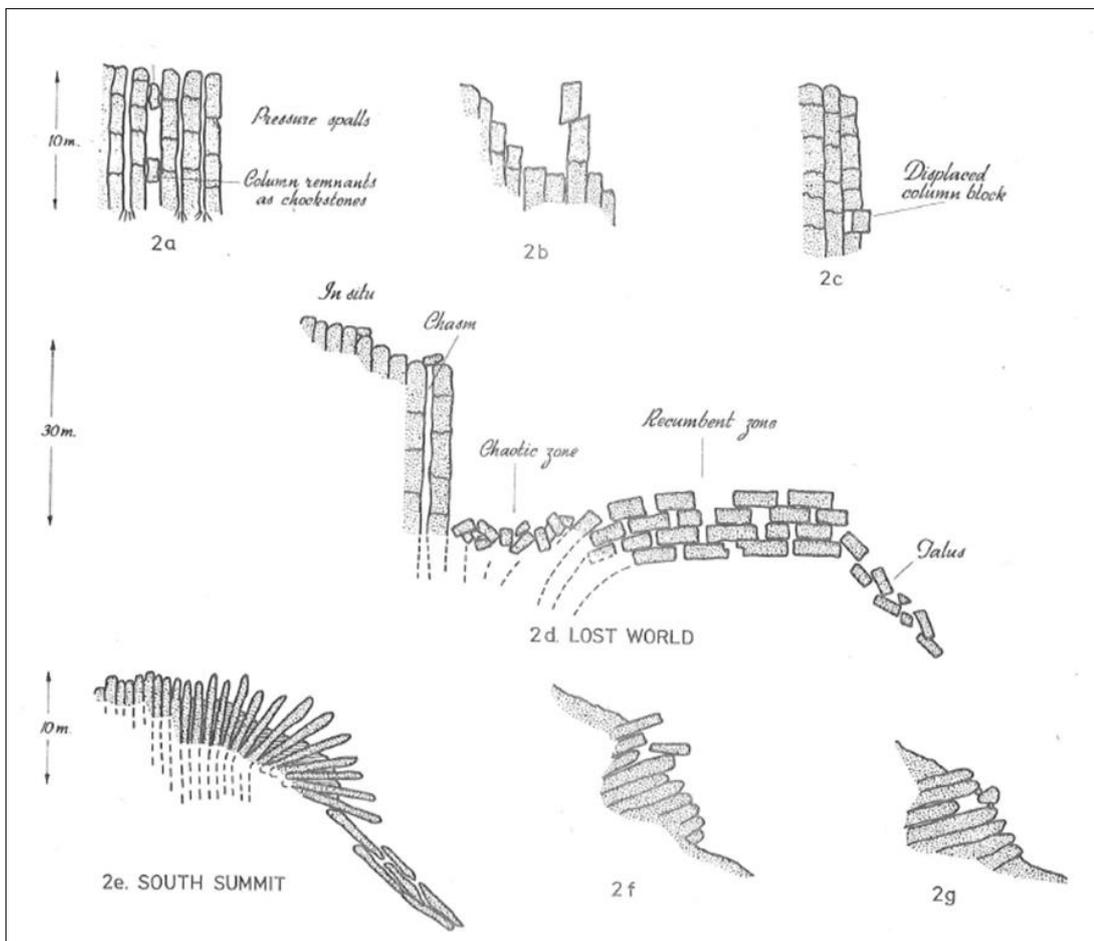
Figure 11. Examples of dolerite escarpment deterioration from P.C. Stevenson (1980). Example 2f provides the closest model for the 2014 rock fall source area.

bouldery deposits have accumulated. However near the base of the escarpment there are large masses of colluvial material that show mass failure structures that the recently acquired LiDAR imagery is able to depict in greater clarity than aerial photos or in the field. These periglacial deposits may have formed gradually over time and not in the more catastrophic and dangerous manner of rock falls.

An understanding of these multiple processes is important for hazard analysis as there is a common ambiguity every time a large boulder is noted close to a track; how did it get there? Was it in a catastrophic manner (and are we in an active rock fall zone) or did it get there very gradually? As it happens there is a boulder of similar dimensions to the 2014 boulder beside Pinnacle Track (Location MtW24, Figure 2) that conceivably arrived there via a rock fall process given its solitary location, but from a different source area. The event responsible for this boulder is probably much older than the 2014 feature given that the forest uphill shows no disturbance (has regrown) and the boulder has subsequently fragmented into large blocks.

Vegetation cover

The presence of forests in rock fall areas can, depending on a number of factors, be significant barriers to rock fall runout. From our inspection we recognise three obvious vegetation classes that can be observed in the 2011 aerial imagery (Figure 3) and in the field.

- The source of the rock fall is in an area of very sparse vegetation where the ground surface is dominated by dolerite boulders and outcrops.
- About 50m downslope the vegetation transitions into eucalypt dominated scrub of fairly uniform dimensions, as described previously.
- Below the walking track and beyond the runout extent of the boulder, the vegetation appears to get taller and more substantial down to Pinnacle Road. We have not examined the vegetation of this area in the current study, but we could use the LiDAR data to obtain vegetation metrics for this area.

Slope characteristics

The topographic profile from the top of the escarpment to the Pinnacle Road, which is approximately parallel to the direction of aspect (Figures 1, 3), can be split into two parts; the upper part with a mean slope of about 33 degrees corresponding approximately to the extent of the Tasmanian Dolerite, and a lower slope of about 22 degrees underlain by Parmeener Supergroup. In detail the upper profile contains minor steeper segments (≥42 degrees) where, based on our observations and previous modelling parameters rock fall source areas are expected. Despite the *Mercury* newspaper article indicating otherwise, the lower slope profile is relatively uniform down to the Pinnacle Road.
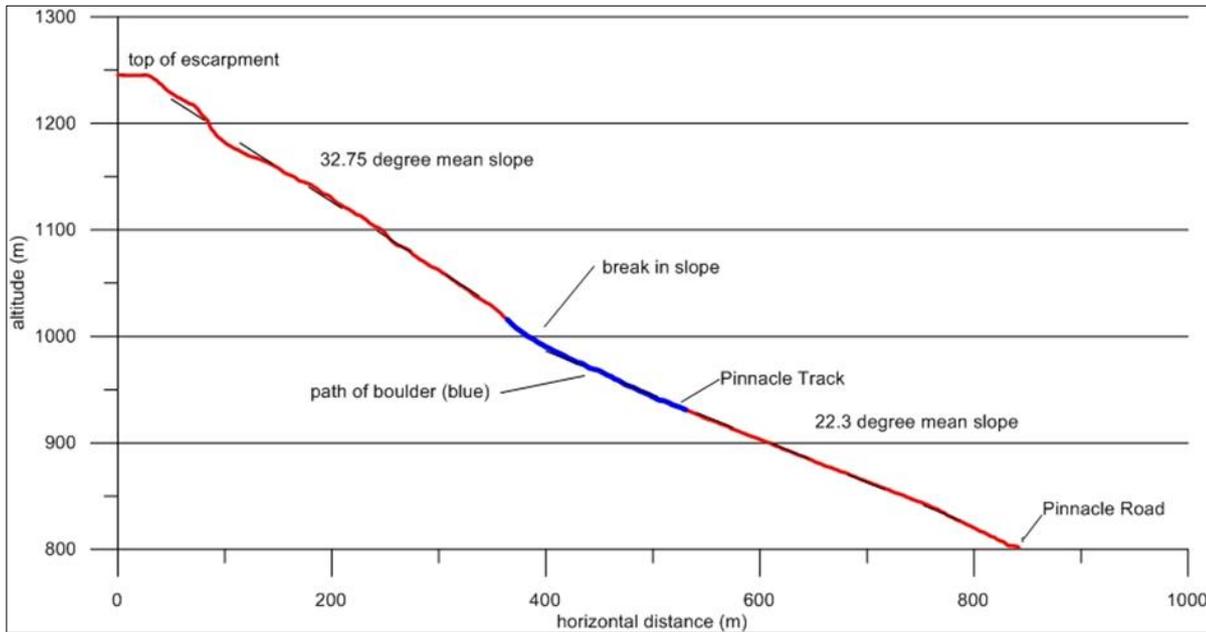
Figure 12. Topographic profile approximately parallel to general slope direction and coinciding with the rock fall path. The labelled break in slope is the approximate contact of the Tasmanian Dolerite over the Parmeener Supergroup. H:V ratio = 1.

Preparatory and triggering causal factors

The geomorphic setting and the mechanism of dolerite escarpment deterioration help explain some of the preparatory causal factors (Popescu, 2002) for rock fall on Mount Wellington. Forward tilting (toppling) of dolerite columns on escarpments as described by P.C. Stevenson (1980) (Figure 13) is presumed to be a gradual process, possibly occurring in periglacial environments associated with globally cooler climatic conditions in the Pleistocene. The physical process of toppling of small sets of columns away from the escarpment allows the originally vertical cooling joints to widen and loosen their lateral constraints. This process along with the formation of cross-cutting joint sets creates precarious situations that can lead to rock fall (Figure 19).

The triggering causal factor of the 8 July 2014 rock fall was not associated with any obvious extreme event such as an earthquake, intense rainfall or significant snow fall on the day. However, there was a significant rainfall the previous day – 34.8 mm at BOM Station 094031: Hobart (Waterworks Reserve) and 29.6 mm at BOM Station 94087: Mount Wellington.

Based on analysis of the Station 94031, rainfall of this magnitude is exceeded on average 2-3 times/year, and therefore it cannot be regarded as exceptional. While the July 7 rainfall cannot be dismissed entirely as the trigger, we consider that the stability of the dolerite block in question has been gradually decreasing with time until it reached a point of failure. This would imply that the many other precarious rocks on the mountain could fail without warning and at any time.

Implications for rock fall modelling

To date, rock fall modelling by MRT has used simplistic DEM based methods for identifying source areas and runout, as described in Mazengarb (2005), with a slope threshold of ≥42 degrees for source areas, rock fall paths that follow the direction of maximum slope, and using the travel angle method for limiting runout extent.

The 2014 rock fall event is situated within the area of the Hobart rock fall susceptibility modelling (Mazengarb, 2004) but was not predicted by this map. The reason for the non-prediction appears to be the quality of the DEM used in the earlier modelling, being derived from photogrammetric contours that were, until the LiDAR imagery acquisition in 2011, the only data available. These contours were created for other purposes and do not

sufficiently capture the topographic detail on the dolerite slopes. Furthermore, the accuracy of photogrammetric contours in forests, where the operator cannot see the ground surface, is often poor. However, when the rock fall modelling is repeated with the benefit of the LiDAR derived DEM, the 42 degree slope threshold criterion successfully predicts the source area (Figure 3).
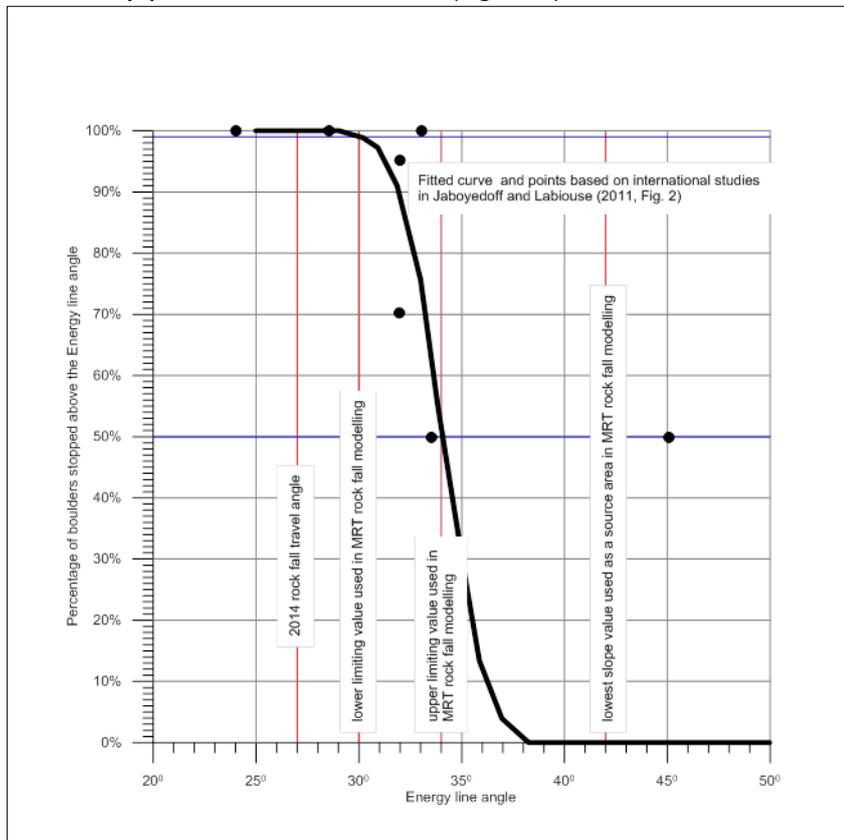

Figure 13. Parameters used in MRT rock fall runout modelling as compared with those in international studies summarised in Jaboyedoff and Labiouse (2011). The 2014 Mount Wellington rock fall is also shown.

The runout path of the 2014 rock fall approximately follows the direction of maximum slope and therefore is consistent with the modelling method previously used by MRT.

MRT rock fall modelling to date has used travel angles of 34 and 30 degrees to constrain rock fall runout based partly on limited empirical observations in Tasmania but also with reference to international studies (summarised by Jaboyedoff and Labiouse (2011)). In the afore-mentioned paper, the two angles have statistical significance representing 50% and 99% population distributions respectively (Figure 15) and equivalent to the lower thresholds for the High and Low quantified susceptibility descriptors of the Australian Geomechanics Society (AGS, 2007a).

However, the travel angle for the 2014 boulder, at approximately 27 degrees, is significant in that it is lower than that used in MRT's modelling to date; i.e. this

boulder has travelled further than previous MRT modelling would predict. If the fitted distribution in Figure 15 is applicable, it indicates that <1% of rocks travel at below 30 degrees but values as low as 24 degrees are still possible. This raises the question as to whether segments of dolerite columns behave differently from rock material involved in the published studies, and whether the travel angle distribution is different, or is the 2014 event truly exceptional and a statistical outlier representing <1% of the rock fall population? We consider that there is insufficient information to resolve this question. However, if the latter option is adopted then the 2014 rock fall event would conveniently fit in the Very Low quantified susceptibility descriptor of the Australian Geomechanics Society (AGS, 2007a).

Wherever possible we consider future modelling by MRT should be adjusted to conform to the 2007 Landslide Risk Management Guidelines (AGS, 2007a) and the adoption of standardised susceptibility descriptors would be an obvious move. An implimentation of this could retain the existing modelling of rock fall source areas and consider where travel angles are ≥34 degress to be High susceptibility, and <34 and ≥30 degrees to be a combined Low to Moderate susceptibility. An additonal zone to represent Very Low susceptibility for travel angles between <30 and ≥27 degrees could be added but would increase the area of susceptibility substantially.

Alternative modelling methodologies

When MRT commenced regional scale (1:25 000) rock fall susceptibility modelling in 2003 there were no off-the-shelf software packages available. It must be acknowledged that site-specific (large scale) proprietary rock fall software has been available for many years but these were missing tools that were suitable for regional scales. As a consequence, the lead author developed somewhat simplistic scripts in-house for this purpose. In recent years several products have become available that are more advanced than those used by MRT. In considering the future of modelling by this agency it is worth outlining two more recent software packages and their approaches:

Conefall

The Conefall method (Jaboyedoff and Labiouse, 2011) applies radiating (cone/fan-shaped) straight-line runout methods and the energy line concept (Figure 16) for creating rock fall susceptibility maps. Input parameters required are predefined source areas, fan angle and shadow angle. According to the authors, Conefall allows a first estimate of rock fall propagation zones but should only be used as a preliminary mapping tool.

However, the energy line concept allows the calculation of instantaneous velocities of rock fall (v) along a runout path based on the height difference between the energy line and the topography (Δh) using the formula below and where g is the gravitational acceleration constant:
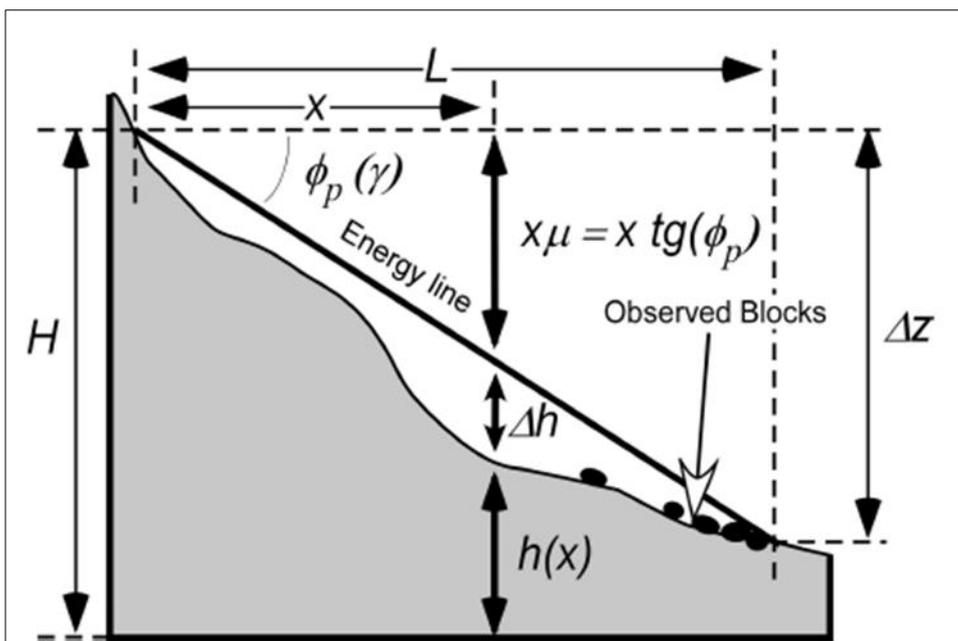
$$v = \sqrt{2g} * \Delta h$$

Fig. 1b. Variables used to calculate velocities and energies based on the energy line concept. The example uses the more distant block to define ϕ_p and estimate Δh, which is used to calculate the velocity $v = \sqrt{2g \Delta h}$. This illustrates the tailor-made possibilities of the cone method.

Figure 14. Sourced from Jaboyedoff and Labiouse (2011).

The energy line equation could be easily incorporated into the MRT rock fall modelling script to allow for the visualisation of velocity and kinetic energy (assuming a nominated rock fall mass). However, it poses conceptual difficulties in how to display this information in conjunction with the travel angle concept (an indication of runout probability) on a single regional scale map.

As a demonstration of the principle, we have applied the energy line equation to provide a rough estimate of the maximum velocity of the 2014 rock fall (Figure 17) suggesting it may have exceeded 40km/hr with a kinetic energy of 400kJ. It is worth cautioning the reader that other, more sophisticated software which takes other factors, such as the effects of the forest barrier, might produce different estimates.
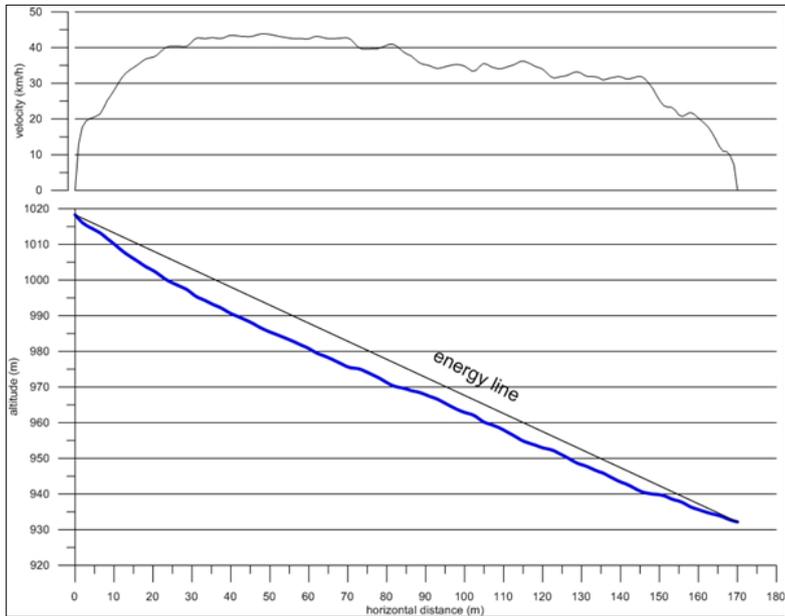
Figure 15. Topographic profile along the 2014 rock fall path with energy line (lower) and calculated velocity (upper).

Figure 16. Example of forward tilted blocks of dolerite, behind person. Location MtW22.
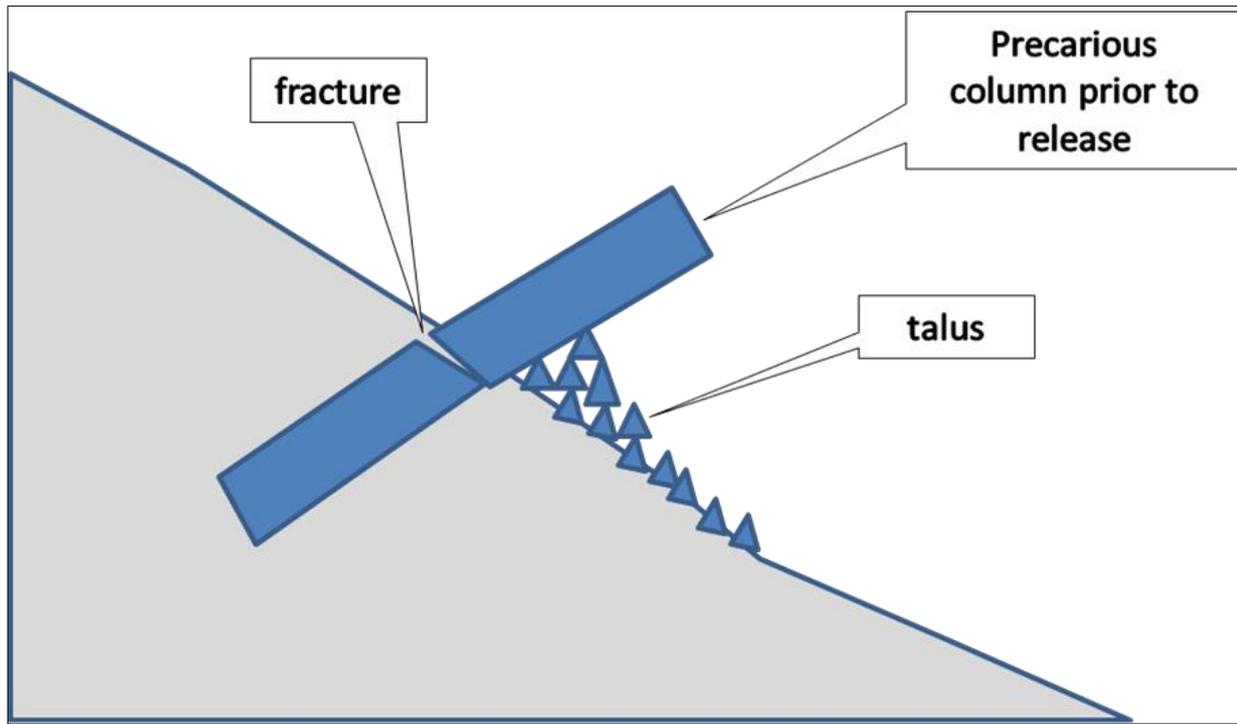
Figure 17. Conceptual model for the 2014 rock fall source area.

Rockyfor3D™

Rockyfor3D (Dorren, 2015) is a "probabilistic process-based rockfall trajectory model" that according to the documentation can be used for regional, local and slope scale rock fall simulations. It has a number of sophisticated features including;

- it explicitly and realistically integrates the barrier effect of trees on falling rocks,
- roughness and soil types can be added as layers, and can be derived from geomorphic and geological mapping,
- boulder density, shape and dimensions can be considered,
- the model is spatially distributed, probabilistic, and process-based.

In contrast to the MRT runout method, the Rockyfor3D paths are probabilistic rather than deterministic. The deterministic approach of MRT results in a source cell having only one possible path governed by the DEM. In contrast the probabilistic solution from Rockyfor3D provides multiple paths for a given rock source using a Monte Carlo (randomised) approach.

The software has been evaluated on the area of the 2014 rock fall (Figure 20). The most obvious difference from the MRT modelling approach is that much more information is required as input layers and model parameters. In the simulation provided, spatial estimations of surface roughness, ground hardness and vegetation were provided along with specific rock fall dimensions, shape and density. The simulation was performed 1000 times on a 2 m DEM with a 1m drop height. Processing time was less than 1 minute from the single source. However, processing time would be expected to be significantly longer if all potential source areas were considered in the area modelled.

The reach probability output shown on Figure 20 indicates a diverging then converging pattern of rock fall distribution from the single source area. The initial divergence is related to minor variations in initial propagation direction created for each simulation occurring on a slightly convex slope in the source area. Lower down the
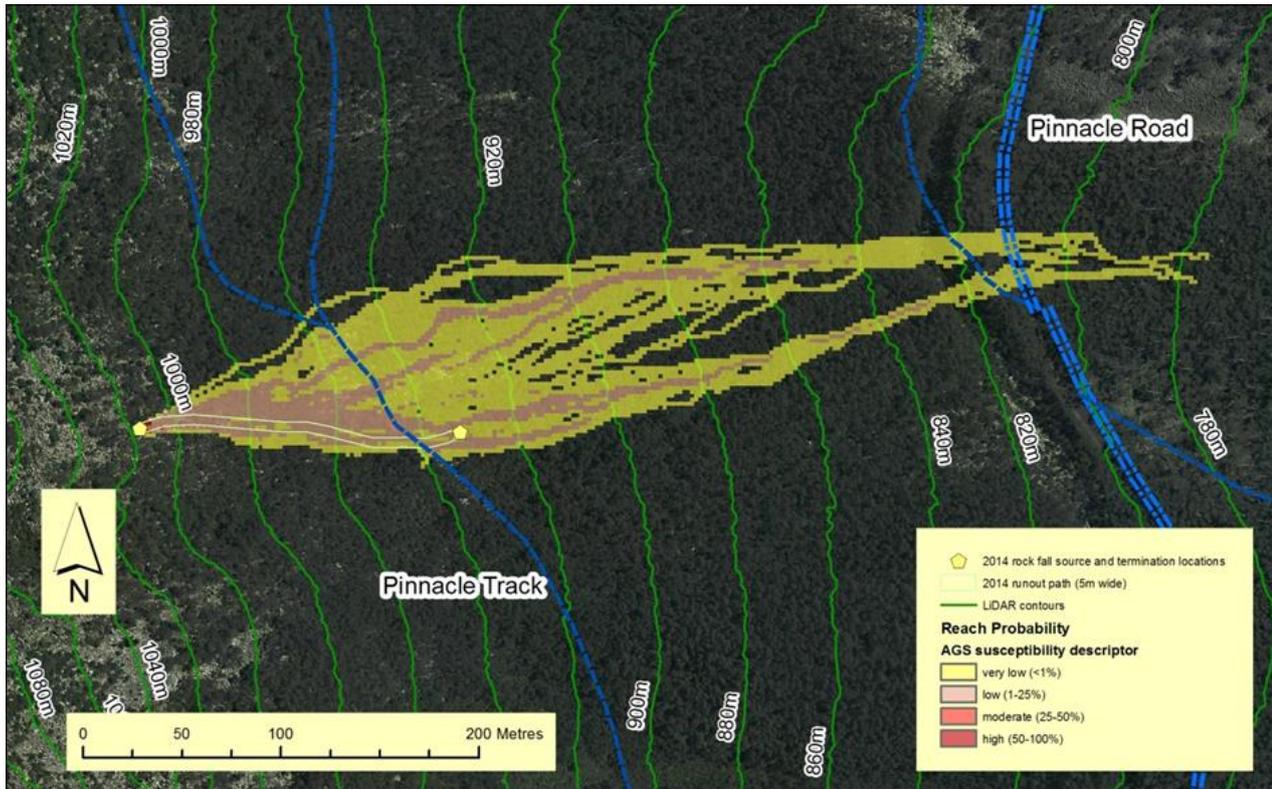

Figure 18. Rock fall reach probability using the Rockyfor3D software. Note that Moderate and High susceptibility areas are restricted to the vicinity of the source area.

hillside a subtle concave slope provides for topographic focussing and convergence. The mapped runout path of the 2014 rock fall is consistent with the simulation output, situated within the 1–25% probability area (a Low quantified susceptibility in terms of AGS (2007a)). Interestingly, the model indicates that a boulder equivalent to the 2014 feature could make it all the way to the Pinnacle Road but the probability of this happening is <1% (a Very Low quantified susceptibility in terms of AGS (2007a)). The furthest runout path shown in this simulation has a travel angle of 23.6 degrees which is just beyond but close to the limit of rock fall runout as shown in Figure 15. It should be stressed that the simulation is indicative only and should not be relied on as we have not mapped in sufficient detail the ground conditions in the entire runout area and the model parameters need further calibration.

For local scale studies the information requirements of the model are reasonable and can be satisfied with field studies. However it raises questions for regional scale susceptibility mapping when several of the input layers are not easily generated from existing data sources. One possible strategy would be to provide generalised layers to allow the software application to run and use the outputs to prioritise field work in areas where elements at risk exist. The model can then be rerun with the benefit of the additional controls.

Conclusions

The 8 July 2014 rock fall has provided a rare opportunity to determine, with high confidence, the parameters necessary for understanding the event and their implications for rock fall susceptibility modelling.

The study has identified a geomorphic process for rock fall on deteriorating dolerite escarpments that is widespread on Mount Wellington, and probably other dolerite capped mountains in Tasmania, but which is not as obvious as the processes active on impressive cliffs such as the Organ Pipes.

Previous modelling by MRT using regional scale photogrammetric contours to create DEMs has been shown to be deficient for predicting the source area of the 2014 rock fall. Using the LiDAR derived DEM now available, with its greater density of data points, does successfully predict the source area.

The rock fall runout modelling used by MRT to date appears to underestimate the area affected and could be adjusted to satisfy the 2014 event and also to conform to the Australian Geomechanics Society guidelines for landslide susceptibility zoning (AGS, 2007a). However, this would lead to a substantial increase in the area identified as susceptible to rock fall runout.

We have considered other approaches to regional rock fall susceptibility modelling that have been developed by respected research communities in Europe. The results of these approaches may suggest that segments of dolerite columns tend to travel further than most types of rock fall. These tools and the documented experience of the users of them provide MRT with the confidence that best practice is being utilised when revising existing rock fall zoning and, where necessary, modelling at more detailed scales.

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