Ruapehu crater rim inspection 13 April 1999: Developments since 1997

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Summary

Changes to the 1995/96 tephra mantle on the Outlet area of Ruapehu crater rim since February 1997 have been limited to the development of shallow gully erosion on adjacent slopes to the north, but larger gullies have formed to the west. Development of these gully systems near the overflow point suggests that a significant part of the tephra mantle might be removed before the rising Crater Lake reaches the pre-1995 overflow level (2530 m), expected in 3 to 5 years. Further development of these gully systems should be closely monitored in following summers, as the lake approaches overflow. This will provide a better appreciation of the likely dimensions of the potential tephra dam that may contain a future overfilled lake.

No areas of significant seepage were identified within the upper Whangaehu River channel, and only minor (apparently superficial) landsliding was seen on the outer slopes of Stump Saddle. However, this part of the crater rim is probably the most vulnerable to collapse, and careful monitoring is required in future summers as the lake rises from its present level of about 50 m below pre-1995 overflow.

1. Introduction

This crater rim inspection was carried at the request of Dr Harry Keys, Department of Conservation, Turangi. The inspection follows on from a report by Hancox et al. 1997. That report recommended regular inspections of Ruapehu crater be made as the Crater Lake rose towards overflow following its ejection during the 1995 and 1996 eruptions. These inspections were to monitor any changes to condition and stability of the tephra cover in the Outlet area, and to examine other areas of the crater rim for evidence of potential instability. The 1997 report shows the locations of features mentioned here.

One day (13 April 1999) was spent in the crater area, including a brief helicopter overflight of the upper Whangaehu River channel. On this day the lake was at about 52 ±5 m below its old (pre-1995) overflow level of 2530 m asl. (P.M. Otway and H. Keys, pers. comm.).

2. Questions to be answered

The following questions were identified in the DOC brief for this inspection:

1. How stable is the tephra dam at the former outlet of Crater Lake?

2. How much has it eroded since the 1997 survey, and by what mechanism(s)?

3. How large has the new ice body on the southern side grown?

4. Is there any sign of seepage from the re-forming Crater Lake below the Outlet area or south through east rims?

5. Has the apparent condition of the eastern rim changed significantly since the 1997 survey?

6. Are there any new concerns for the stability of this section of the rim?

Results of this investigation suggest answers, numbered as above:

1. The 1997 analysis (Hancox et al. 1997) of tephra dam stability is still current, as there have been no major physical changes in the overflow area at the Outlet. The tephra mantle is as stable as it was in 1997, although the potential dam is slightly reduced in effective width by gully encroachment.

2. Shallow gullies are approaching the Outlet from the northern (Crater Lake) side, and there has been slight development of gullying on the southern (Whangaehu channel) side of the overflow area. There have been a few centimetres of surface downwasting (sheet erosion) of the ash-covered ground surface in this area.

3. The ice wedge, which formed against the tephra-covered pre-1995 waterfall lava cliffs to south of the Outlet during the 1996 winter, was smaller on 13 April than it was in February 1997. This is consistent with the light snow year in 1998 and considerable melt during the 1998/99 summer.

4. No seepage outflows were seen within the upper Whangaehu River channel (or expected, given the present low lake level). The potential development of seepage discharges into the river channel as the lake level rises requires that more detailed inspections are made in following summers (see 6 below).

5. Small landslides have occurred on the outer slopes of Stump Saddle, but do not appear to be of more than superficial significance. Fissuring of the northeast crater rim and collapse of a near-surface welded scoria block at Station J may be due to loss of support resulting from 1996 superficial landsliding and subsequent erosion. However, this fissuring may extend to significant depths, and this part of the rim should continue to be closely monitored.

6. The Stump Saddle section of the crater rim appears the most vulnerable to collapse - possibly accelerated by any further erosional undercutting of the crater wall in the upper Whangaehu River channel. This area requires careful monitoring during and after lake filling, as does the rim around Station J.

3. Observations

3.1 UPPER WHANGAEHU RIVER CHANNEL AND OUTER RIM SLOPES

Comparison of oblique aerial photos (Figs. 1-4) taken on 18 January 1996, 18 February 1997, and 13 April 1999 shows that only minor erosion of the outer slopes of the Pyramid Peak-Stump Saddle-Outlet area has occurred during the intervening 39 months. [Little time was available for the overflight inspection during the 13 April 1999 visit, and my position in the helicopter prevented clear photography.] A small, apparently superficial, landslide had recently occurred from high on the outer slopes of Stump Saddle. The photographs show that the upper Whangaehu River channel cuts through the young (<2000 year) lavas, breccias and pyroclastics of the Crater Lake crater eruptives, to form the waterfalls immediately to the east of Stump Saddle (Fig. 2). These young eruptives unconformably overlie the altered older lavas of the Tahurangi Peak cone to the south, which are also exposed in the river channel downstream of the falls. Considerable erosion of the channel at and below the falls must have occurred here during passage of the 1995 lahars. The extent of the 1995 erosion cannot be quantified as all previous map contour data here have been obtained when the channel was filled with snow and ice. The effect of this erosion is to undercut the Stump Saddle and Pyramid slopes to the west and north.

A ground inspection of the upper 0.4 km of the Whangaehu channel (from the Outlet down to the first waterfall) was carried out in misty conditions later on 13 April. No significant changes, or localised seepage discharges, were observed in the channel. This result was expected, given that all except the most downstream part of the traversed channel was above the present lake level. The channel carried some meltwater, flowing under remnants of glacier ice on the channel floor.

3.2 OUTLET AREA

Changes in the Outlet area of the southern crater rim since February 1997 have been minor but significant. The slowly rising lake has triggered some slumping of the 1995-96 pyroclastic mantle over pre-eruption lake floor sediments and lavas which form the steep slopes beyond about 100 m to the north of the Outlet. There has been some sheet erosion of the ground surface ash deposits, revealed by the April 1999 exposure of some lava blocks (to ~ 0.4 m dimensions) which were partly buried or not visible in 1997 photographs of the Outlet area. The sample pit excavated close to the overflow divide in February 1997 is still evident, although partially infilled.

Breakdown of radio communications with the surveyor on Dome, and increasing steam and atmospheric cloud prevented any instrumental surveying of gully features in the Outlet area on 13 April. However, comparison of oblique aerial and ground photos taken in 1997, 1998, and 1999 shows that there has been considerable southward growth of shallow dendritic gully systems towards the Outlet divide (Fig. 4). These gully systems are being eroded by surface runoff from the summer melting of snow and ice, and heavy rainfalls. The gullies become shallower (0.5 - 1 m) as they extend south on to the gentle slopes near the overflow point. They are re-excavating the large gullies that had been rapidly eroded within the relatively fine-grained 1995 ejecta during the 1995-96 summer (see fig. A3 in Hancox et al. 1997), and which were subsequently infilled during the 1996 eruptions.

The Outlet area is "protected" to the extent that it comprises a nearly flat-lying broad divide between the crater lake basin and the upper Whangaehu channel, and it receives no surface runoff from adjacent higher areas of the crater rim to east and west. [This runoff is captured by larger gullies forming to the east and west of the overflow point, which carry runoff north towards the lake.] The micro-catchments feeding each gully head directly approaching the overflow area will have a diminishing area as the gullies get closer to the rim, and so gully head migration rates should decrease with time. Despite this, small gullies are encroaching on to the rim area, although only very minor development has occurred of the gullies draining south into the Whangaehu channel from the overflow point.

Significant gully development has occurred about 90 m to west of the overflow point, where runoff from the scoria ridge above has excavated a 1.5 m deep gully head, with most dissection to ~lm depths. At ~120 m west of the overflow area, a larger gully system has eroded to about 4 in depth, with the gully head sited beneath the 1945 lava flow bluffs. This gully seems to have been largely excavated by meltwater and rainfall runoff from the glacier above. The gully deepens rapidly downslope north into the crater (Fig. 5), and demonstrates the ready erodibility of the 1995-96 ash and scoria deposits. When examined, the gully wall deposits were firmly cemented by ice, but this would be melted by proximity to a rising hot lake.

3.3 NORTHEAST RIM

Landslides occurred on both inner and outer slopes of the northeast crater rim in April 1996, where fissures later developed after the 1996 eruptions. I did not examine this part of the rim during the 1997 February inspection so these comments are restricted to observations made during the 1999 visit. At the site of Station J there has been considerable recent collapse of a large block of densely-welded red scoria which overlies partially to non-welded black scoria falls. The welded scoria block is mantled by non-welded brown altered scoria falls on the outer slopes, where the 1996 landsliding appears to have occurred in this deposit. Within the crater, the landsliding and subsequent erosion has removed part of the non-welded scoria deposit underlying the welded block, removing support from the block, and causing it to fracture and collapse into the crater. I am uncertain if the fissures that have developed on the crater rim here have a superficial origin - controlled by the landsliding removal of support - or if both the landsliding and the surface fissuring are related to fracturing at greater depths. The previous occurrence of weak fumarolic emission in these fissures (H. Keys and P.M Otway pers.

comm.) suggests that the fissures may extend to more than superficial depths. This area should continue to be watched during lake filling.

4. Discussion

At the present rate of filling, and assuming no major hiatus occurs such as large eruptions ejecting lake water, or major slumps or magmatic intrusions causing the lake level to rise, the lake should reach the pre-1995 overflow level sometime between 2002 and 2005, i.e. in 3 to 5 years. With the lake presently at about 50 m below overflow, groundwater pressures are relatively low (compared with a full lake), and the development of seepage outflows does not appear active. However, the stripping of lake sediments from the crater floor and walls during and after the 1995-96 eruptions has exposed the lavas and breccias forming the eastern crater wall. This, and any mechanical effects of the explosive eruptions, must have increased the accessibility of the crater wall to lake water, so that seepage losses from the refilled lake are likely to be higher than before the 1995-96 eruptions. [See Beetham et al. 1980, for an earlier discussion of seepage from Crater Lake.]

Although the crater rim below Stump Saddle forms a stable structure under engineering analysis (Hancox et al. 1997), nearly all the past and anticipated changes to this area (thinning by erosion, mechanical weakening by explosive and seismic shaking, increased groundwater inflows, slope undercutting by channel erosion) are in the direction of decreasing stability. There is downstream geological evidence that several major collapses of the crater rim have occurred in the last 2000 years (K. Hodgson, pers. comm. 1999), although the specific causes of these collapses are unclear. An apparent erosional unconformity is visible in photographs of the lava/breccia sequence exposed on the Stump Saddle inner crater wall at slightly below lake overflow level. This unconformity is likely to record an earlier rim collapse. The Stump Saddle crater rim and adjacent upper Whangaehu channel will require careful monitoring during and after lake filling.

At the Outlet, the 1997-99 rate of gullying is such that, if maintained over the next 2 or 3 summers, gully development may have excavated channels into the tephra mantle on the overflow area, which could reduce its effective width as a dam from an original ~80 m to a few tens of metres. The large gullies eroded to the west of the overflow point would be occupied by a nearly full lake. The rapid formation of these large gullies suggests that shore erosion by a high lake could quickly enlarge their lateral dimensions. If so, the tephra mantle on the overflow area could be rapidly diminished by a rising lake margin encroaching from both the north and west. Further development of these gully systems should be closely monitored during the next (and following) summer(s), as this would better indicate the likely configuration and erodibility of the tephra dam when the lake reaches the pre-1995 overflow level.

5. Recommendations

1) As the Crater Lake level rises, more detailed and frequent summer inspections are required of the outer slopes of Stump Saddle, Pyramid Peak and within the upper Whangaehu channel. These inspections are to look for development of slope instability, and seepage paths into the river channel, and should continue after overflow is re-established. Chemical sampling of the river water in the channel below the falls each summer until overflow occurs might identify the initiation and/or increase of any lake seepage outflows into the channel.

2) Detailed mapping of the development of gullying on the Outlet terrace should be carried out, with gully depths and locations plotted by total station (theodolite/EDM) measurements from the Dome, using a long staff with a reflector mounted on the top. This will provide a better understanding of when and how the lake is likely to cut through the tephra mantle on the overflow area.

3) Consideration should be given to flying low-level vertical aerial stereophotography of the south, east, and north crater rim (Outlet-Stump Saddle-Pyramid-Dome) to be carried out in February or March 2000. This would provide a detailed record of the rim geology and topography prior to lake filling, and a baseline against which any future macro instability of the rim could be measured.

6. Acknowledgements

Harry Keys, Katy Hodgson and Peter Otway provided background data used in this report.

7. References

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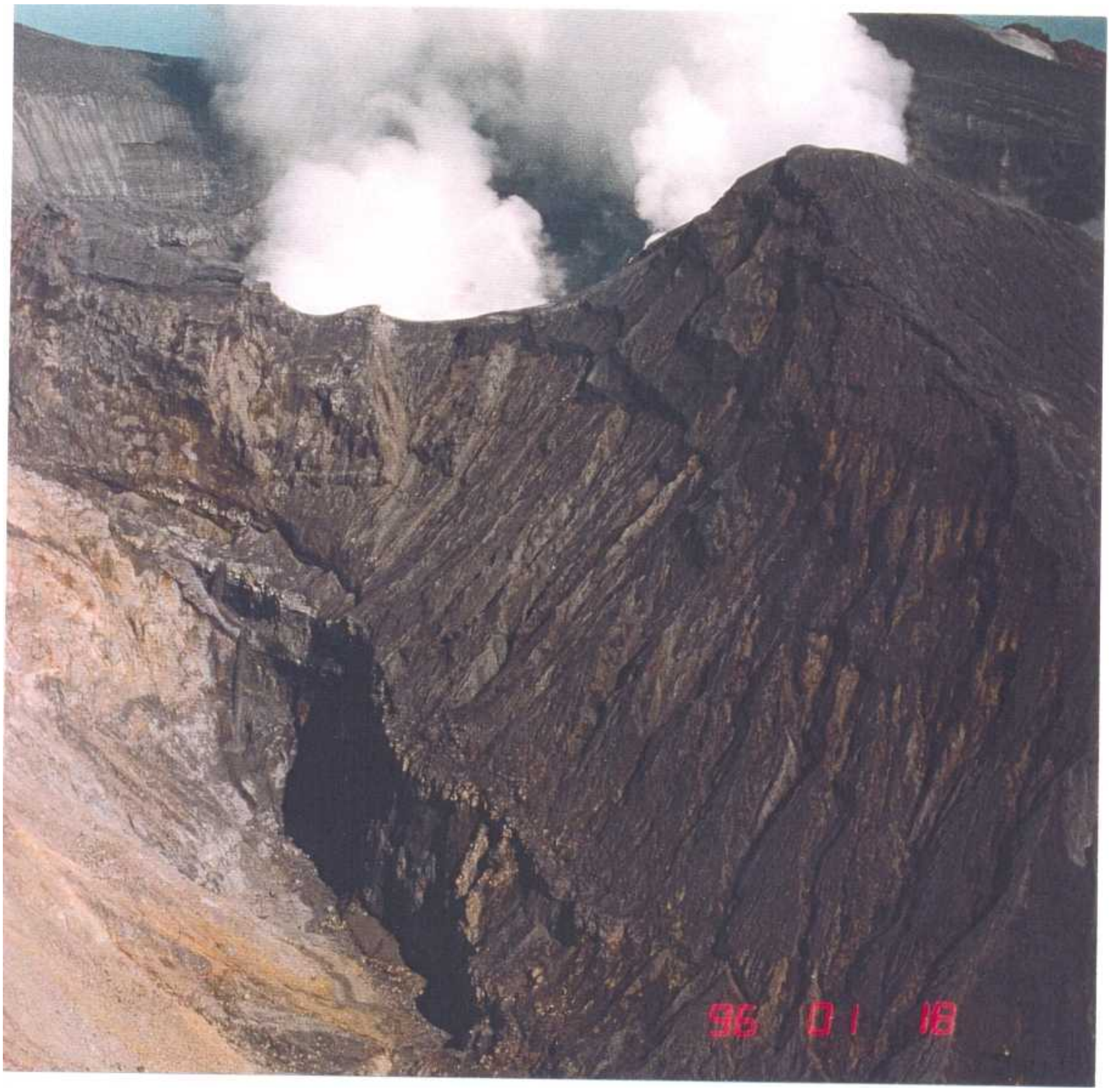

Figure 1. View of the outer slopes of the southeastern crater rim and the upper Whangaehu River channel in January 1996. A white gas plume rises from the crater behind Stump Saddle, with Pyramid Peak to right. The dark-coloured lavas and pyroclastics of the <2000 year crater rim eruptives unconformably overlie the altered (lighter-coloured) lavas and agglomerates of the much older Tahurangi peak cone. Waterfalls (see Fig. 2) in the Whangaehu channel are fed by ice melt. At this time a shallow lake in the crater was at about 90 m below overflow, i.e. at similar elevation to the upper waterfall.

Figure 2. Closer view of the waterfalls flowing over the young lavas and inter-bedded scorias at the base of the Stump Saddle outer slopes. Photo taken 18 February 1997.

Figure 3. Aerial view of Ruapehu Crater Lake about 50 m below the overflow level controlled by the tephra-covered outlet terrace at upper middle of picture. Photo taken 13 April 1999.

Figure 4. Dendritic gully erosion is approaching the overflow area at the Outlet. View is to south from above Crater Lake. Arrow marks the Outlet basin at head of the Whangaehu channel; rectangle is sited on the overflow area. Photo taken 13 April 1999.

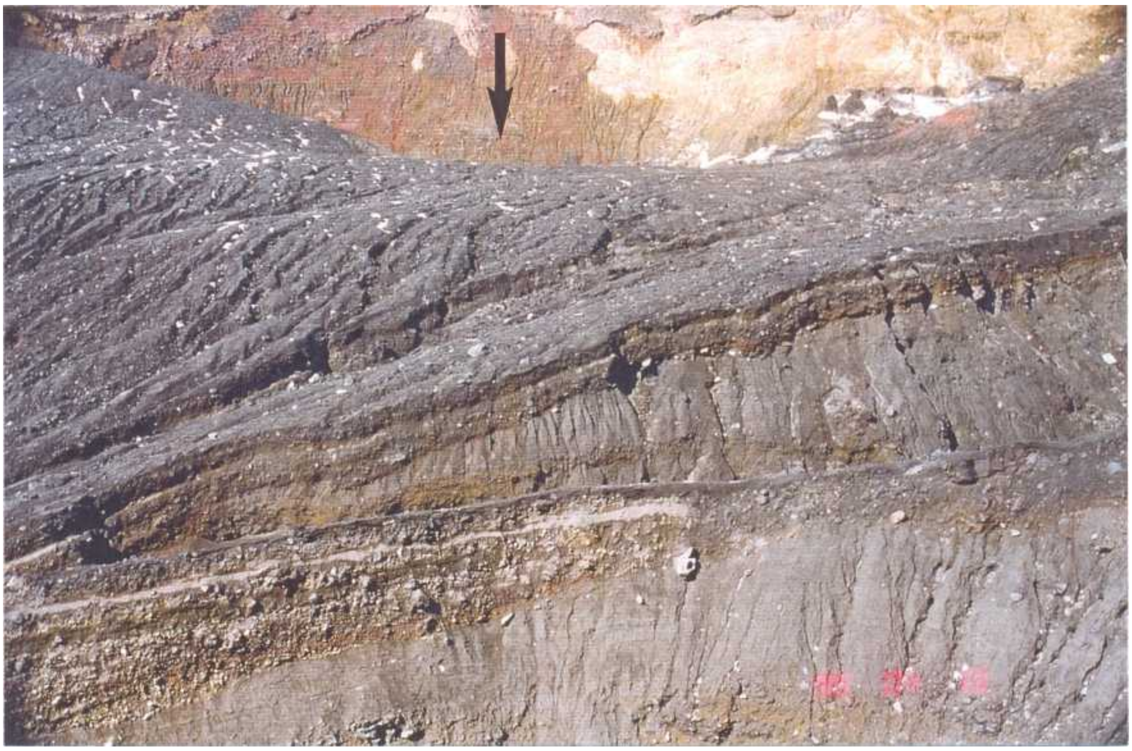

Figure 5. Ground view of the gullying to west of the Outlet (arrow - upper centre of photo). Coarse 1996 scoria falls overlie finer (ash-dominated) 1995 ejecta. Photo taken 13 April 1999.