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A glacial lake outburst flood associated with recent mountain glacier retreat, Patagonian Andes

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Abstract: Geomorphological mapping, sedimentology, lichenometry and dendrochronology were used to assess the nature and timing of glacier recession, moraine development and catastrophic mass movements in a tributary of the Leones valley, east of the Hielo Patagónico Norte, Chile. We show that during the ‘Little Ice Age’ Glaciar Calafate advanced downvalley to produce a terminal moraine. Recession of the glacier from this position occurred in the 1870s and produced a moraine dammed lake. In late 2000 a large rockfall into the lake breached the moraine and triggered a glacial lake outburst flood (GLOF) that entrained and subsequently deposited some 2×10^6 m^3 of material. We interpret this event as a delayed paraglacial response to the retreat of Glaciar Calafate during the twentieth century.

Key words: Glacier, Patagonia, mass movement, glacial lake outburst flood (GLOF), ‘Little Ice Age’, paraglacial.

Introduction

Most mountain glaciers worldwide have been receding from their ‘Little Ice Age’ positions during the last century (eg, Chinn, 1996; Dyurgerov and Meier, 2000; Solomina *et al.*, 2004) and the rate of recession has increased over the past decades partly as a consequence of global warming. Because glaciers are coupled to their slope and valley-floor geomorphic systems, recession impacts upon these in a number of complex ways (Owen, 1991; Blair, 1994; Abele, 1997; Ballantyne, 2002). Rockfalls and glacial lake outburst floods are associated with glacier recession and form significant hazards in many mountain regions of the world. Here we describe a catastrophic geomorphic response to glacier retreat in Chilean Patagonia, a region where mountain glaciers have been responding dynamically to global warming (Rignot *et al.*, 2003).

Around the Hielo Patagónico Norte, or North Patagonian Icefield, many mountain massifs support independent glaciers, the recession of which has led to the formation of proglacial lakes dammed by moraines. Catastrophic moraine failures have caused large lake outbursts in the recent past in the area (Aniya and Naruse, 2001), but the geomorphic impacts of these floods have not been described in detail. In February 2000, two of the authors investigated a moraine damming a proglacial lake, which we call Lago Calafate. The lake drains northwards into the Río Leones valley, which runs eastwards from Lago Leones, a large lake on the eastern flank of the Hielo Patagónico Norte (Figure 1). Later in 2000, probably during the austral winter, the moraine dam failed and caused a glacial lake outburst flood (GLOF).

This paper has three aims. First, it aims to describe the geomorphology and sedimentology of the GLOF and the local site; second, it assesses the possible trigger mechanisms of this event; and third, the paper places the event into the wider geomorphological context of paraglaciation and contemporary

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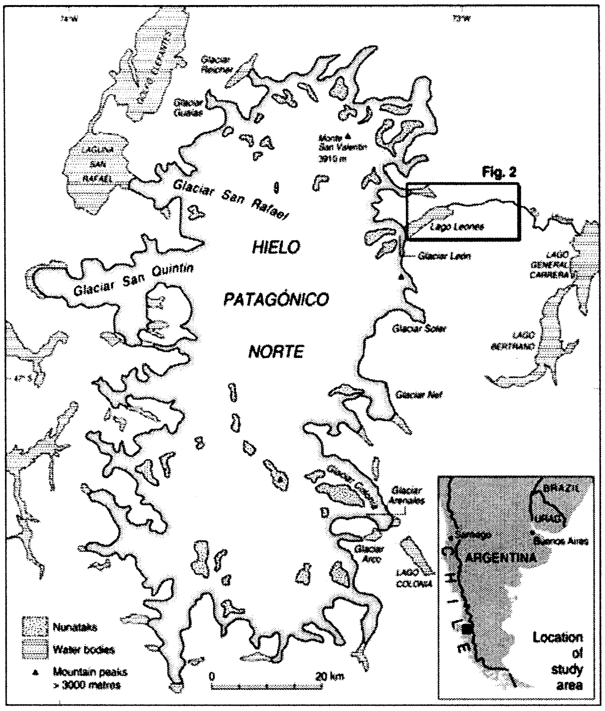

Figure 1 The Hielo Patagónico Norte showing the location of the study area

glacier recession. Finally, the site provides a rare opportunity to assess the timing and triggering mechanisms of catastrophic paraglacial processes because the timing of glacier recession and the GLOF are comparatively well constrained. Field visits shortly before and after the outburst flood allowed the events to be documented in considerable detail.

Study area

The Hielo Patagónico Norte (centred around 47° 00′S, 73° 39′W) is about 120 km long and 40–60 km wide and caps the Andean Cordillera between elevations of 700 and 2500 m a.s.l. (Figure 1). Annual precipitation on the western side of the icefield increases from 3700 mm at sea level to an estimated 6700 mm at 700 m a.s.l. (Escobar *et al.*, 1992). Large outlet glaciers drain the icefield and have undergone considerable recession since the 'Little Ice Age' (Winchester and Harrison, 1996; Harrison and Winchester, 2000; Warren *et al.*, 2001; Winchester *et al.*, 2001). Glacier retreat has impacted upon valley-side geomorphic systems by destabilising bedrock and drift-covered slopes (eg, Harrison and Winchester, 1997; Harrison *et al.*, 2005).

Steep, independent glaciers in the surrounding mountains have also undergone considerable recession from 'Little Ice Age' terminal positions, locally producing proglacial lakes dammed by unstable moraines. An example is Lago Calafate, a lake dammed by a moraine constructed by a 'Little Ice Age' advance of Glaciar Calafate. Glaciar Calafate drains a small icefield adjacent to the Hielo Patagónico Norte and flows through a steep, deep rock-walled valley. It now terminates about 500 m south of the lake. North of the moraine the valley narrows to a gorge, confined on its east side by rockwalls and on its west side by moraines and boulder fields. Below the gorge, and about 1.5 km downstream of the lake, the valley opens into the main Leones valley, which is drained by the east-flowing Río Leones.

The GLOF in 2000 dramatically altered the form of the lake, moraine and valley, forming a depositional apron of coarse debris some 1 km wide and 800 m long, inundating the Leones valley below the Calafate drainage basin (Figures 2a, b and 3). The deposit temporarily dammed Río Leones and permanently altered its course.

Methods

The glacial geomorphology of the area surrounding Glaciar Clafate was mapped using a combination of field mapping and visual interpretation of Terra ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) satellite images. The images were radiometrically and geometrically corrected based upon the orbital parameters supplied by the USGS, allowing a horizontal error in the order of one pixel size (15 m for ASTER and 30 m for Landsat ETM+).

Lichenometry and dendrochronology were employed in 2000, before the GLOF, to provide minimum age estimates for land surfaces. Lichenometric ages for surface stabilization were derived from size–age relations (Innes, 1985), and corrected for delayed colonization (establishment). Measurements of the longest axis of 90 of the largest, circular *Placopsis perrugosa*, thalli, the most common rock-inhabiting lichen species in the area, were made using a flexible tape accurate to ±1 mm (Figure 4). Surface stabilization dates are based on a linear growth rate of 4.7 mm/yr and an establishment time of 2.5 yr, derived from earlier studies around the Hielo Patagónico Norte (Winchester and Harrison, 1994, 2000). Possible errors in these dates stem from measurement errors resulting from irregular rock surfaces and variable colonization time and growth rates caused by differences in aspect, exposure, rock type, colour and mineral composition, temperature, water supply and competition. Control of these factors for valleys draining the Hielo Patagónico Norte is described in Winchester and Harrison (1994, 2000) and Winchester *et al.*, (2001).

Dendrochronological dates for surface stabilization (see Table 2) were obtained using a 5 mm increment borer. Forty cores were collected from the largest *Nothofagus nitida* trees growing on moraine sides, valley-sides and the outwash plain in the Leones Valley. The cores were mounted and finely sanded. Ring counting was carried out using a microscope. Surface age estimates include corrections for the number of years of growth below core height and ecesis. Ecesis estimates are based on differences between tree age and the surface date derived from lichen measurements, with estimates ranging from 34 to 67 years (Table 1). Estimates of growth below core height were obtained by measuring the height of, and number of rings in 18 small trees in the Leones, Cachorro and Calafate valleys. Thus, tree age is equal to core height/annual growth + ring count, and a surface exposure date is provided by the consequent sum plus an establishment delay (Table 2).

Preliminary field observations of the GLOF deposits were made during November 2001 and further quantitative data were gathered in March 2003. Sediments were described according to texture, particle size and clast shape in order to differentiate between sediment source areas. Poorly sorted sediments were described in the field using the Hambrey and Glasser (2003) modification of the Moncrieff (1989) classification. The clast morphology of samples of 50 stones was determined using a modified Powers (1953) scale and measurement of a, b and c axes. These data were further analysed using the approach of Benn and Ballantyne (1993, 1994) in which the RA index (percent of angular and very angular clasts) is

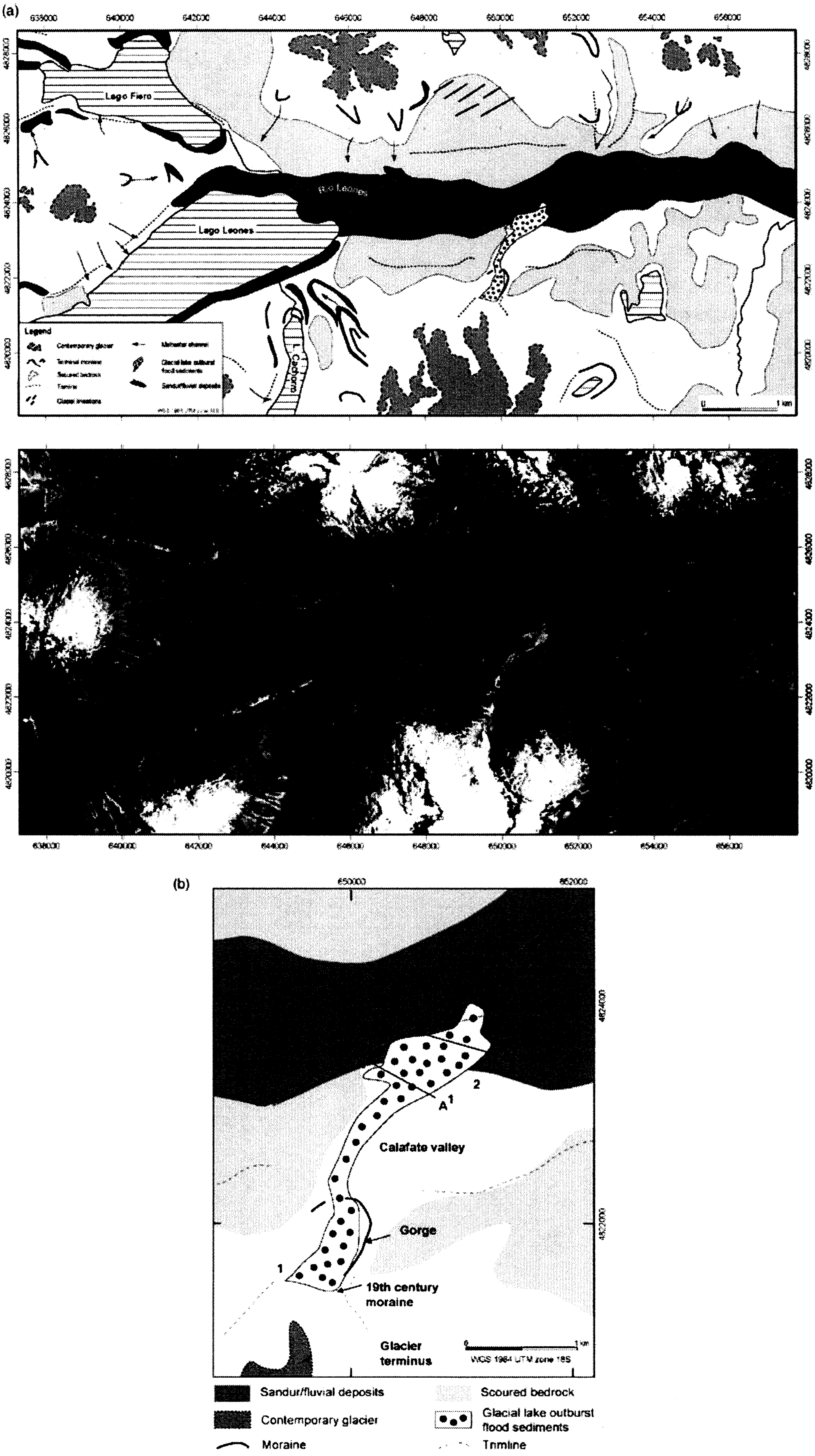

Figure 2 (a) ASTER image of the GLOF site and part of the Leones valley. (b) Inset of GLOF site from (a) with the location of the profiles shown in Figure 5a and c. The locations of the photographs shown in Figures 3 and 6b are marked as 1 and 2, respectively

plotted against the C_{40} index (percent of clasts with c/a axial ratio ≤ 0.4) on a co-variant plot. This method has been shown to discriminate glacial facies (Bennett *et al.*, 1997; Glasser and Hambrey, 2002; Hambrey and Glasser, 2003). Clast lithological analysis was based on field identification of surface stones. All sedimentary descriptions come from surface samples, since few vertical sections exist in the GLOF apron area. Topographic profiles across the GLOF apron were constructed using tape and Abney level.

Results

Interpretation of the ASTER image (Figure 2a, b) shows that the GLOF has developed in a glaciated valley with large tracts of ice-scoured bedrock along the valley sides. This undulating bedrock surface is draped in places by a thin (*c.* 0.5–2 m thick, but locally thicker in places) layer of sandy gravel, sandy boulder gravel or diamicton. The presence of large areas of ice-scoured bedrock along the valley sides and its patchy cover of glacigenic sediments indicates sustained vigorous ice flow by a temperate glacier in the main valley. The GLOF apron has been deposited on top of an extensive sandar (glaciofluvial outwash plain), fed by meltwater streams draining the contemporary Glacier Leon (buffered by Lago Leon) and Glacier Fiero.

Glacier recession chronology

Lichenometry and dendrochronology indicate surface stabilization during glacier recession in the 1870s (an 1893 lichen date probably reflects later colonization). The moraine damming Lago Calafate was constructed at the time of the 'Little Ice Age' maximum or later in the early 1900s and probably did not possess an ice core. By 1925 the glacier had receded from this moraine as shown by the post-1925 lichen date and tree dates on the proximal flanks of the moraine. Further recession led to the formation of Lago Calafate, which drained over and through the moraine. Dates from the proximal side of the moraine suggest declining lake levels in the 1930s (Figure 4). Glacier recession throughout the twentieth century is suggested by recessional moraines, which were present downvalley of the present glacier snout and observed by SH and VW before the rockfall and GLOF.

When SH and VW visited the site on 16 February 2000, the instability of the moraine was apparent. A mass movement 10 m below the moraine crest on the proximal side of the moraine had snapped the trunk of a small tree, as shown by its barely formed earlywood growth and its newly dead leaves, and other tree sections show recent damage.

Geomorphology

The research site comprises three zones.

Upstream of the moraine dam

This zone includes the glacier, Lago Calafate and the glacier forefield between them. Glaciar Calafate terminates in a steep ice front. East of the terminus, and towering above it, is a steep bedrock cliff with recent rockfall scars. Large amounts of distinctive reddish rockfall debris can be traced from the base of the cliff, extending down-valley past the present lake and over the moraine dam. This rockfall material was absent in February 2000.

Prior to the GLOF, Lago Calafate had a surface area of about 28 000 m^2 and was dammed by the 40-m-high moraine with 3-m-high trees growing on it. Two smaller moraine ridges lay south of the lake; the one nearer the lake had 2-m-high trees growing on it; the moraine near the present glacier snout was treeless. In March 2003 Lago Calafate had an area of about 14 000 m^2 and was dammed by an openwork boulder deposit about 250 m wide. The small moraines south of the lake had been largely destroyed or buried beneath hummocks and ridges of rockfall debris elongated downvalley. The former 40-m-high moraine was completely covered by an irregular, massive deposit of angular boulders. Several post-GLOF rockfalls occurred from the cliffs on the west edge of the valley above the lake. One of the rockfalls contained blocks up to 15-m long. An area of debris-covered glacier ice was present 400-m south of the lake. At the southern edge of the present lake there are a number of deep hollows that may be the result of ice melting. The level of the post-GLOF lake was high enough in March 2003 to partially submerge living trees at its west shore.

Calafate Valley

Downvalley of the moraine and the bedrock gorge the valley widens out and has an asymmetric cross profile with its east side hemmed in by 50-m-high bedrock cliffs and its west side bordered moraines. In February 2000 the valley walls were covered by dense forest and the valley bottom covered by large boulders. The forest on the lower valley walls was completely removed by the GLOF (Figure 3). The boulders on the valley floor were transported several hundred metres, and redeposited on a debris apron in the main valley (Figure 3, and see Figure 6

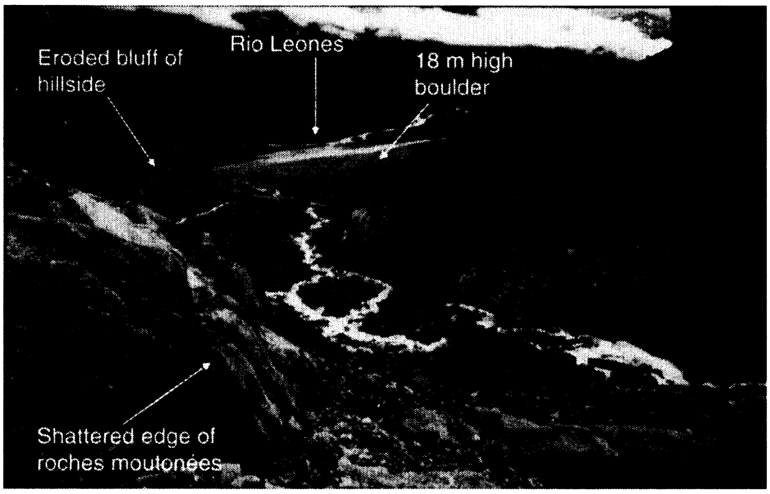

Figure 3 The Calafate valley after the GLOF showing the GLOF apron

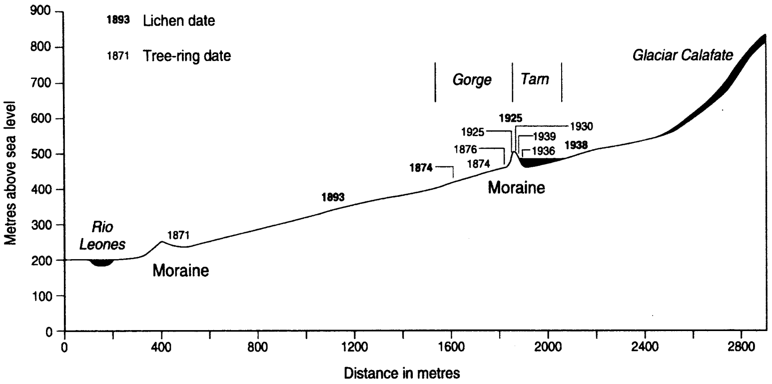

Figure 4 Age of surfaces in the Calafate valley area derived from lichenometry and dendrochronology

a–c). A lateral moraine at the west edge of the valley was eroded to a height of 55 m above the Calafate valley bottom during the event. Following the GLOF, sections exposed along the stream channel show an *in situ* bouldery till consisting of subrounded and striated clasts. The stream channel was displaced in several locations by the rockfall debris. The debris lobes in the valley have transverse boulder ridges up to 5 m high spaced 7–8 m apart. A section through the valley-bottom deposits reveals imbricated boulders up to 8 m long set in a cobble gravel matrix. The section coarsens upward. Near

Table 1 Lichen size/age correlations are derived from the diameter measurement divided by growth rate of 4.7 plus 2.5 years for colonization. Delays in tree establishment are based on differences between tree age and the surface date derived from lichen measurements

Location	Lichen size (mm)	Lichen date	Tree age	Establishment (yr)
Calafate lake moraine 5 m above lake level	280	1938	1970	34
Calafate Moraine @ 495 m distal	580	1874	> 1941	67
Calafate mid-valley	492	1893		
Calafate in gorge section stream-flank	560	1878		
Calafate summit of moraine	340	1925	1984	59

Table 2 Estimated lichen dates and tree establishment for surfaces in the Leones, Cachorro and Calafate valleys

Location	Comments	Tree height (cm)	Average growth (cm/yr) to core height	Core height (cm) = years to core height	Establishment (years)	No. rings	Surface date
Lago Leones							
Peninsula 46°44′85″S 73°10′67″W	Twinned trunks	900	8.8	114 = 13	(30[a])	90	1867
L. Cachorro							
N. lake end	Twinned basal trunks + dead limbs	1000	11.0	96 = 9	45	76	1870
Ridge above outflow	Multiple trunks @ 50 cm	900	9.6	79 = 8	45	83	1864
Outwash fan	Multiple trunks	1400	18.0	135 = 7	45	> 70	> 1877
Calafate							
Prox valley-bottom moraine	Stagheaded	600	16.2	110 = 7	59	63	1871
Same moraine by stream	Stagheaded rotten centre	600	16.1	50 = 3	59	> 53	> 1884
Lago Calafate							
Prox. moraine 5 m above water 46°44′06″S 73°02′09″W	Unstressed	300	10.3	38 = 4	34	26	1936
Prox. moraine mid-upper slope	Tree dead due to rock movement	300	11.2	42 = 4 Sectioned	34[b]	22	1939
Prox. crest moraine	Unstressed	180	16.4	32 = 2	59	9	1930
5 m below distal crest moraine	Unstressed	140	8.75		59	16	1925
Distal moraine 40 m below top	Stagheaded v. damaged	1000	8.75	95 = 11	67	> 48	> 1874
Distal moraine 45 m below top	Leading trunk broken	900	8.75	50 = 6	67	> 51	> 1876

> = Minimum value, core does not reach pith.

[a] Establishment delay for *Nothofagus* on fertile ground near the Soler Glacier (Sweda, 1987).

[b] The number of estimated years before establishment of the dead tree is tentative.

Establishment years for trees in Calafate valley indicate that there is good evidence (based on tree height divided by ring count from a basal section) to support growth rate to core height.

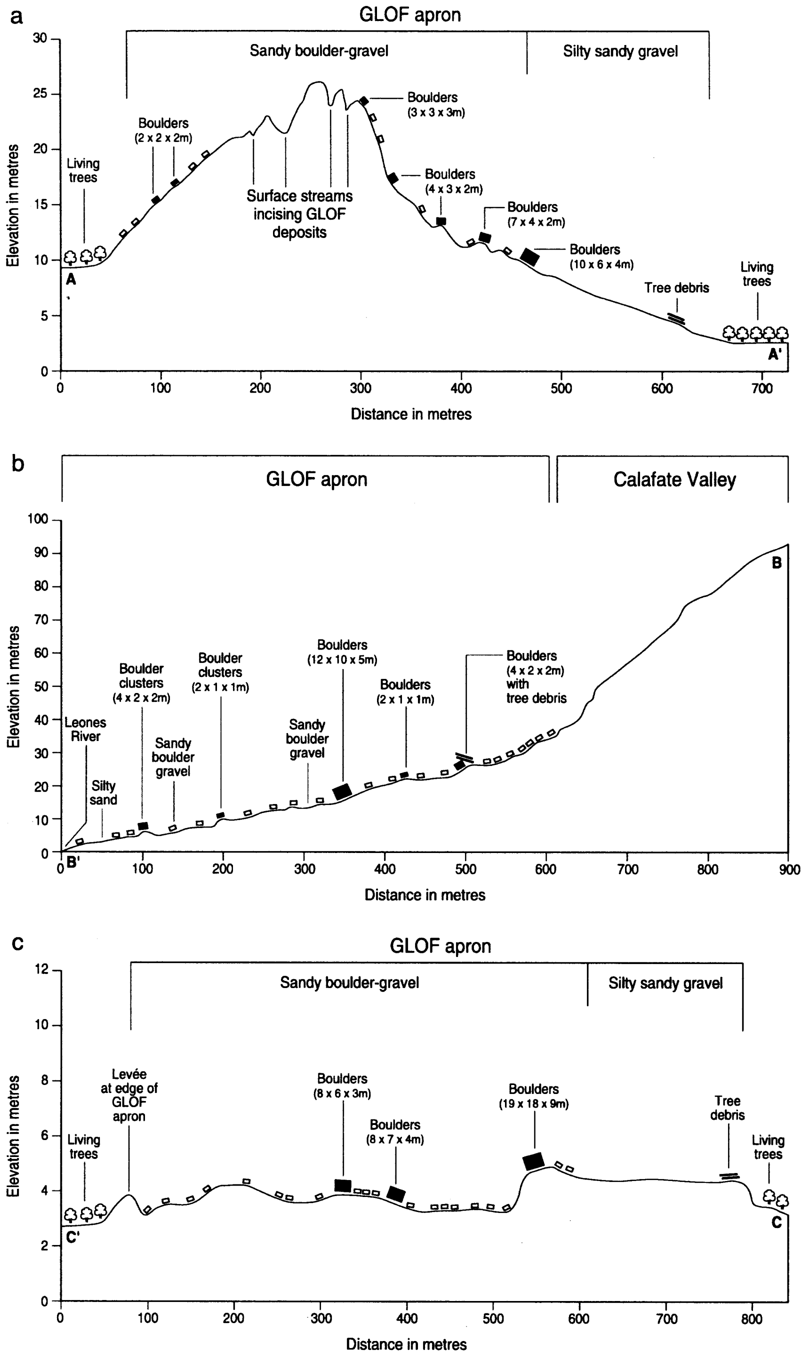

Figure 5 (a) Profile across the southern (proximal) part of the GLOF apron. (b) Long profile across the centre of the GLOF apron. (c) Profile across the northern (distal) part of the GLOF apron

the south end of the valley, the edges of large roches moutonées and whalebacks were extensively crushed and shattered during the event. The volume of material deposited during the GLOF in the upper and middle zones is estimated at 0.5 × 10^6 m^3.

GLOF apron

The GLOF apron is 1.5 km long, 800 m wide and has an estimated volume of 1.5 × 10^6 m^3 (Figures 5 and 6). The river channel in 2003 was 4–5 m above the main apron surface, perched on a series of boulder berms. The apron is not incised and lacks channels, scour marks, potholes and large or small ripples associated with water floods.

The GLOF diverted Río Leones 50 m to the north and widened it considerably. This stretch of the river is now strewn with boulders up to 6 m long. The ground bordering the west edge of the apron is flooded and ponding of water has occurred, probably as the result of the development of a reverse slope caused by a topographic change during loading of the land surface by the GLOF. Boundaries between the GLOF apron and the surrounding forest are sharp, marked by a 3–4 m high levée consisting of boulders up to 3 m long and large uprooted trees.

Sedimentology

The surface of the GLOF apron is composed of three main lithofacies (Figure 7).

(1) *Sandy gravel and sandy boulder-gravel.* The most widespread lithofacies is a massive, structureless sandy gravel

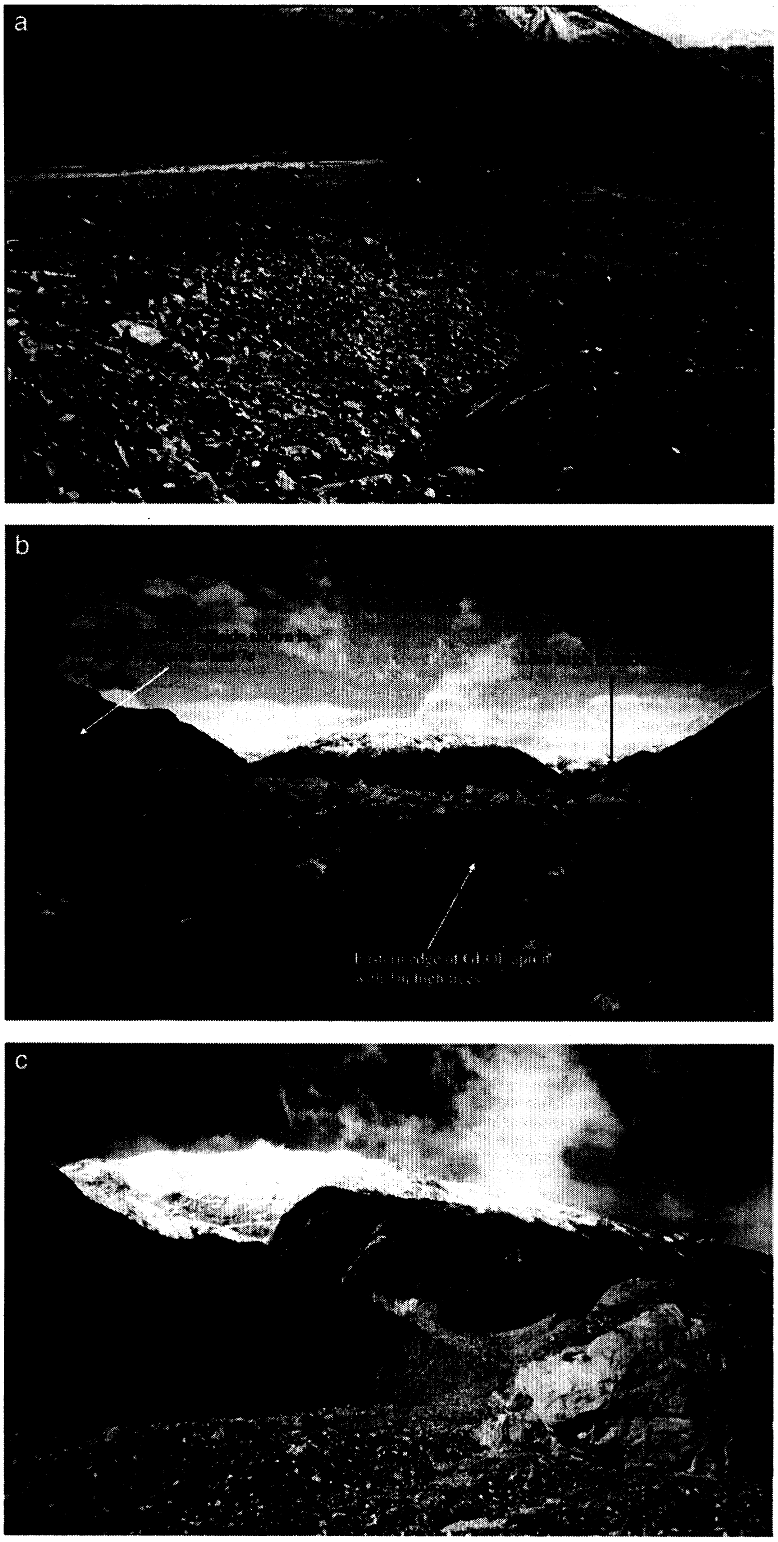

Figure 6 (a) Photograph taken from the bottom of the Calafate valley and looking north showing the eastern edge of the GLOF apron. Incision into the valley bottom is shown in the foreground. The large boulder in the middle distance of the photograph is 18 m high. Rió Leones forms the northern boundary of the GLOF. (b) The eastern edge of the GLOF apron. The 18-m-high boulder is on the right of the photograph. Trees in the foreground are 1–2 m high and form the eastern edge of the GLOF apron. (c) Looking up towards the Calafate valley from mid-way down the GLOF apron. Note figure in the foreground

with 70% gravel and 30% sand. Sandy boulder-gravel covers much of the centre of the apron. The gravel fraction is dominated by cobble- to boulder-sized clasts of granite and metamorphic rock. Most boulder-sized clasts are subangular or subrounded. Boulders in this lithofacies are up to 18 m long and partly covered with silty sandy gravel and silty sand. Low (metre-scale) ridges of sandy boulder-gravel occur upslope of large isolated boulders. The facies forms widespread areas of hummocky ground containing boulder berms, isolated hummocks and sinuous ridges.

(2) *Silty sandy gravel.* This lithofacies occurs mainly at the east edge of the apron as part of a washed surface with elongate bars and cobble berms 2–3 m in length and 20 cm in

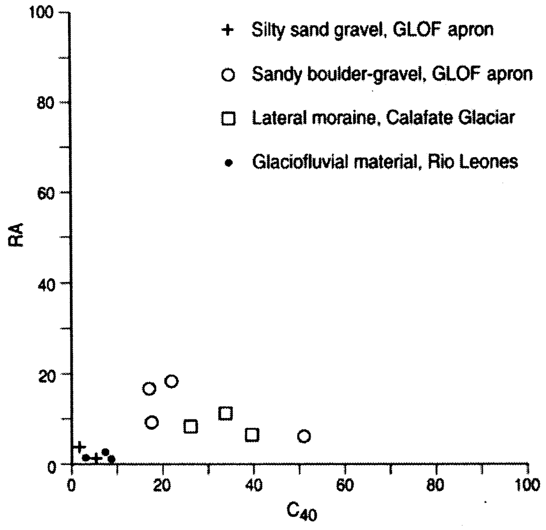

Figure 7 Co-variant plot of the RA index (% of angular and very angular clasts) against the C_{40} index (% of clasts with c/a axial ratio <0.4) for sediments on and around the GLOF apron. Each symbol represents a sample of 50 clasts. Note the similarity in clast form between the sandy boulder-gravel on the GLOF apron and material in the lateral moraine of the Calafate Glacier, from which it is derived

height. Between the bars and berms are small, shallow braided channels. Silty sandy gravel is relatively poorly sorted and contains approximately 60% gravel, 30% sand and 10% silt. Gravel-sized clasts are subangular to subrounded and range from granules to cobbles, with rare boulders.

(3) *Silty sand.* A veneer of silty sand locally covers the GLOF apron, particularly towards its margins. This lithofacies comprises about 70% sand, 25% silt and 5% clay.

Discussion

Here we assess the dating estimates for the moraine, the timing of the GLOF, possible trigger mechanisms, and place the events into their geomorphological context.

Dating

The inferred date 1870s date for ice recession in the lower Calafate valley is consistent with the 'Little Ice Age' maximum date of 1867 for retreat of Glaciar León in Lago Leones (S. Harrison, V. Winchester and N.F. Glasser, unpublished data, 2000) and for other glaciers on the eastern side of the Hielo Patagónico Norte (Harrison and Winchester, 2000; Winchester *et al.*, 2001).

Sequence of events

The geomorphology of the site and sedimentology of the GLOF deposit suggest the following sequence of events.

(1) Glacier Calafate receded from its nineteenth-century maximum position, probably between 1870 and 1890. A proglacial lake formed behind the 'Little Ice Age' terminal moraine at that time. The presence of high rock walls above the moraine and its bouldery nature suggests that rockfall contributed the bulk of material making up the moraine. Because of the very bouldery nature of the moraine, it formed a permeable dam, so the outflow of the lake was not able to incise through the moraine. Rather, water flowed through the moraine and winnowed out fine material, reducing its structural integrity. The moraine was almost certainly not ice-cored; such moraines are largely absent from the termini of Patagonian glaciers.

(2) Bedrock cliffs above the glacier, oversteepened by glacial erosion, became debuttressed following glacier recession. In late 2000, part of this cliff collapsed, generating a rockfall that travelled into the lake, displacing water. The rockfall destroyed and removed much of the central part of the moraine and travelled 200 m downvalley of the moraine.

(3) The moraine dam failed, probably as a result of incision by overflowing water and collision by the rockfall debris. The displaced water entrained sediment forming a viscous debris flow which began to entrain large boulders. The presence of large imbricated boulders deposited in the Calafate valley and the coarsening-upwards sequence in deposits in the Calafate Valley (Figure 6b) suggests that the entire bed of the valley was in traction at the flow peak (cf Clague *et al.*, 1985; Kershaw *et al.*, 2005).

(4) This debris flow formed an apron of coarse boulders and sediment at the mouth of the Calafate valley.

(5) The tail of the debris flow was less viscous but still sediment-charged. It deposited debris on top of and upstream of large boulders. Subsequent fluid flow incised the channel in Calafate valley and eroded apron sediments, producing isolated mounds. At this time, angular material from the bedrock in the centre of the valley was deposited in the centre of the apron.

(6) After cessation of coarse debris flow activity, fine sediments were deposited at the margins of the apron.

Triggering mechanisms

The cause of most rock failures in mountain regions is the gradual deterioration of a marginally stable slope to the point that an event triggers failure and we can only speculate on the nature of the trigger. Rockfalls in glaciated mountainous terrain are generally triggered by three phenomena: (1) increased pore water pressure along joint surfaces and failure of the rock mass during heavy rainfall; (2) weakening of the cliff face by frost shattering or permafrost melt; and (3) earthquakes, possibly associated with unloading following glacier recession. We believe that mechanism (1) is unlikely since heavy rainfall is very common in this region and the large size of the failure means that rainfall alone would probably not be sufficient to trigger collapse. Because there is no evidence of permafrost at moderate altitudes in the region, nor extensive contemporary frost shattering, we believe mechanism (2) to be equally unlikely. It seems that the rockfall was probably triggered by a small earthquake, perhaps associated with glacier recession. Similar, although smaller, rockfalls are common in this tectonically active region.

Broader context

In many mountain regions unstable moraine dams pose a significant and increasing hazard to communities (eg, Richardson and Reynolds, 2000). Collapse of the moraines occurs following displacement of water during rockfalls and following failure of the moraine during melting of ice cores. The subsequent GLOFs may involve debris transfer an order of magnitude greater than in the event described here (eg, Hubbard *et al.*, 2005).

As a result, whilst GLOFs and rockfalls of this size are common in other mountain regions (eg, Hewitt, 1988; Evans and Clague, 1994; Richardson and Reynolds, 2000; Hermanns *et al.*, 2004; Kershaw *et al.*, 2005), they have not previously been described in detail in Patagonia. A similar, although smaller, landslide in the Soler valley, south of Glaciar Calafate caused the catastrophic drainage of a proglacial lake in 1987 or 1989 (Aniya and Naruse, 2001). A large boulder spread occurs south of Lago Reicher and probably records rapid outflow from the lake in the 1970s. However, the precise ages and triggering mechanisms of these events remain unknown. At several times in the historic period proglacial Lago Arco was dammed by Glaciar Colonia. Catastrophic drainage of the lake probably occurred periodically between 1881 and 1963, flooding the Colonia valley (Winchester and Harrison, 2000).

Large rockfalls in this region are one component of a complex paraglacial response to widespread glacier recession since the 'Little Ice Age'. In eight of the eleven valleys draining the Hielo Patagónico Norte that the authors have worked in, the largest mass movements are located within the 'Little Ice Age' glacier limits. The only rockfall events of known age, however, are the Calafate rockfall described in this paper and a rockfall from recently deglaciated cliffs north of Glaciar San Rafael which occurred some time between March 1991 and February 1992 (S. Harrison, unpublished data, 1993).

Delayed responses of bedrock cliffs to glacier recession have been termed neoparaglacial effects by Matthews and Shakesby (2004) and interpreted as part of the landscape response to 'Little Ice Age' glacierization. It appears that nineteenth- and twentieth-century recession of outlet glaciers of the Patagonian icefields has debuttressed inherently unstable bedrock slopes leading to subsequent failure. Rapid glacier recession, accompanied by dramatic ice-surface lowering, may lead to an increased incidence of catastrophic rockwall failures during the twenty-first century.

Conclusions

In late 2000 a large rockfall occurred from the steep cliffs above Glaciar Calafate, a satellite glacier of the Hielo Patagónico Norte in southern Chile. The rockfall entered and partially displaced a moraine-dammed proglacial lake we name Lago Calafate. The moraine had been previously dated using lichenometry and dendrochronology as having been emplaced during glacier recession from 'Little Ice Age' maximum positions sometime during the 1870s. The mixture of moraine debris and water produced a debris flow that travelled down-valley, forming an apron of sediment. The combined volume of debris deposited in the valley downslope of the moraine and in the apron probably exceeds 2×10^6 m^3.

GLOFs of this size have not been previously described from Patagonia and appear to represent one response of valley-side geomorphological systems to twentieth-century glacier recession.

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