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Correspondence

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A large calving event of Ventisquero San Rafael, southern Chile

This note records a large calving event of Ventisquero San Rafael in southern Chile. The glacier drains from the western edge of the north Patagonian ice cap into the tidal Laguna San Rafael (Fig. 1) and has a grounded terminus. Ice velocity near its terminus has been measured at 18 m d^{-1} (personal comunication from V. Winchester), making it the second fastest flowing non-surging glacier in the world.

Calving patterns of Ventisquero San Rafael were monitored continuously for 3 weeks between 5 and 26 February 1991. By far the largest of these events occurred at 1755 h on 23 February 1991 and was observed by the author at an observation point above the northern flank of the glacier, about 800 m from the ice terminus. An ice mass about 210 m wide and 50 m deep calved into the laguna. The ice cliff, in this section, averages a height of approximately 70 m. The dimensions of this ice mass represent one-third of the glacier front visible from the observation point. The calving event started when a series of medium-sized ice blocks from the glacier front toppled into the laguna. Immediately behind these, much larger ice masses, up to 70 m high, 40 m wide and 30 m deep, which had been supported by the smaller blocks in front of them, fell into the laguna. This sequence of multiple calving lasted for 45 s. During this time five submarine ice blocks up to 55 m long became dislodged from an ice shelf immediately in front of the glacier terminus and rose to the surface, further dislodging ice masses from the glacier front (Figs 2 and 3).

In the vicinity of this part of the glacier, a subglacial meltwater stream had been flowing into the laguna for about 48 h (its location had been observed to vary from day to day). The flow from this is powerful enough to carry the largest ice flows rapidly from the glacier front. On this occasion, the power of the subglacial current and the momentum generated by the calving event itself carried ice debris to a point level with the observation point (i.e. 800 m from the glacier front) within 3 min of the end of calving activity (implying a flow of 4.4 m s^{-1}) and to

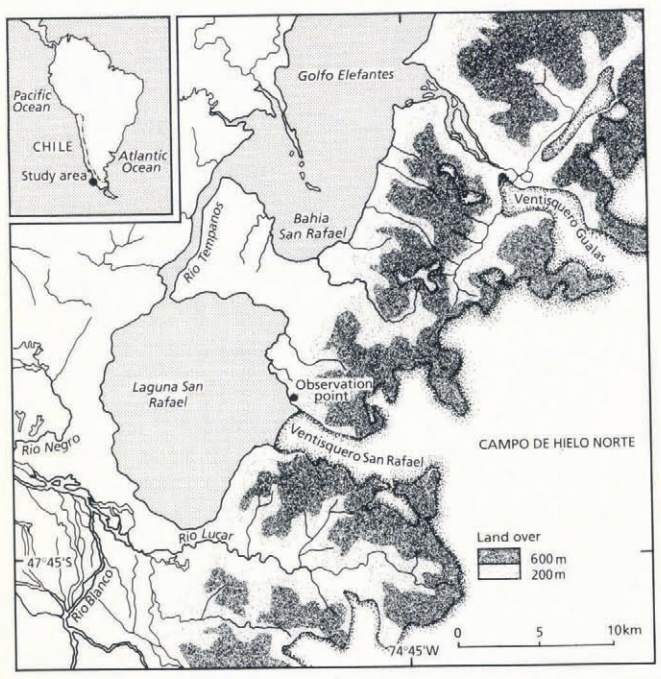

Fig. 1. The San Rafael region, southern Chile.

Fig. 2. 40 s after the beginning of the calving event. Note the emergence of a submarine block in centre of photograph.

Fig. 3. 3 min after the beginning of the calving event.

1 km within 6 min. All ice particles had been cleared from an area 500 m wide and 600 m long in front of the glacier by 1810 h (15 min after the calving started). At this time, a total of 38 ice blocks, associated with the calving event, with long axes greater than 50 m were observed floating in the laguna. Most were elongate in shape, with long to intermediate axis ratios in the order of 2 : 1, and on average protruded 5 m above the surface of the laguna. Assuming that the volume of ice below the surface is 85% of the total mass (although, with dense ice subjected to high pressure in the subglacial zone, this may be an underestimate), this implies that a minimum of 1 560 000 m^3 of ice calved into the laguna. This is a conservative estimate, for it does not take into account the very large number of smaller ice blocks, the volume of which cannot be calculated. Therefore, it is not unreasonable to assume that the total volume of ice discharged into the laguna during this event approached 2 000 000 m^3.

DISCUSSION

Although records of the rate and size of calving events of Ventisquero San Rafael have only recently been kept, scientific expeditions have visited the region and conducted studies of the glacier and the laguna every year since at least 1984. Discussions with members of some of those expeditions make it clear that calving events of the magnitude reported here are very rare. None of these expeditions was operating during the winter months, so records are incomplete and it is conceivable that similar events have occurred previously. However, glacier activity (and hence the rate and magnitude of calving events) is likely to be greatest during the summer ablation season and least during the accumulation phase of winter.

The weather during 22 and 23 February was dry, largely cloudy and settled. Glacier flow is most rapid and shear stresses at the ice/rock interface are low when meltwater pressures in the subglacial zone are high (e.g. Hodge, 1976; Kamb and others, 1985). Thus, during periods of dry, cloudy conditions, subglacial meltwater pressures (and hence rates of glacier flow) would be relatively low. With a large and continuous through-flow of ice mass through the glacial system, fed by the accumulation areas on the north Patagonian ice cap, a slow-moving or inactive terminus might allow sufficient stresses to be built up to cause massive failure of the ice front. Thus, large-scale calving of the glacier would occur following long periods of relative inactivity. In this context, it is interesting to note that calving activity of the glacier in the 9 h previous to the event was noticeably subdued. In the area of the glacier front affected by the 1755 h calving event, only six large ice blocks (defined as those with long axes 40 m or over) were discharged into the laguna.

Although the far, southern, side of the glacier front was not visible from the observation point, the effects of another large calving event were observed at 1240 h on 23 February. Approximately only one-fifth of the size of the 1755 h calving, it was at the time, however, larger than any other single ice discharge observed during the 18 d of continuous monitoring. Therefore, following a period of inactivity, two extremely large events occurred.

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Department of Geography and Planning, STEPHAN HARRISON
Middlesex Polytechnic,
Queensway, Enfield,
Middlesex EN3 4SF, England

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The accuracy of references in the text and in this list is the responsibility of the author, to whom queries should be addressed.