George VI Ice Shelf: Holocene stability and interactions with fluctuating valley glaciers on Alexander Island, Antarctic Peninsula

Bethan J. Davies[1], Michael J. Hambrey[2], Neil F. Glasser[2], Tom Holt[2], Angél Rodes[3], John S. Smellie[4], Simon Blockley[1], Jonathan L. Carrivick[5]

[1]Centre for Quaternary Research, Royal Holloway University of London, Egham, Surrey, TW20 0EX, England. Bethan.davies@rhul.ac.uk;
[2]Institute of Geography and Earth Sciences, Aberystwyth University, Ceredigion, SY23 3DB, Wales;
[3]SUERC, Rankine Avenue, East Kilbride G75 0QF;
[4] Department of Geology, University of Leicester, Leicester LE1 7RH, England;
[5]School of Geography and water@leeds, University of Leeds, Woodhouse Lane, Leeds, West Yorkshire, LS2 9JT, UK.

Abstract

George VI Ice Shelf extends across George VI Sound, separating Alexander Island from the mainland Antarctic Peninsula. It lies on the mean annual -9°C isotherm, meaning that its long-term stability may be threatened. Investigations into its past dynamics and behaviour during previous warm periods are therefore especially pertinent. Ablation Point Massif on Alexander Island is a rare ice-free oasis that preserves a geological record of past ice-shelf dynamics in the form of ice-shelf moraines, which are spread across the hillside at elevations of up to 140 m asl. These moraines bear distinctive exotic clasts derived from the mainland Antarctic Peninsula. Overlapping relationships between valley glacier moraines and ice-shelf moraines preserves a rare opportunity to reconstruct past valley glacier and ice-shelf interactions, to which we applied ^{10}Be cosmogenic nuclide dating. By 9.2 ± 0.4 ka the ice shelf was at 75 m in Erratic Valley, and at 90 m asl at 8.2 ± 0.4 ka at the head of Ablation Valley. These palaeo ice-shelf moraines were formed during a period of high relative sea levels, when Alexander Island was isostatically depressed. This is the first age constraining the timing of ice-shelf formation, and suggests that it occurred immediately following recession of Marguerite Trough Ice Stream. Following isostatic uplift, the surface of the ice shelf declined until around 2.6 ± 0.2 ka, at which point it was no longer able to flow over the rock bar damming Ablation Lake, resulting in the formation of the epishelf lake. Moutonnée Lake likely formed earlier due to its higher rock bar impeding ice-shelf flow into the lake, and was extant from 7.5 ± 0.5 ka. There is no indication of past ice-shelf collapse in our data set, suggesting that the ice-shelf was extant for the entire Holocene. A readvance of the valley glaciers on Alexander Island is recorded in valley glacier moraines directly overlying the older ice-shelf moraines. Cosmogenic nuclide dating indicates that this readvance occurred at 5.4 ± 0.7 ka. By 4.3 ± 0.4 ka the ice shelf had again penetrated into Erratic Valley, with ice-shelf moraine overlying the degraded valley glacier moraines. Undated but sharp-crested, ice-cored valley glacier moraines in turn overly the ice-shelf moraine, presumably related to a Neoglacial readvance. The valley glaciers are currently receding from this most recent advance. This is the first record of a mid-Holocene valley glacier readvance in this sector of the Antarctic Peninsula, which occurred during a period of relative warmth, perhaps caused by a dynamic response to changes in George VI Ice Shelf.

Keywords: Antarctic Peninsula, Ice Shelf, Cosmogenic nuclide dating, Alexander Island