PALAEO-ICE THICKNESS CONSTRAINTS OF GLACIER VIEDMA, SOUTHERN PATAGONIAN ICEFIELD, SANTA CRUZ, ARGENTINA

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The Patagonian Ice Sheet (PIS) was the largest ice body in the southern hemisphere during the last glacial cycle (LGC) outwith Antarctica stretching across 18° of latitude (36-54°S, Casassa *et al*. 2002). Although numerous studies in Patagonia have focused on establishing chronologies of glacier extent and retreat over the LGC through geomorphological mapping and the utilization of terrestrial dating techniques (Rabassa 2008, Kaplan *et al*. 2008), empirical constraints of PIS thickness and therfore ice volume is lacking in the region. Without knowledge of ice volume changes, estimation of PIS contributions to global sea level is highly uncertain. To reduce this uncertainty, empirical field based constraints of changes in ice thickness and the rate of ice thinning are required.

Currently only numerical modeling experiments have estimated PIS thickness, the timing of glacier disintegration, its volumetric configuration and consequent sea level contibutions. However this work has focused on PIS configuration and disintegration since the global last glacial maximum (ca. 26 ka; Hulton *et al*. 2002). The only empirical palaeo-ice thickness data available is from the margins of the Pueyrredon Ice Lob, which drained the PIS eastward at 46°S (Boex *et al*. 2013). Palaeo ice-thicknesses were established 120 km east of the current centre of the Northern Patagonian Icefield (NPI, Fig. 1A). Ice-thicknesses of ca. 1750 meters at 29 ka and ca. 1300 meters at 18 ka were established with rapid vertical ice thinning of ca. 1000 meters over a period of 1000 years after 18 ka (Boex *et al.* 2013).

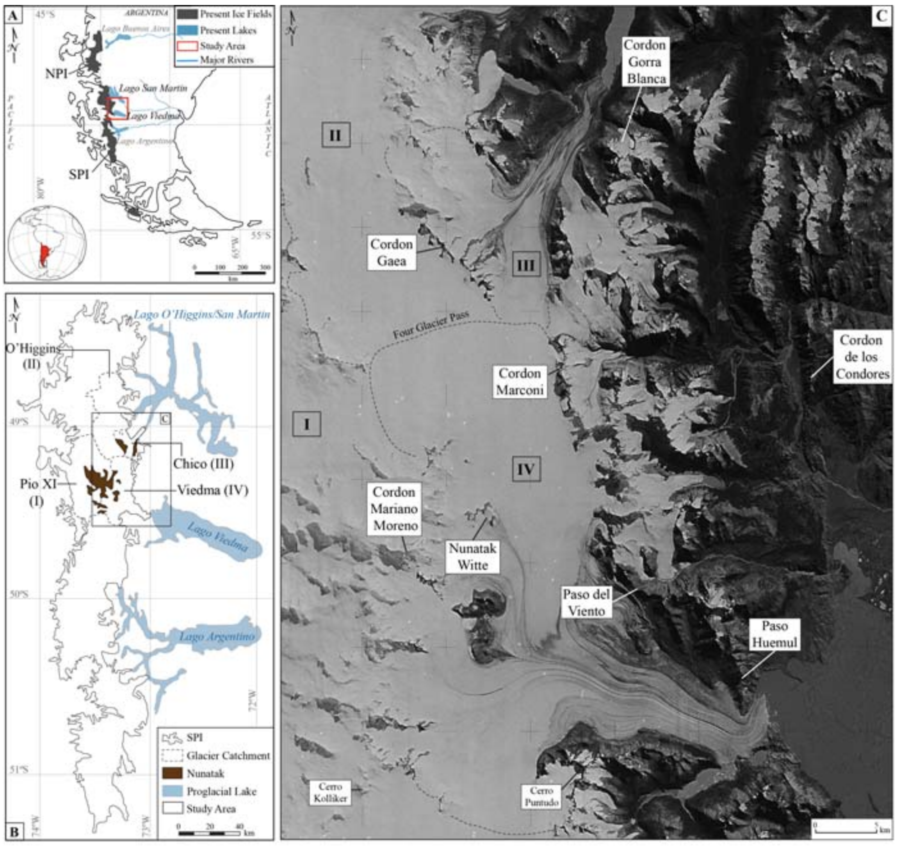

Figure 1. Location maps of study area 49°S, 72-73°W: A) Northern and Southern Patagonian Ice Field (SPI) B) Southern Patagonian Ice Field, Glacier Viedma C) Areal Photograph with sampling sites: Nunatak Witte, Paso del Viento and Paso Huemul.

This study provides the first empirical ice thickness constraints from the former latitudinal centre of the PIS (49°S) over 40 ka. Key in-ice localities (Nunataks protruding the SPI, Fig. 1B/C), and ice-proximal and distal summits (Fig. 1C) are used as dipsticks to ascertain glacier Viedma's palaeo-ice elevation. This is established by sampling erratic boulders and/or bedrock along vertical mountain transects for in-situ produced cosmogenic nuclide analysis. ^{10}Be and ^{26}Al are utilized to obtain the surface exposure ages of the erratic boulders and/or bedrock. This provides the timing of ice abandonment at a given elevation.

Sample Location Name	Number and type of sample	Elevation Range of collected samples (m a.s.l)	Glacier Viedma Elevation (m a.s.l.)
Nunatak Witte	5x B, 1x E-B pair	1330-1740	1250
Paso del Viento	8x E, 1x E-B pair	1000-1650	850
Paso Huemul	1 B, 3x E-B pair	960-1630	450

Table 1. Number and type of samples (E = erratic, B = bedrock) obtained from three localities along the glacier Viedma outlet toungue. The present day elevation of glacier Viedma at each locality is also provided (from Google Earth, 2013).

Sampling took place on Nunatak Witte, at Paso del Viento and Paso Huemul during the 2012 field season (Fig. 1C, Table 1). Samples obtained from Paso del Viento and Paso Huemul suggest maximum ice thickness prior to the global LGM. Based on the exposure ages, glacier Viedma was thickest ca. 40 ka ago. At Paso del Viento the glacier was 700 meters thicker whilst at Paso Huemul it was 850 meters thicker than today. None of the exposure ages obtained at the three sites fall within the range of the LGM. Based on the geomorphology and the exposure ages otbained, the lack of a LGM ice thickness expression is likely due to overprinting by the Antarctic Cold Reversal (ACR: ~14 ka) expansion at this locality. This means glacier Viedma was thinner or just as thick during the LGM as over the ACR.

Surface exposure ages from the summit of Nunatak Witte became exposed shortly after the ACR. This means glacier Viedma was at least 500 meters thicker than today at this locality during the ACR. Samples from Paso del Viento and Paso Huemul also became exposed over the ACR. Glacier Viedma therefore was 570 meters thicker at the former and 630 meters thicker at the latter locality. Lower elevated samples from Nunatak Witte, Paso del Viento and Paso Huemul provide a chronology of mid- to late-Holocene ice down-waisting.

Thicker ice at ca. 40 ka than over the LGM suggests that a decrease in strength and/or northward migration of the southern westerly winds is likely to have occured. This would have deprived the locality of the precipitation needed to substantially increase glacier Viedma's ice thickness over the LGM to the pre-LGM level. In addition the strength of the climate forcing over the ACR must have been equal to or stronger than that over the LGM at this site.

The exposure ages obtained from Nunatak Witte, Paso del Viento and Huemul make it possible to reconstruct the palaeo ice-surface profiles of glacier Viedma over a period of 40 ka. In addition, the rate of vertical ice loss, volume loss and therefore sea level contributions of glacier Viedma can be established through time.

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