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Holocene glaciations in the Ema Glacier valley, Monte Sarmiento Massif, Tierra del Fuego

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Abstract

Investigations carried out in the Ema Glacier valley, Tierra del Fuego, on the eastern side of Monte Sarmiento Massif, enable the recognition of five Holocene glacial events. The oldest glacial advance deposited the so-called external moraines of Ema Glacier, with a probable occurrence between 6000 and 5000 14 C y BP without discarding the potential for these deposits to be from Lateglacial time. The remaining four readvances built up a complex inner moraine system named informally internal moraines of Ema Glacier. The oldest recognized till unit that constitutes this proximal moraine system was deposited shortly before 3135 14 C y BP, when glaciolacustrine sedimentation took place during glacier recession. Subsequent glacial advances accumulated till at about 1288 14 C y, shortly after 695 14 C y, and between 379 14 C y and 60 y BP. This chronology of Holocene glacier events coincides with and is well complemented by the one established by other authors for Fiordo Pía at Cordillera Darwin, 75 km to the east. The Ema-Pía chronology is used to calibrate tentatively a series of moraine belts previously identified in the mountain ranges adjacent to Ushuaia, 150 km SE of the surveyed region. A comparative chart shows that the chronological data obtained for the neoglacial readvances in Tierra del Fuego are in accordance with those for the southern Patagonian Andes further north. It follows that the Holocene behavior of the glaciers in the Andean region of Tierra del Fuego and southern Patagonia is essentially a response to the same regional climate change.

Keywords: Glacier; Stratigraphy; Chronology; Neoglacial; Holocene; Tierra del Fuego

1. Introduction

Monte Sarmiento Massif (2300 m a.s.l.) is located on the southwest tip of Isla Grande de Tierra del Fuego, which is characterized by fjords and high mountains (Fig. 1). During the Last Glaciation, Monte Sarmiento Massif, Cordillera Darwin, and other adjacent high mountain ranges hosted a vast icefield that nourished large ice tongues, occupying the present fjords, channels and principal valleys of the cordillera (McCulloch et al., 2002). A major deglaciation occurred during the Late Pleistocene which resulted in the complete withdrawal of glacier tongues such the Beagle Glacier (Heusser and Rabassa, 1987). No readvances of these main glaciers were detected during this recession, but some fresh moraine systems located in front of hanging tributary valleys north of the Beagle Channel, and close to Ushuaia, are considered to be responses to a glacier readvance that correlates with the European Younger Dryas cold period (Rabassa et al., 1990; Clapperton, 1993; Coronato, 1995; Planas et al., 2002).

A stratigraphic section and radiocarbon dates demonstrate that the part of the Beagle Channel fronting Ushuaia was ice-free at 10,080 ^{14}C y BP (Heusser and Rabassa, 1987). A proglacial lake formed at the frontal area of the wasting Beagle Glacier until flooding by seawater (or glacial lake drainage) between 9400

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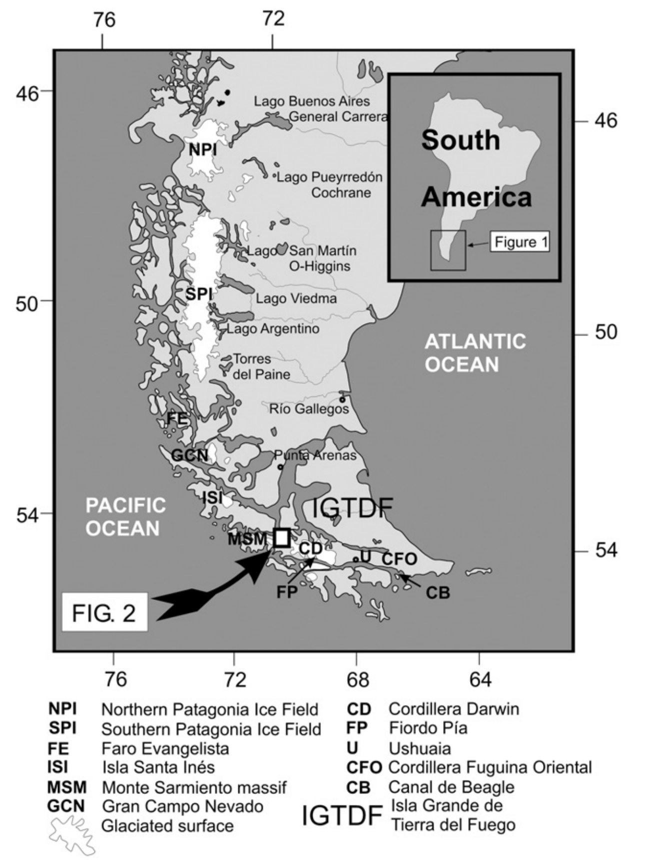

Fig. 1. Location map. The icefields and smaller ice masses are shown in white.

and 8000 ^{14}C y BP (Rabassa et al., 1986). Paleoclimatic data indicate that the glaciers of the cordillera reached or were within their present-day limits soon after 9000 ^{14}C y BP (Heusser, 1998), and consequently the main channels and fjords have been ice-free since this time.

In the coastal area, maximum, marine transgression was reached approximately 6000 ^{14}C y BP (Porter et al., 1984; Rabassa et al., 1986). Since then glacioisostatic uplift prevails, reaching a normal maximum level of 4 m a.s.l. in the eastern Beagle Channel and Magellan Strait. However, anomalous heights of 10–12 m, probably due to the addition of a tectonic component, have been recorded along the coast of the Beagle Channel at the Chilean–Argentinean boundary (Porter et al., 1984; Rabassa et al., 1986).

Fresh moraines can be found close to the present glacier fronts, located deep inside the valleys of eastern mountain ranges (Cordillera Fueguina Oriental, Fig. 1). These moraines have been considered to be of neoglacial age, and the youngest were associated with the European Little Ice Age episode (Rabassa et al., 1990), although absolute dating has not been performed yet.

Many outlet glaciers in the Cordillera Darwin, and in other western high mountain ranges of Tierra del Fuego, still reach the sea, and many flow into deep fjords. Frontal and lateral moraines are common features in the vicinities of these fjords. Kuylenstierna et al. (1996) obtained the first neoglacial chronology for Cordillera Fueguina from sites located in Fiordo Pía, one of the most outstanding of these fiords, which is located on the southern slope of Cordillera Darwin.

Paleoecological and stable isotope records from peat cores, sampled from sites located in the eastern part of the Beagle Channel, have yielded valuable paleoclimatic proxies (Markgraf, 1993; Heusser, 1998; Obelic et al., 1998; Pendall et al., 2001), thus contributing significantly to understanding the glacier response to Holocene climate variability.

This work was performed in order to establish the Holocene glacier stratigraphy and chronology in the Monte Sarmiento Massif (Fig. 1), within the framework of an interdisciplinary study of biotic settlement in deglaciated areas (FONDECYT 1941113, directed by Edmundo Pisano, V.). Given the previous limited researches carried out in the cordillera of Tierra del Fuego, especially around the Monte Sarmiento Massif, the compilation of basic mapping was also needed. A more detailed regional scope is also presented here, for a better understanding of the context of the new stratigraphy and chronology.

2. Physical setting and vegetation

Morphostructurally, the Monte Sarmiento Massif is part of the orogenic core of the cordillera of Tierra del Fuego, formed by highly-deformed Paleozoic and Jurassic igneous and sedimentary metamorphic rocks, Late Jurassic acidic volcanic rocks, Early Cretaceous volcaniclastic turbidites and deep marine mudstones, all of them intruded by Late Cretaceous plutonic rocks (Olivero and Martinioni, 2001). Since the Late Eocene oceanic rifting opened the Drake Passage, separating South America from the Antarctic Peninsula. Thus new ocean and atmospheric circulation patterns were established, with significant cooling of the regional climate, as evidenced by decreased seawater temperatures on the Atlantic coast of Tierra del Fuego (Olivero and Malumián, 1999), coincident with the build up of the East Antarctic ice sheet.

As a consequence of these changes, the climate of Tierra del Fuego became an important factor in the development of new landforms, especially those of glacial and cryogenic origin. At least five main glaciations have shaped the landscape since the late Pliocene (Meglioli et al., 1990). However, the simultaneous tectonic deformation in the region has not allowed the morphoclimatic characteristics to prevail clearly over the structural features. Monte Sarmiento (2300 m a.s.l.) is in fact surrounded by fjords Negri and Contraalmirante Martínez, which coincides with possible faults oriented 345° and 20° respectively, and by Keats channel which follows a strike–slip fault direction of 280° (Fig. 2).

At present, the climate of the region is dominated by the Southern Hemisphere westerly wind circulation; being of maritime nature, cold, humid and windy throughout the year. The annual average temperature at sea level is ca. 5 °C (Núñez, 1994). The annual precipitation decreases from west to east, reaching about 7200 mm along the main divide of the Andes at Gran Campo Nevado (Schneider et al., 2003), and reducing to 500 mm at Ushuaia (Núñez, 1994) (Fig. 1). The Equilibrium Line Altitude (ELA) is located at about 600 m a.s.l. (De Agostini, 1959). Under such climatic conditions, approximately