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# Cosmogenic nuclide measurements in southernmost South America and implications for landscape change

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**Abstract**

We measured in situ $^{10}$Be, $^{26}$Al and $^{36}$Cl on glacial deposits as old as 1.1 Myr in the southernmost part of Patagonia and on northern Tierra del Fuego to understand boulder and moraine and, by inference, landscape changes. Nuclide concentrations indicate that surface boulders have been exposed for far less time than the ages of moraines they sit upon. The moraine ages are themselves constrained by previously obtained $^{40}$Ar/$^{39}$Ar ages on interbedded lava flows or U-series and amino acid measurements on related (non-glacial) marine deposits. We suggest that a combination of boulder erosion and their exhumation from the moraine matrix could cause the erratics to have a large age variance and often short exposure histories, despite the fact that some moraine landforms are demonstrably 1 Myr old. We hypothesize that fast or episodic rates of landscape change occurred during glacial times or near the sea during interglacials. Comparison with boulder erosion rates and exhumation histories derived for the middle latitudes of semi-arid Patagonia imply different geomorphic processes operating in southernmost South America. We infer a faster rate of landscape degradation towards the higher latitudes where conditions have been colder and wetter.


*Keywords:* Cosmogenic; Geomorphology; Quaternary; Glacial geology; South America; Argentina

## 1. Introduction

Surface exposure measurements using in situ cosmogenic nuclides in southern South America allow study of the timing and rates of Earth surface processes well beyond the limits of the radiocarbon method. We investigated the exposure history of boulders on moraines older than the last glacial maximum (LGM, ~25 to 17 ka; Kaplan et al., 2004; McCulloch et al., 2005) in the southernmost part of Patagonia and on northern Tierra del Fuego. Our investigation indicates that in these areas cosmogenic nuclide data from erratics located on glacial drift deposits cannot be used reliably to constrain glacial chronologies of landforms older than ~25 ka. This finding differs from that in central Patagonia (Kaplan et al., 2005), despite the semi-arid climate and preservation of original morphology in the area (Ercolano et al., 2004), but is similar to other studies on 'old'

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moraines (cf., Putkonen and O'Neal, 2006). On the other hand, the data provide quasi-quantitative information on the rates of moraine degradation, boulder exhumation and erosion, and thus geomorphic processes in this region. Such knowledge has potentially a wide range of implications, from understanding South American landscape development to offshore studies of the products of continental erosion.

## 2. Regional setting and prior chronology

Southern South America has the longest, most complete record of Quaternary glaciations in the world outside Antarctica (Mercer, 1983; Clapperton, 1993; Coronato et al., 2004a; Rabassa et al., 2005). Figs. 1 and 2 show the boundaries of former glaciations in Patagonia and Tierra del Fuego, including the maximum extent of

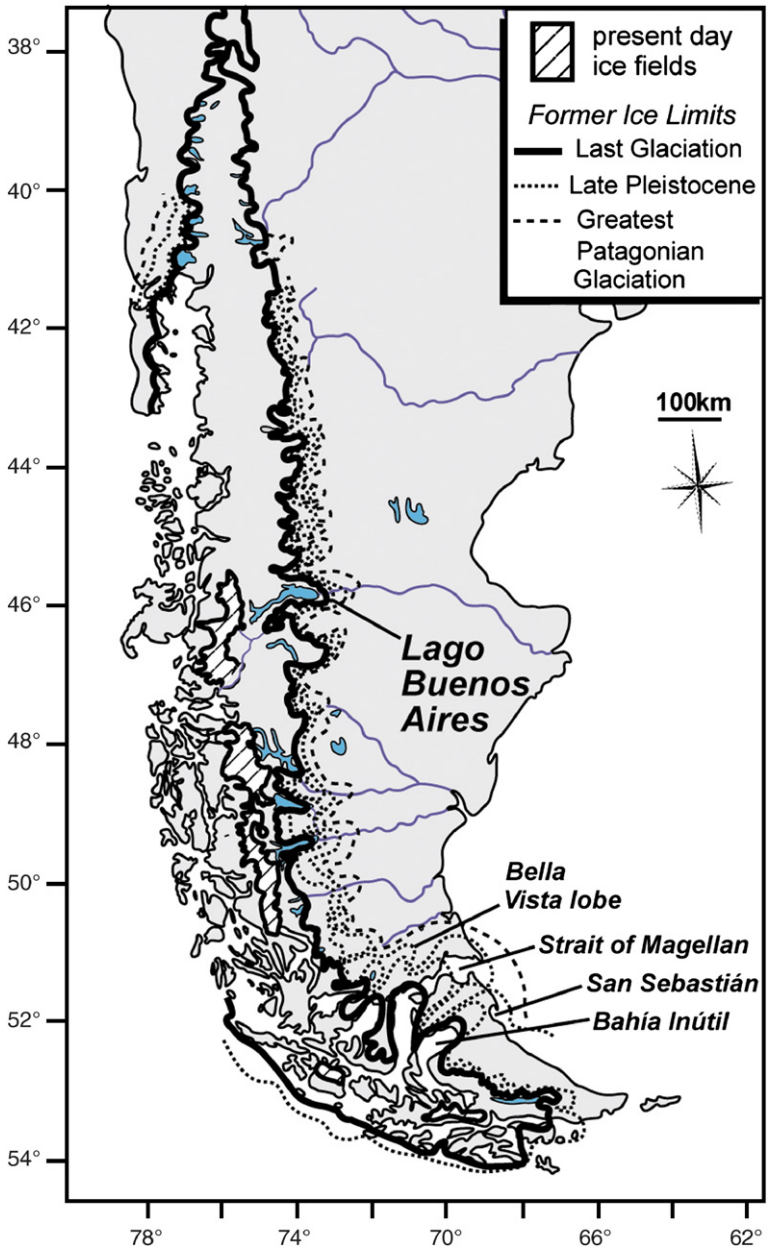


Fig. 1. Simplified from Singer et al. (2004) and based on original work of Caldenius (1932). Map of southern South America showing major areas mentioned in the text and outline of Quaternary glaciations. The locations of the three former ice lobes discussed throughout the text are indicated (Table 1).