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Geochemical signatures from the Atlantic coast of Tierra del Fuego and their provenance implications for Magallanes basin sediments

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ABSTRACT

The Magallanes foreland basin, located along the northern periphery of the Scotia Arc and extending up to 51°S to its northern terminus, contains a near-complete sedimentary record of Fuegian Andes tectonics since the Early Cretaceous. Herein we report trace- and rare-earth-element (REE) geochemistry and Nd isotope ratios from Upper Cretaceous to lower Oligocene mudstones of the eastern Magallanes basin, Argentina. The REE patterns of all of these samples are typical of average post-Archean upper continental crust. The older Upper Cretaceous to middle Eocene samples contain an overall lower concentration of light REE (smaller La_N:Sm_N ratio) than do the younger, middle-upper Eocene and lower Oligocene samples, although a strict temporal change is not observed. These REE patterns suggest a Patagonian Batholith and mafic volcanic provenance for the older successions and an Eastern Andean metamorphic complex provenance for the younger sediments. The lower Th:Sc ratio of the older samples suggests a mafic origin, whereas the higher Th:Sc ratio of younger samples indicates a felsic origin. Nd isotope data show a broadly coeval shift in εNd values from less negative to more negative. These data, combined with previously reported geochronological and mineral composition provenance analysis, suggest an increased Eocene–Oligocene tectonic exhumation of the southern Andes, concurrent with independent evidence of the opening of the adjacent Drake Passage.

1. Introduction

The southernmost Andes is a Meso-Cenozoic subduction-related mountain belt with associated strike-slip deformation, possible orocline development, and limited sedimentary recycling (Nelson, 1982; Wilson, 1991; Pankhurst et al., 2000; Augustsson and Bahlburg, 2008; Barbeau et al., 2009). Initial breakup of Gondwana in Patagonia marks the beginning of its tectonic history during Middle to Late Jurassic time, when an extensional phase of deformation resulted in widespread silicic volcanism and emplacement of associated felsic plutons in southern Patagonia and West Antarctica (Gust et al., 1985; Pankhurst et al., 2000; Calderón et al., 2007). Obduction of the basin floor (Fildani et al., 2003) onto the craton margin during Middle Cretaceous time is widely suggested to mark the transition from the extensional phase into contraction, with the resultant development of a retroarc fold-thrust belt along the east margin of the Cordillera (Klepeis, 1994a; Fildani and Hessler, 2005; Klepeis et al., 2010). Crustal thickening and shortening via folding and faulting have thus contributed to uplift the greater Andean Cordillera (Ramos, 1989; Kley and Monaldi, 1998; Fildani and Hessler, 2005; Fosdick et al., 2011) and subsequent development of a retro-arc foreland basin adjacent to the southern Andes.

The region's possible relationship to the development of the Drake Passage and earliest Oligocene glaciation of Antarctica (Barker and Burrell, 1977; Scher and Martin, 2004; Eagles et al., 2006) makes the understanding of this region's kinematic history particularly important (Livermore et al., 2007). Ice-volume and ocean-temperature proxy data from benthic foraminifera $\delta^{18}O$ isotope ratios and water-mass tracer data from εNd preserved in fossil fish teeth indicate shifts in ocean geochemistry leading up to and including the Eocene–Oligocene transition (ca. 34 Ma; Barker and Thomas, 2004; Scher and Martin, 2004). A decrease in global $\delta^{18}O$ ratios from the middle Paleocene to the early Eocene was followed by a prolonged, gradual increase in these ratios until the end of the Eocene. This increased cooling trend concluded with an abrupt further increase in $\delta^{18}O$ ratios across the Eocene–Oligocene boundary (ca. 34 Ma) that is widely interpreted to record the onset of the Oi-1 Antarctic glaciation (Barker and Thomas, 2004).

Formation of the Drake Passage, the deep-water gateway between South America and the Antarctic Peninsula, initiated the onset of a continental-scale revolving current known as the Antarctic Circumpolar Current (ACC). Initiation of this circumpolar current has been argued to be the cause of the thermal isolation of Antarctica from the remaining equatorial warm water (Barker and Thomas, 2004; Pfuhl and McCave, 2005; Lyle et al., 2007). Whether the development of the ACC made a significant contribution to Oi-1 glaciation (Livermore et al., 2007 and

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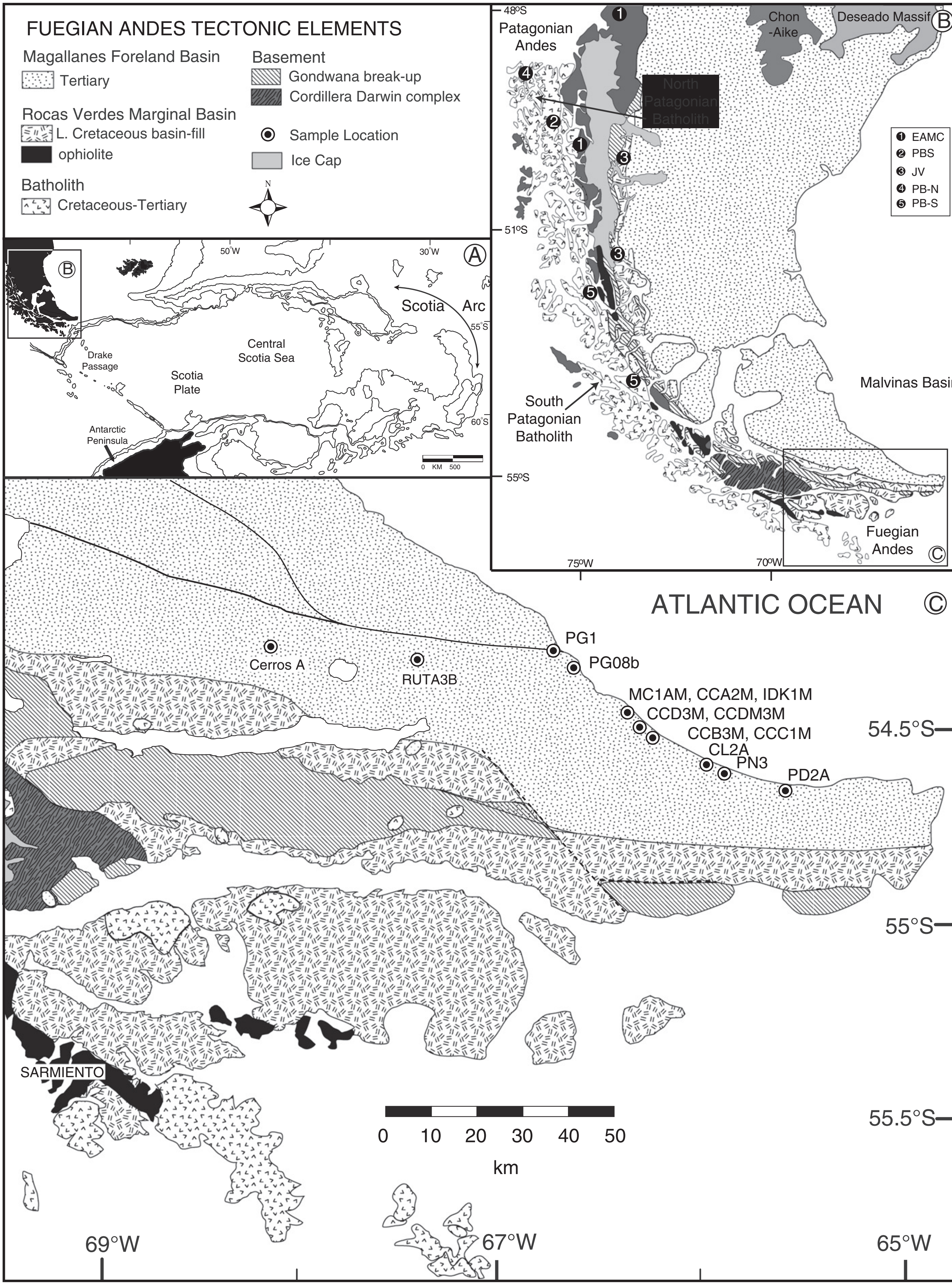
FUEGIAN ANDES TECTONIC ELEMENTS
Magallanes Foreland Basin
Tertiary
Rocas Verdes Marginal Basin
L. Cretaceous basin-fill
ophiolite
Batholith
Cretaceous-Tertiary
Basement
Gondwana break-up
Cordillera Darwin complex
Sample Location
Ice Cap
N
A
B
50°W
30°W
Scotia Arc
55°S
60°S
Drake Passage
Central Scotia Sea
Scotia Plate
Antarctic Peninsula
0 KM 500
48°S
51°S
55°S
Patagonian Andes
Chon -Aike
Deseado Massif
North Patagonian Batholith
1 EAMC
2 PBS
3 JV
4 PB-N
5 PB-S
South Patagonian Batholith
Malvinas Basin
Fuegian Andes
75°W
70°W
C
ATLANTIC OCEAN
PG1
PG08b
Cerros A
RUTA3B
MC1AM, CCA2M, IDK1M
CCD3M, CCDM3M
CCB3M, CCC1M
CL2A
PN3
PD2A
54.5°S
55°S
55.5°S
SARMIENTO
0 10 20 30 40 50
km
69°W
67°W
65°W