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Neogene paleoelevation of intermontane basins in a narrow, compressional mountain range, southern Central Andes of Argentina

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A B S T R A C T

The topographic growth of mountain ranges at convergent margins results from the complex interaction between the motion of lithospheric plates, crustal shortening, rock uplift and exhumation. Constraints on the timing and magnitude of elevation change gleaned from isotopic archives preserved in sedimentary sequences provide insight into how these processes interact over different timescales to create topography and potentially decipher the impact of topography on atmospheric circulation and superposed exhumation. This study uses stable isotope data from pedogenic carbonates collected from seven different stratigraphic sections spanning different tectonic and topographic positions in the range today, to examine the middle to late Miocene history of elevation change in the central Andes thrust belt, which is located immediately to the south of the Altiplano-Puna Plateau, the world's second largest orogenic plateau. Paleoelevations are calculated using previously published local isotope-elevation gradients observed in modern rainfall and carbonate-formation temperatures determined from clumped isotope studies in modern soils. Calculated Neogene basin paleoelevations are between 1 km and 1.9 km for basins that today are located between 1500 and 3400 m elevation. Considering the modern elevation and $\delta^{18}O$ values of precipitation at the sampling sites, three of the intermontane basins experienced surface uplift between the end of deposition during the late Miocene and present. The timing of elevation change cannot be linked to any documented episodes of large-magnitude crustal shortening. Paradoxically, the maximum inferred surface uplift in the core of the range is greatest where the crust is thinnest. The spatial pattern of surface uplift is best explained by eastward migration of a crustal root via ductile deformation in the lower crust and is not related to flat-slab subduction.

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1. Introduction

Constraints on the elevation history of mountain ranges provide topographic boundary conditions that are important for evaluating tectonic (DeCelles et al., 2009; Hilley et al., 2004; Isacks, 1988; Jordan et al., 1983), geodynamic (Meade and Conrad, 2008; Whipple and Meade, 2006; Willett, 1999) and paleoclimate models (Jeffery et al., 2012). Over the past decade, large orogenic plateaus have been the major focus of paleoaltimetry studies (e.g., Garzione et al., 2000, 2008; Mix et al., 2011; Rowley and Currie, 2006) in an attempt to couple deformation histories and geodynamic processes with elevation history (Ehlers and Poulsen, 2009; Hoke and Garzione, 2008; Lamb, 2011; Mulch et al., 2006). However, elongate, longitudinally oriented mountain ranges that are located at right angles or obliquely with respect to the prevailing wind directions and atmospheric moisture transport are especially attractive targets to assess the regional impact of topographic growth on atmospheric circulation patterns and ensuing changes in climate and surface processes. Yet, narrow, non-collisional mountain ranges dominated by fold-and-thrust belts, which should have simpler uplift and sedimentary histories, have received less attention (Blisniuk and Stern, 2005; Chamberlain et al., 1999; Hren et al., 2010). Measuring more than 7000 km in length and at the interception of two major precipitation regimes sourced in the southwest and northeast, respectively, the meridionally oriented

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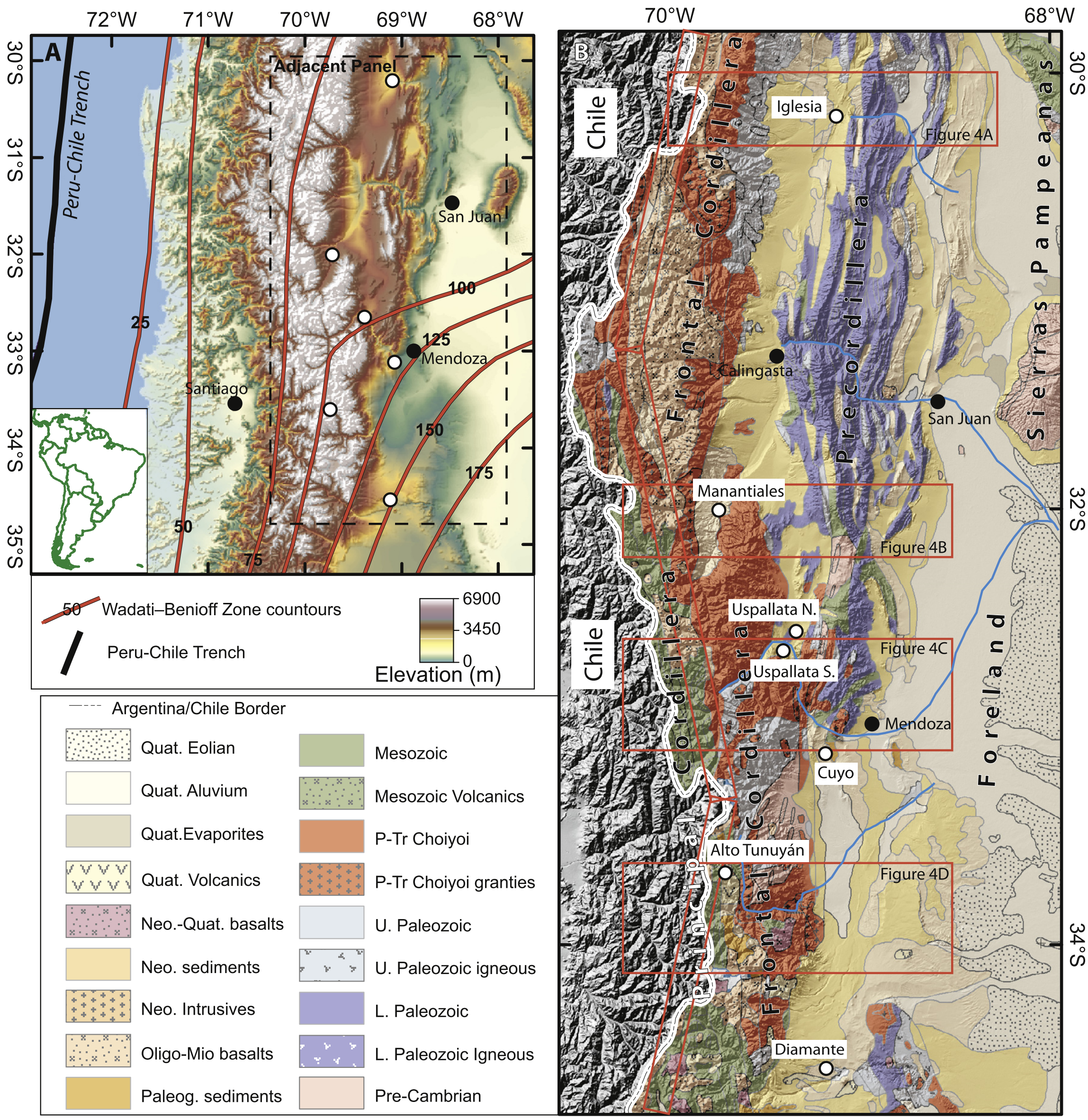

Fig. 1. Overview of the study area and sampling locations. A. Shaded relief topographic map generated from 250 m resolution SRTM data (http://srtm.csi.cgiar.org/). The contours of the subducting Nazca plate are from Cahill and Isacks (1992). Major cities are labeled with black dots for reference and the white dots are the locations of stratigraphic sections sampled in this study. The dashed line box indicates the outline of the area in B. B. Simplified geology of the study region from the 1:3,000,000 geologic map of Argentina showing the major geologic provinces, Cities (black circles) and the names and locations of the stratigraphic sections mentioned in the text (white circles).

Andes are a prime site to examine these relationships (Bookhagen and Strecker, 2008; Garreaud et al., 2009; Montgomery et al., 2001; Strecker et al., 2007).

Ideally, paleoaltimetry studies span sites likely to have remained at similar elevations through time as well as sites thought to have undergone significant elevation change over the same period. The eastern flanks of the southern central Andes in central Argentina between 30°S and 35°S (Fig. 1) contain a combination of largely synchronous late Cenozoic intermontane and foreland basin deposits rich in calcareous paleosols (Figs. 2A and 2B), making it an excellent locality for constraining elevation history in the context of crustal shortening (Fig. 2C). Furthermore, the magnitude of deformation at these latitudes is well-constrained (Allmendinger et al., 1990; Cristallini and Ramos, 2000; Giambiagi et al., 2012) with total shortening decreasing nearly threefold from north to south across the study area (Fig. 2C) and geophysical data indicating a 15 km decrease in crustal thickness over the same interval (Gans et al., 2011; Giambiagi et al., 2012). Despite these dramatic changes in total crustal shortening and differences in geophysical characteristics, there is no significant change in mean elevation (Fig. 2D). This study uses the isotopic composition of pedogenic carbonates preserved in topographically distinct Miocene to Pliocene sedimentary basins to evaluate the spatial and temporal relationships between crustal thickening and topographic growth over a 500 km segment of the Andes with the goal of understanding what drives elevation change in narrow, linear mountain ranges.

2. Geologic and tectonic background

The western margin of the southern South American continent has been convergent since at least the Jurassic, if not earlier (Mpodozis and Ramos, 1989). An abrupt transition in the subduction angle of the Nazca Plate occurs at ∼33°S (Fig. 1), with the area to the north constituting the wider section of flat-slab subduction (Fig. 1; Anderson et al., 2007; Cahill and Isacks, 1992). South of 33°S, dip of the subducting slab returns to ∼30°

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