Tectonics

RESEARCH ARTICLE
10.1029/2023TC008185

Key Points:

- We present a structural study in the southern Puna region focused on the late Cenozoic evolution of the tectonic stress field
- The study emphasizes the link between internal architecture of an orogen, plateau uplift and the stress field during Miocene-Pleistocene
- The southernmost Puna is not undergoing extensional orogenic collapse

Supporting Information:

Supporting Information may be found in the online version of this article.

Correspondence to:

R. Quiroga,
rquirogo@gmail.com

Citation:

Quiroga, R., Giambiagi, L., Echaurren, A., Mescua, J., Pingel, H., Fuentes, G., et al. (2024). Boundary effects of orogenic plateaus in the evolution of the stress field: The southern Puna study case (26°30′–27°30′S). *Tectonics*, *43*, e2023TC008185. https://doi.org/10.1029/2023TC008185

Received 13 NOV 2023
Accepted 12 JUN 2024

Author Contributions:

Conceptualization: R. Quiroga, L. Giambiagi, A. Echaurren, J. Mescua, G. Fuentes, M. Peña, J. Suriano, M. R. Strecker
Formal analysis: R. Quiroga, H. Pingel, M. R. Strecker
Funding acquisition: L. Giambiagi, F. Martínez, M. R. Strecker
Investigation: R. Quiroga, L. Giambiagi, A. Echaurren, J. Mescua, M. Peña, J. Suriano, C. Mpodozis, M. R. Strecker
Methodology: R. Quiroga, L. Giambiagi, J. Mescua, F. Martínez, M. R. Strecker
Project administration: L. Giambiagi, J. Mescua, J. Suriano
Resources: L. Giambiagi, J. Mescua, J. Suriano, F. Martínez, M. R. Strecker
Software: R. Quiroga
Supervision: L. Giambiagi, M. R. Strecker
Validation: R. Quiroga, L. Giambiagi, A. Echaurren, J. Mescua, H. Pingel, M. Peña, F. Martínez, C. Mpodozis, M. R. Strecker

Boundary Effects of Orogenic Plateaus in the Evolution of the Stress Field: The Southern Puna Study Case (26°30′–27°30′S)

R. Quiroga[1,2], L. Giambiagi[1], A. Echaurren[1], J. Mescua[1,3], H. Pingel[2], G. Fuentes[4], M. Peña[5,6], J. Suriano[1], F. Martínez[7], C. Mpodozis[8], and M. R. Strecker[2]

[1]IANIGLA-CONICET, Parque San Martín s/n, Mendoza, Argentina, [2]Institut für Geowissenschaften, Universität Potsdam, Potsdam, Germany, [3]Universidad Nacional de Cuyo, Mendoza, Argentina, [4]Escuela de Geología, Facultad de Ingeniería, Universidad Santo Tomás, Santiago, Chile, [5]Escuela de Geología, Universidad Mayor, Santiago, Chile, [6]Advanced Mining Technology Center, Universidad de Chile, Santiago, Chile, [7]Carrera de Geología, Facultad de Ingeniería, Universidad Andres Bello, Campus República, Santiago, Chile, [8]Departamento de Geología, Universidad de Chile, Santiago, Chile

Abstract We present a study in the southern Puna (26°30′–27°30′S), aiming to explore the late Cenozoic evolution of the deformation and the stress field during its uplift. Through U-Pb geochronology, structural observations, paleostress analysis, and balanced cross-sections, we propose an structural evolutionary model over the past 24 million years, separated in four stages: Stage 1, in the late Oligocene to middle Miocene, the region experienced E-W compression. Stage 2, from middle to late Miocene, a transition from predominant compression to an incipient strike-slip regime is observed. Stage 3, from late Miocene to early Pliocene, showed a further shift in the stress field, resulting in a combination of a predominant strike-slip regime, and less predominant compressional regime. Finally, Stage 4, from late Pliocene to Quaternary, featured a dominance of strike-slip regimes. Our results show that the stress field in each stage is associated with the orogen's internal architecture and its evolution. Vertical stress variations are linked to plateau uplift, creating topographic gradients across the orogen. Horizontal rotations of the principal stress axes are caused mainly by an edge effect resulting from the growth of the plateau while it reaches a critical crustal thickness and elevation. This leads to a transfer of compression from high-lying areas to lower regions. The southernmost Puna region shows no significant evidence of normal faulting, suggesting it is not undergoing orogenic collapse associated with a regional tensional stress regime.

1. Introduction

High-elevation orogenic plateaus, such as the Cenozoic Tibetan, Altiplano-Puna or Turko-Iranian plateaus, are high-elevation areas with low relief, associated with major mountain belts that constitute first-order morphotectonic and topographic features on Earth (Jamieson & Beaumont, 2013; Rey et al., 2001; Vanderhaeghe, 2012).

In turn, plateaus and their topographic signature exert a far-reaching influence on late-stage orogenic processes, including style of faulting, volcanism, forcing of rainfall patterns along their flanks and coupled surface-processes, as well as the dispersal of plant and animal species (Fossen et al., 2017; Hodges, 2000; Jamieson & Beaumont, 2013; Pingel et al., 2020; Royden et al., 2008; Vanderhaeghe et al., 2003). Furthermore, in the face of global climate change and its impact on high-elevation mountains and plateaus, tectonically active orogens have become increasingly important for hazard evaluation and mitigation efforts, particularly within the transition between high- and low-elevation sectors along the plateau flanks (e.g., Allen et al., 2013; Tian et al., 2022).

The origin of these plateaus is a matter of debate. Various processes have been proposed to explain their formation, including lithospheric-scale mass transfer, the buildup and transmission of plate-tectonic stresses, and thermal processes in the mantle during the vertical and lateral growth of mountain ranges (e.g., Garzione et al., 2017; Molnar et al., 1993; Strecker et al., 2007). Furthermore, several factors influence the kinematics, spatial extent, and elevation of orogenic plateaus. These factors include crustal heterogeneities, the thermal state of the upper plate, and the changing influence of gravitational potential energy during crustal shortening (e.g., Artyushkov, 1973; Fleitout & Froidevaux, 1983; Jamieson & Beaumont, 2013; Lithgow-Bertelloni & Guynn, 2004). A number of models have been invoked to explain orogenic plateaus; these include crustal thickening due to tectonic shortening and magmatic addition, negative buoyancy of deep crustal roots, isostatic response to lithospheric delamination processes, or a complex combination thereof (Allmendinger et al., 1997;