Tectonophysics 586 (2013) 65–83

Contents lists available at SciVerse ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Review Article

Teleseismic tomography of the southern Puna plateau in Argentina and adjacent regions

M. Bianchi [a], B. Heit [a,*], A. Jakovlev [b], X. Yuan [a], S.M. Kay [c], E. Sandvol [d], R.N. Alonso [e], B. Coira [f], L. Brown [c], R. Kind [a,g], D. Comte [h]

[a] Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany
[b] Institute of Geology, SB RAS, Novosibirsk, Russia
[c] Cornell University, EAS, Snee Hall, Ithaca, NY 14850, United States
[d] Department of Geological Sciences, University of Missouri, Columbia, MO 65211, United States
[e] Universidad Nacional de Salta, Buenos Aires 177, 4400-Salta, Argentina
[f] CONICET, Instituto de Geología y Minería, Universidad Nacional de Jujuy, Avda. Bolivia 1661, 4600-San Salvador de Jujuy, Argentina
[g] Freie Universität Berlin, Maltesserstr. 74-100, 12227 Berlin, Germany
[h] Departamento de Geofisica, Universidad de Chile, Santiago, Chile

ARTICLE INFO

Article history:
Received 15 May 2012
Received in revised form 7 September 2012
Accepted 19 November 2012
Available online 30 November 2012

Keywords:
Central Andes
Puna plateau
Teleseismic tomography
Arc and back-arc volcanoes
Velocity anomalies
Lithospheric structure

ABSTRACT

We performed a teleseismic P wave tomography study using seismic events at both teleseismic and regional distances, recorded by a temporary seismic array in the Argentine Puna Plateau and adjacent regions. The tomographic images show the presence of a number of positive and negative anomalies in a depth range of 20–300 km beneath the array. The most prominent of these anomalies corresponds to a low-velocity body, located in the crust, most clearly seen in the center of the array (27°S, 67°W) between the Cerro Peinado volcano, the Cerro Blanco caldera and the Farallon Negro in the east. This anomaly (southern Puna Magmatic Body) extends from the northern most part of the array and follows the line with the highest density of stations towards the south where it becomes smaller. It is flanked by high velocities on the west and the east respectively. On the west, the high velocities might be related to the subducted Nazca plate. On the northeast the high velocity block coincides with the position of the Hombre Muerto basin in the crust and could be indicating an area of lithospheric delamination where we detected a high velocity block at 100 km depth on the eastern border of the Puna plateau, north of Galan. This block might be related to a delamination event in an area with a thick crust of Paleozoic metamorphic rocks at the border between Puna and Eastern Cordillera. In the center of the array the Southern Puna magmatic body is also flanked by high velocities but the most prominent region is located on the east and is interpreted as part of the Sierras Pampeanas lithosphere with high velocities. The position of the Sierras Pampeanas geological province is key in this area as it appears to limit the extension of the plateau towards the south.

Contents

* Corresponding author. Tel.: +49 3312881860; fax: +49 3312881277.
E-mail address: heit@gfz-potsdam.de (B. Heit).

0040-1951/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.tecto.2012.11.016

1. Introduction

The Andean mountains are directly related to the process of subduction of the oceanic Nazca plate beneath the South American continental plate. The main topographic feature in the Central Andes is known as the Altiplano-Puna plateau, which is flanked by regions of sub-horizontally subducting segments to the north and south. The approximate dividing line between the distinctive Puna and Altiplano parts of the plateau is approximately at the latitude of 22°S, near the Bolivian–Argentine border (Fig. 1A). Significant variations along the plateau include local differences in the pre Andean geologic history; Andean uplift, amount of shortening and magmatism, and modern topography and Wadati–Benioff geometry. (e.g., Allmendinger et al., 1997; Cahill and Isacks, 1992; Kay and Coira, 2009; Oncken et al., 2006 and references therein).

In general, the Puna plateau is bounded to the west by the Andean Neogene Central Volcanic Zone (Western Cordillera, WC or Central Volcanic Zone, CVZ) and to the east by an active westward verging thin-skinned foreland thrust belt (deformed Paleozoic rocks of the Eastern Cordillera). Allmendinger et al. (1997) summarize the evidence that the Puna does not present a well-developed thin-skinned thrust belt to the east and has more irregular topography than the Altiplano.

The more irregular topographic surface of the Puna plateau is due to the effects of crustal segmentation that created small closed basins that are responsible for localized shortening and surface uplift at both margins of the plateau (e.g., Riller and Oncken, 2003). Such segmentation is induced, in part, by a number of lineaments or strike-slip faults limiting continuous deformation across the plateau. Some of these lineaments are seismically active (e.g. Schurr et al., 1999), with small earthquake concentrated along the eastern border of the plateau and the Olacapato-Toro Lineament (known as the Olacapato-El Toro Fault Zone). The Olacapato-Toro Lineament (OT-L) is a prominent shear zone located to the north of our study region which extends northwest from the city of Salta across the Puna plateau and may reach the coast of Chile. A recent magnitude Mw 6.1 earthquake on the 27th February 2010 indicates that this fault system is still tectonically active. These lineaments are considered to play a key role in the differences between the northern and southern Puna plateau (e.g. Alonso et al., 1984; Ramos, 1999) (Fig. 1A).

The northern Puna plateau, between ~22°S and 24.5°S, is structurally separated from the southern Puna, ~25°S–28°S, by the NW–SE-trending lineament (i.e. O–T–L) (Fig. 1A). A system of parallel strike-slip faults to the north and south, which are considered to be zones of lithospheric weakness (i.e. Archibarca, Culampaja and Ojos del Salado lineaments) coincide with a series of strato-volcanic edifices that comprise the largest volcanoes of the Puna plateau and some of the highest active volcanoes on earth (e.g. Ojos del Salado). The most significant north–south structural changes in the back-arc, along the eastern border of the plateau are the termination of the thin-skinned Subandean belt near 23°S. This change correlates with the end of Paleozoic basins and the superposition of the Upper Cretaceous rift basins in the foreland south of 24°S where the thick-skinned Santa Barbara System replaces the thin-skinned Subandean belt and south of 26°S where northern Sierras Pampeanas replace the Eastern Cordillera (Fig. 1B) (e.g., Allmendinger et al., 1997; Kay and Coira, 2009; Kley and Monaldi, 1998).

Topographically, the Puna plateau in Argentina has an average altitude of ~4.2 km above sea level and is about 1 km higher than the Altiplano plateau of Bolivia (~3.2 km). The crustal thickness of the northern Puna plateau is ~60 km (i.e. 10 km thinner than the

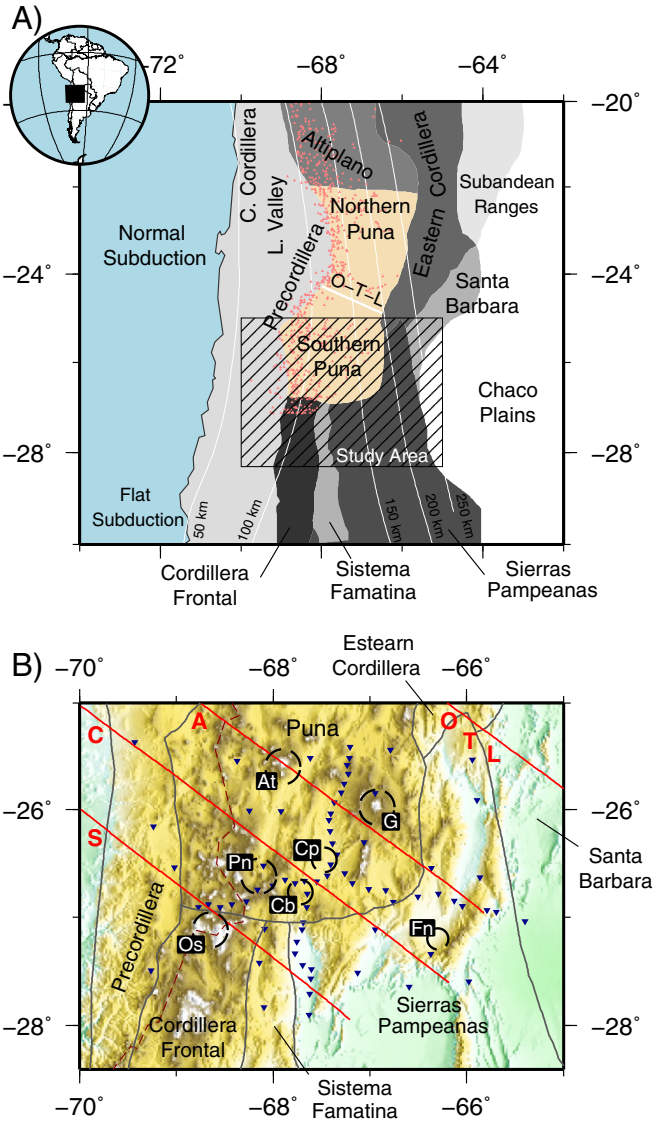

Fig. 1. A) Map showing the main tectonic units in the region of the central Andes between 20° and 28°S. Red triangles denote volcanoes. White curves denote contours of the subducted slab (Cahill and Isacks, 1992). B) Map showing the distribution of stations (blue inverted triangles) and the different tectonic units (gray lines) in the southern Puna. The red dashed line is the Chile/Argentina border. The red solid lines are tectonic lineaments (A: Archibarca, C: Culampaja; S: Ojos del Salado, OTL:Olacapato-Toro-Lineament). The major volcanic centers inside the array are marked with black circles; At: Antofalla; G: Cerro Galan Caldera; Cp: Carachi Pampa; Pn: Peinado; Cb: Cerro Blanco Caldera; Os: Ojos del Salado; and Fn: Farallon Negro.