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More constraints to determine the seismic structure beneath the Central Andes at 21°S using teleseismic tomography analysis

B. Heit [a,*], I. Koulakov [d], G. Asch [a], X. Yuan [a], R. Kind [a], I. Alcocer-Rodriguez [b], S. Tawackoli [b], H. Wilke [c]

[a] *GeoForschungsZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany*
[b] *Servicio Geológico Minero de Bolivia, Zuazo 1673, 2729 La Paz, Bolivia*
[c] *Universidad Católica del Norte, Departamento de Geologia, Antofagasta, Chile*
[d] *Institute of Geology, SB RAS, Novosibirsk, Russia*

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Abstract

A set of seismological stations was deployed in the Central Andes region along a ~600 km long profile at 21°S between Chile and Bolivia and operated for a period of almost two years, from March 2002 to January 2004. Here we present the results of the tomographic inversion for *P*-wave velocity anomalies, based on teleseismic data recorded at the stations. The reliability of the results has been checked by a series of synthetic tests. The tomographic images show high-velocities on the west of the profile that are indicative of cold material from the fore-arc. A low-velocity anomaly is detected at the border between the fore- and the volcanic arc where the Quebrada Blanca seismic anomaly was previously described. This anomaly might be related to the presence of fluids that originate at the cluster of earthquakes at a depth of ~100 km in the subducted plate. A strong low-velocity anomaly is detected beneath the entire Altiplano plateau and part of the Eastern Cordillera, in agreement with previous receiver function results. The Brazilian Shield is thought to be responsible for the strong high-velocity anomaly underneath the Interandean and Subandean regions.

Keywords: Central Andes; Altiplano; *P*-Waves; Teleseismic tomography; Velocity anomalies; Lithospheric structure

1. Introduction

1.1. The Central Andes at 21°S and the Altiplano plateau

The "Cordillera de los Andes" is a long mountain belt that extends for more than 6000 km along the entire western margin of the South American continent. The central part of this orogen between ~3 and ~47°S is called the Central Andes (e.g. Gansser, 1973; Ramos, 1999) and represents one of the world's best examples of an area that has been formed under the effects of uplift and magmatism arising from the subduction of an oceanic plate (Nazca plate) under a continental plate (South American plate) (e.g. Barazangi and Isacks, 1976; Coira et al., 1982; Reutter et al., 1988; Isacks, 1988; Baby et al., 1992; Gubbels et al., 1993; Wigger et al., 1994; Allmendinger et al., 1997). The orogen reaches its greatest width between ~14 and ~24°S where subduction of the Nazca plate occurs at angles near 20–30° at a rate of 65 mm/yr (Cahill and Isacks, 1992; Angermann et al., 1999). The Central Andes are flanked by flat slab areas to the north (between ~5 and ~14°S) and to the south (~28 to ~32°S) where subduction is horizontal to sub-horizontal (e.g. Isacks, 1988; Ramos, 1999). The Altiplano–Puna plateau is the main tectonic feature of the Central Andean region and stretches for about ~1700 km from north to south, with an average elevation of ~4 km. The ~400 km wide Altiplano plateau (Fig. 1a)

* Corresponding author. Tel.: +49 3312881860; fax: +49 3312881277.
E-mail addresses: heit@gfz-potsdam.de (B. Heit), ivan@gfz-potsdam.de (I. Koulakov), asch@gfz-potsdam.de (G. Asch), yuan@gfz-potsdam.de (X. Yuan), kind@gfz-potsdam.de (R. Kind), ivaralcocer@hotmail.com (I. Alcocer-Rodriguez), sohrab@acelerate.com (S. Tawackoli), hwilke@ucn.cl (H. Wilke).

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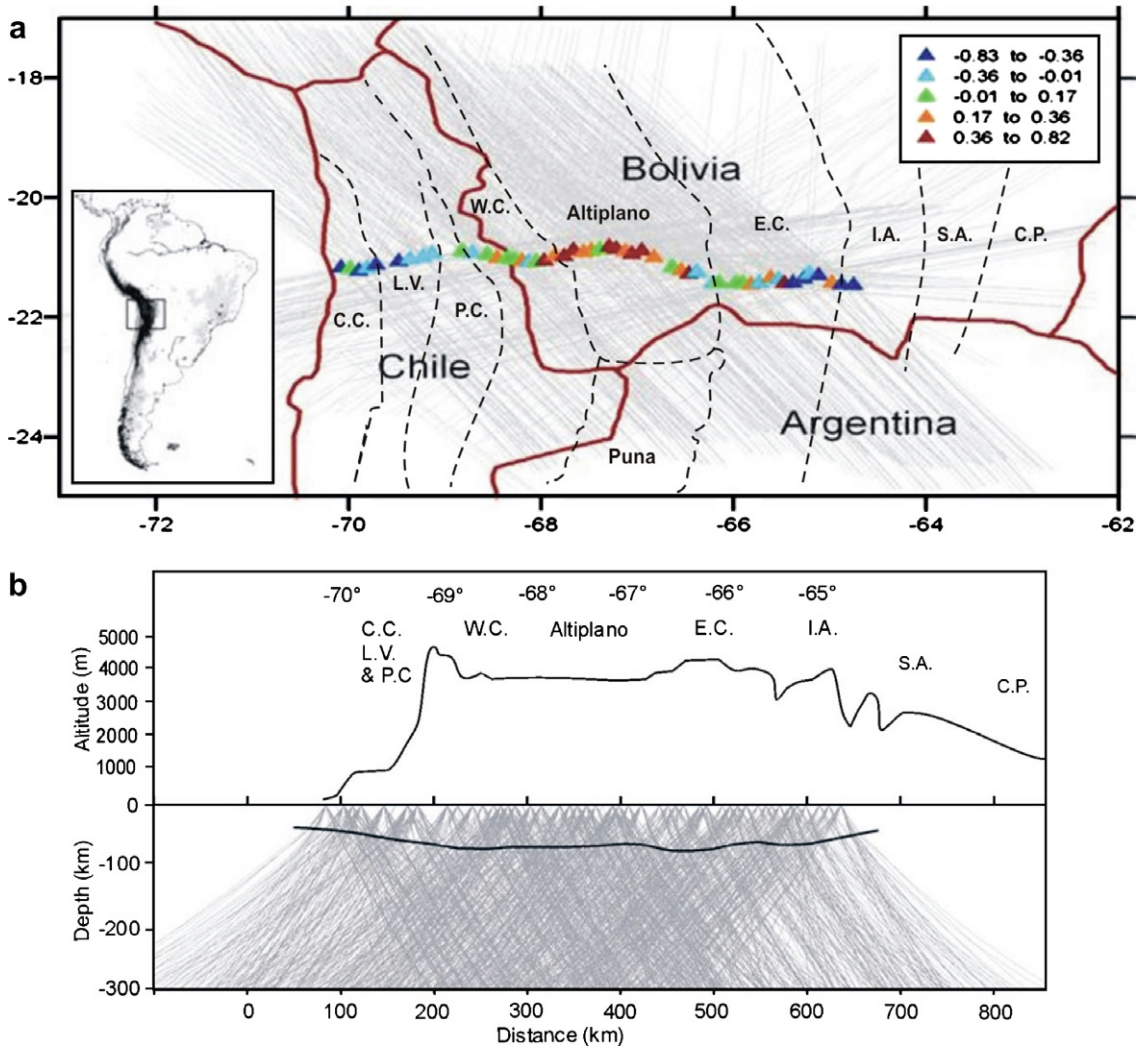

Fig. 1. Configuration of the observation system. (a) Map view of the station distribution along 21°S. Stations are indicated with different color triangles according to the values of average residuals after corrections for topography and Moho discontinuity. Positive residuals (red triangles) correspond to areas of slow seismic velocities. Negative values are high-velocities (blue triangles). Ray paths down to the depth of 300 km are shown by grey lines. Morphological units (dashed lines) along the profile are C.C., Coastal Cordillera; L.V., Longitudinal Valley; P.C., Precordillera; W.C., Western Cordillera; Altiplano; E.C., Eastern Cordillera; I.A., Interandean; S.A., Subandean; C.P., Chaco Plain. (b) Projection of the ray paths onto the vertical profile with an exaggerated topography scale from station coordinates. The bold black line in the vertical section shows the Moho depth (Yuan et al., 2000, 2002) used in this study to correct the residuals.

is limited to the west by an active volcanic arc (Western Cordillera) and to the east by an active westward verging thick-skinned foreland thrust belt (Eastern Cordillera) (e.g. Allmendinger and Gubbels, 1996; Whitman et al., 1996; Scheuber and Giese, 1999). Further east, the topography descends by steps at the Interandean Zone, the currently active Subandean Fold–Thrust Belt and the Chaco Plain that overlaps progressively with the Precambrian Brazilian Shield (also called Guaporé Shield).

The variable thickness of the crust, the associated shortening, as well as different subduction angles of the subducting plate under the same tectonic conditions have created an elevated plateau with geological, morphological and magmatic characteristics that enable a differentiation between northern Altiplano (Bolivia and Peru) and Puna in the south (north-western Argentina) (e.g. Allmendinger et al., 1997). The crustal thickness has been investigated by several authors (e.g. Schmitz et al., 1993; Wigger et al., 1994; Zandt et al., 1996; Beck et al., 1996) and reaches ~70–75 km under the Altiplano. Crustal shortening occurring mainly in the Eastern Cordillera (EC) and Subandean region is likely to be responsible for the thickened crust (e.g. Pilger, 1981, 1983; Isacks, 1988; Reutter et al., 1988; Allmendinger et al., 1997; Sempere et al., 1997; Kley and Monaldi, 1998). Towards the south of the Altiplano a detailed map of crustal thicknesses for the Central Andes based on receiver functions (Yuan et al., 2002) shows that the crustal thickness underneath the southern part of the Puna plateau is on average 10–15 km shallower than that of the Altiplano. Other projects carried out in the region also provided important results concerning lithospheric structure, crustal-thickness variations and lateral