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Research paper

Payenia Quaternary flood basalts (southern Mendoza, Argentina): Geophysical constraints on their volume

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ABSTRACT

The Quaternary volcanic province of Payenia is located in southern Mendoza and northern Neuquén provinces of Argentina and is characterized by a dominant basaltic composition. The volcanic province covers an area larger than 40,000 km^2 and its origin and evolution has been the center of several studies. In this study we analyzed gravity data together with more accurate volcanic volumes calculations in order to investigate the subsurface structure of the Payenia volcanic province. The volume of material was calculated using digital elevation models and geographic information system (GIS) techniques to estimate the volume of material erupted and then, with those values, make an estimation of the intrusive material that could be located within the crust. The results of the calculations were compared with different 2D-sections constructed to model the gravity data and compare with the observed satellite gravity. After evaluating different models which have been generated to match both: the observed gravity data and the subsurface material calculated, we discuss those that best fit with observation. The results clearly indicate that the lithosphere is attenuated below the region.

1. Introduction

In this study we used two independent techniques to study the subsurface structure of the Payenia volcanic province. We used geographic information system (GIS) techniques for volume calculations and gravimetric modeling to obtain a quantification of the volume of igneous material by each independent method and then we combined those results. The Southern Volcanic Zone of the Andes has a Quaternary basaltic province along the retroarc which has a unique tectonic setting. The presence of Payenia, a large Quaternary volcanic province of basaltic composition in the foreland region, behind the active volcanic arc is unique in the entire Andean chain from Colombia to Tierra del Fuego (Fig. 1). This volcanic province erupted through more than 800 volcanic centers in the last ~2 Ma, is developed between 33°30′S and 38°S over more than 40,000 km^2 parallel to the active volcanic arc of the Southern Volcanic Zone (Stern et al., 2004).

The entire volcanic region of mostly basaltic magmas was grouped by Ramos and Folguera (2011) into three genetically related segments: (1) the northern sector (33°30′ to 35°S), which is characterized by monogenetic volcanoes and cinder cones with ages of less than 1.2 Ma; (2) the central section (~35° to 36°30′S), which is dominated by large volcanic centers, and the Cerro Nevado, Llancanelo and Payún Matrú volcanic fields, and represents the largest erupted volume of the area; and (3) the southern sector (~36°30′ to 38°S), which is dominated by the Auca Mahuida and Tromen volcanoes together with several minor centers like Cerro Morado, La Carne, Carrizo, and Cerro Los Loros (Ramos and Folguera, 2011).

The three segments share similar volcanic histories which postdate a common continuous basaltic plateau (erupted after

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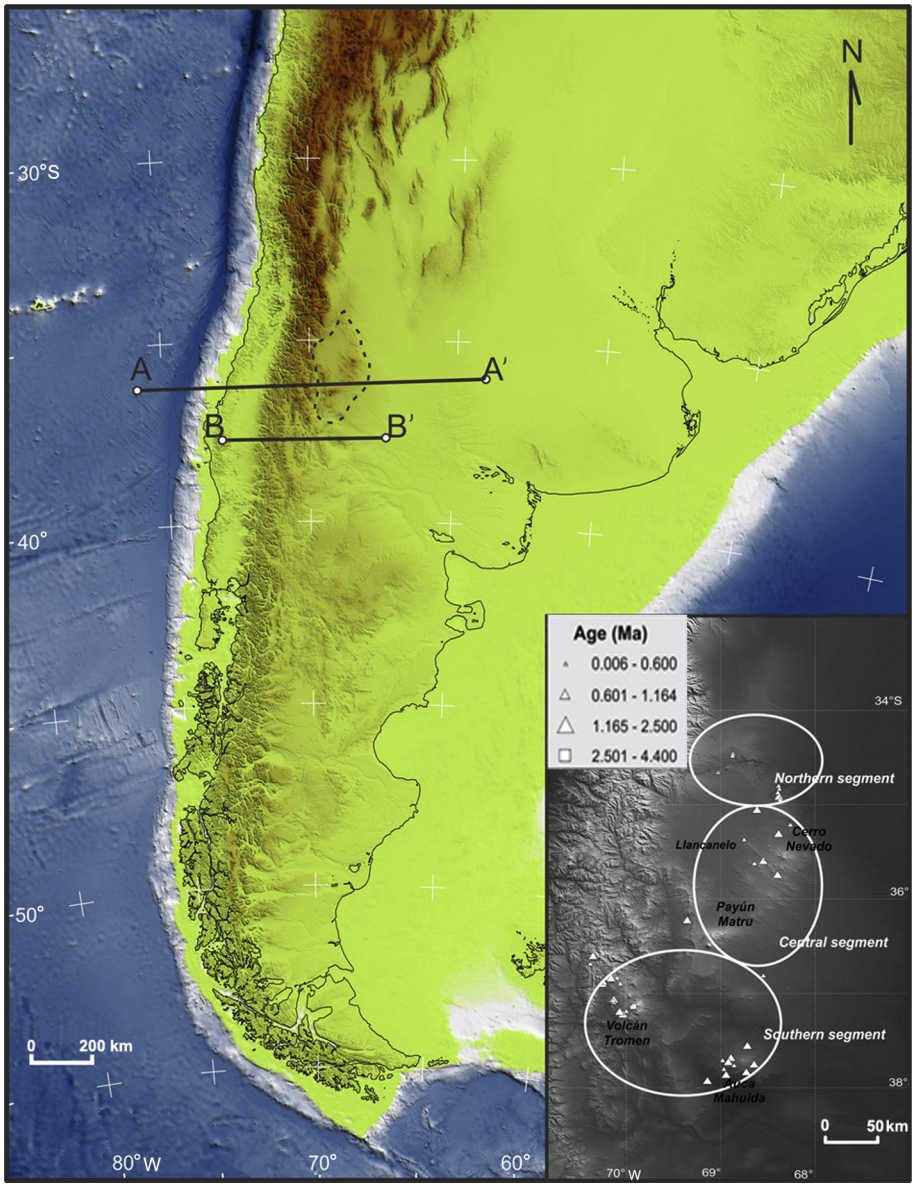

Figure 1. (A–A′) Location of the gravimetric profile modeled in this work. (B–B′) magnetotelluric and seismic tomography profiles from Gilbert et al. (2006) and Burd et al. (2008); dashed line represents the array from Burd et al. (2014). Inset shows three volcanic segments of the studied area and ages of the main volcanic centers (Ramos and Folguera, 2011).

2 Ma) characterized by intraplate geochemical signatures (Ramos and Kay, 2006). This initial event, which would have developed from south to north, is the basement over which the later volcanic fields and monogenetic centers were established from 1.5 to 0.005 Ma (Ramos and Folguera, 2011).

The focus of this study is to arrive at a plausible density model of the subsurface structure of the Payenia volcanic province, based mainly on gravimetric studies supported by estimations of the extrusive and intrusive material volume. The scope is to reconcile the large volumes of volcanic rocks with possible subsurface material emplaced in the crust and the geodynamic evolution of the area.

We start the study by analyzing the gravity data in Section 2 and follow with the volume calculations techniques to constrain the subsurface structure of the Payenia volcanic province. In order to obtain a 2D density model of the central sector of the Payenia, we determined a rough geometry from magnetotelluric information using the subsurface data from Burd et al. (2008, 2014) because it is an independent method and gives ancillary information for the properties and densities of the materials. Then we refined the profile to match the modeled gravity with the observed gravity values obtained freely from the ICGEM (http://icgem.gfz-potsdam.de/ICGEM/). The observed values were derived from the EGM-2008 model (Pavlis et al., 2008, 2012) which uses complete spherical harmonics up to a degree and order of 2150 and contains additional coefficients to reach the degree of 2190 and order 2159. Finally we quantified volcanic volume erupted based on the topography and then we estimated the volume of associated intrusive material with those extrusive rocks. These results of these calculations helped to constrain the amount of material and density contrasts in the 2D-sections used in the gravity modeling. The obtained section was then discussed within the geodynamic context for the area since Cretaceous times, in which the Payenia volcanic province developed.