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A preliminary crustal geophysic model at 29°18'S based on the observed Bouguer anomaly

M. Patricia Martínez & Mario E. Gimenez

CONICET- IGSV (Instituto Geofísico Sismológico Ing. F. S. Volponi) FCEFyN, UNSJ, Meglioli 1160 Sur, Rivadavia, CP 5400, San Juan. E-mail: mpm@unsj-cuim.edu.ar

Introduction

The present study, which complements previous ones (Martinez and Gimenez, 2003) presents a profile perfectly centered at latitude 20°18'S (Section A-A, figure 1). This profile is extended towards both East and West with respect to a previous one (Section B-B, figure 1), so that it includes the subhorizontal subduction system that bounds to the W the South American continent. For this reason, its western end is in the Pacific Ocean, then crosses the Republic of Chile and reaches the Argentine province of Catamarca in the East. In this transect, therefore, four geomorphostructural provinces are crossed, which, from East to West are: the Pampean Ranges, the Famatina System Ranges, the Precordillera and the Frontal Cordillera, in Argentine territory.

Earlier geophysic studies include: 1- The Bpuguer anomaly map in the Velasco Range (Martinez et al., 1999); 2- The map of simple Bouguer anomalies for the province of La Rioja (Martinez et al., 2000.a); 3- The analysis of the isostatic behaviour (in the hydrostatic sense) of the Velasco Range (Martinez et al., 2000.b). Ruiz and Introcaso (2000) carried out a gravimetric interpretation at the latitude of the Ischigualasto-Villa Unión basin, which is situated to the SW of the Famatina Range, and detected a crustal attenuation shown by the gravimetric inversion and hydrostatic methods.

Since no information of earlier geophysic contributions on the region is known to exist, the present studies are the first ones done here. On the other hand, several geologic research works have been published, among them those by Turner (1962), Caminos (1979), Rapela et al. (1992), Toselli et al. (1996), López et al. (1996), Avila et al (1999), Manheim (1993) among others, which have been considered for the present investigation. Gravimetric results that indicates sutures shown by a high horizontal gradient have been known after the work of Gibb and Thomas (1976), Marangoni et al. (1995), Ramé et al. (1995) and Martinez (1997).

Gravimetric profile at 29°18' S latitude – A crustal model

The map of Bouguer anomalies (Martinez et al., 2000.a) was enriched with more than 50 measures points situated near the studied profile. In figure 2 is observed a window in the Bouguer anomalies map, which includes the zone between 28° and 30° S latitudes. The profile at 29°18' S latitude, which was taken from this map, extends from east to west along a distance surpassing 800 km, with the purpose of determining the configuration of the interior of the crust. In the first place, the map of Bouguer anomalies was corrected for the positive gravimetric effect of the Nazca plate. Once corrected, the gravimetric signal for this effect (AB) shoes significant perturbations directly related to the intersected structures (figure 3). The first 90 km in the west of the profile were not considered because correspond to the AB portion in the Pacific Ocean and here we should change the coefficient for the calculation of the Bouguer anomalies.

For the construction of this crustal model (figure 3) we used two criterions (Martinez and Gimenez, 2003). In the first place, the information furnished by the use of methods of maximum depth: a) beneath the Famatina Range, were the depth of the anomalous mass is in the lower crust; b) under the Velasco Range were the depth of the negative anomaly is in the upper crust. In the second place, we incorporated the current knowledge of the research in plate tectonics.

The model obtained is a model of densities, based on a crust with two layers with explains the coupling of different terranes as a lateral variation of densities. In this way the model considers, first the subhorizontal subduction of the Nazca plate and the collision with the Chilenia terrane and, second, the different collision of the Chilenia, Cuyania, Famatina and Pampia terranes, and the River Plate craton.

The initial densities in the reference model are 2.79 g/cm^3 for the upper crust, 2.9 g/cm^3 for the lower crust and 3.3 g/cm^3 for the upper mantle. This values are based on worldwide average densities (Talwani et al., 1959) and were used in our research group in several occasions (Introcaso and Lion, 1988; Martinez,1997; Introcaso et al., 2000, among others).

Inspired mainly by the geologic model given by Ramos, et al. (2002), the geophysic-geologic model in figure 3 contains:

- The Nazca plate in subhorizontal subduction, based on the ideas of Grow and Bowin (1975) and Introcaso and Pacino (1988). In this way, the Nazca plate is subdivided in three portions: the first and the third ones, with a slope of 30°, both with a density contrast of + 0.05 g/cm^3, whilst the portion central of the plate, which is subhorizontal, has a density contrast of +0.02 g/cm^3.
- The Chilenia terrane, whose densities are those of the reference model. The root excess was modeled with a differential density of -0.4 g/cm^3, which resulted in a maximum depth of 69 km beneath the central part of the Andean Cordillera.
- The Cuyania (or Precordillera) terrane, which was modeled with an average differential lateral density of +0.07 g/cm^3. this positive variation in density is related to the positive gravimetric anomaly determined at 30° South latitude by Gimenez et al. (1997). The density assigned to this terrane is based on geologic evidences which allows to infer that is constitutes an allochtonous fragment of Gondwanaland (Astini et al., 1996). Mafic and ultramafic rocks have long been known in the Precordillera (Borello, 1963).
- The Famatina terrane which is situated to the east of the former ones. The gravimetric signal gives evidence beyond doubt of the presence of a suture zone with vergence to the west, which was mentioned by several authors (Ramos, 1995; Astini et al., 1996; Toselli et al., 1996) among others. A differential density of +0.06 g/cm^3 was determined by us and is ascribed to the positive gravimetric anomaly under the Famatine Ranges, interpreted as originated from an insular arc (Toselli et al., 1996; Rapela et al., 1992). The Moho depth beneath the Famatina system would, then, be 56 km.
- The Velasco Range has been modelled with two types of mass discontinuity, both in the upper crust. In the western part has been interpreted the occurrence of acid igneous bodies with -0.29 g/cm^3 differential density, whilst, in the eastern part, the interpretation postulates the presence of heavy intrusive bodies with a differential density of +0.26 g/cm^3.

Both differential densities (+ and -) can be explained by following the ideas of Toselli et al. (1996) and López et al. (1996) who postulated that basic and acid magmas rose through the shear zone between the Famatina and Eastern Pampean Ranges. The maximum Moho depth beneath the Velasco Range would, then, result in 46.5 km.

- The Villa Unión basin was modelled with a differential density of -0.3 g/cm^3, and the same differential was used for the model of the La Rioja Valley basin. The geometry of the latter was modeled as if it were related to an extensional basin of the rift type, with basement blocks on echelon, as proposed by Fisher et al., 2002).
- The suture zone between the Pampean and the River Plate cratons was determined based on a lower density of the former (-0.03 g/cm^3) following the considerations of Miranda and Introcaso (1999).

As can be observed in figure 3, the Moho resulting from the gravimetric inversion is not continuous and shows some thickening and thinning that correspond with the different blocks.

Conclusions

Through the inversion of the gravimetric signal in this profile, centered at 29° South latitude, are shown beyond doubt very important structural features that find support in the latest geologic research.

In this way, from a model based on an anomalous upper mantle, with a subhorizontal subduction of the Nazca plate under the Andean Cordillera (Chilenia block), can also be distinguished: the suture zone between Chilenia and Cuyania; the suture zone between the Precordillera and the Famatina Ranges, with the Villa Unión basin in between; the shear zone between the Famatina and Velasco Ranges; and the La Rioja Valley basin.

In short, considering a collisional model with lateral density discontinuities, in the crust - different terranes, para-autochtonous or allochtonous- are determined blocks that correspond with the following terranes: Chilenia ($\Delta\sigma$=0 g/cm^3), Cuyania ($\Delta\sigma$=+0.07 g/cm^3), Famatina ($\Delta\sigma$=+0.06 g/cm^3), Pampia ($\Delta\sigma$= -0.03 g/cm^3) and the River Plate craton ($\Delta\sigma$=0 g/cm^3).

The differential densities are widely explained as originated from the ophiolites on the Cuyania terrane and from the probable existence of an island arc in the Famatina Ranges.

This density model gives a gravimetric response coherent with the observed anomaly.

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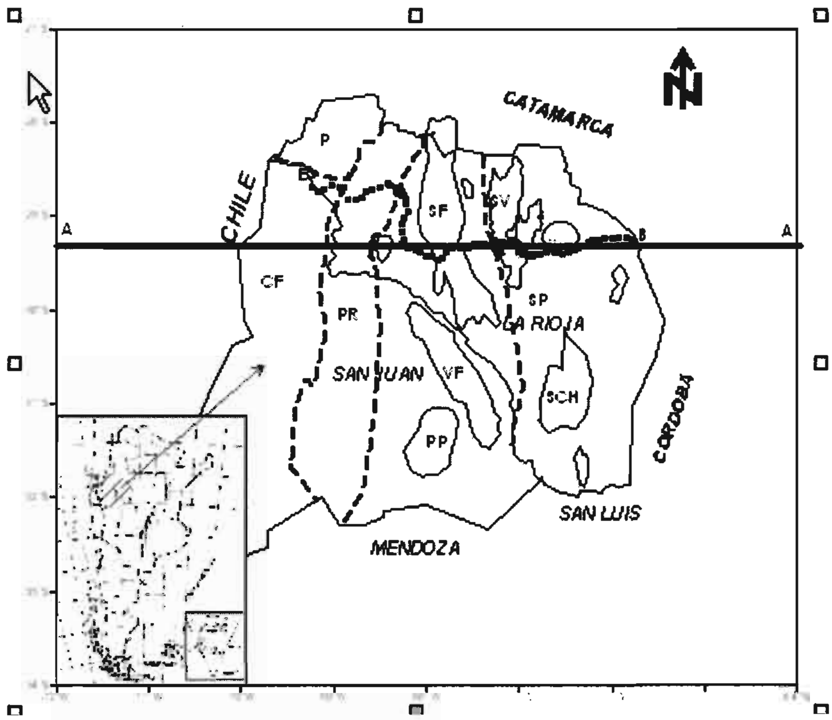

Figure 1: Location map of A_______A gravimetric inversion profile (this paper) and, B........B gravimetric inversion profile (Martinez and Gimenez, 2003). Separation of geomorphostructural provinces: CF: (Frontal Cordillera), PR (Precordillera), SF (Famatina System), SP (Eastern Pampean Ranges), SV (Velasco Range), SCH(Chepes Range), VLR (La Rioja Valley), VF(Valle Fértil Range), PP (Pie de Palo Range) y, P (Puna).

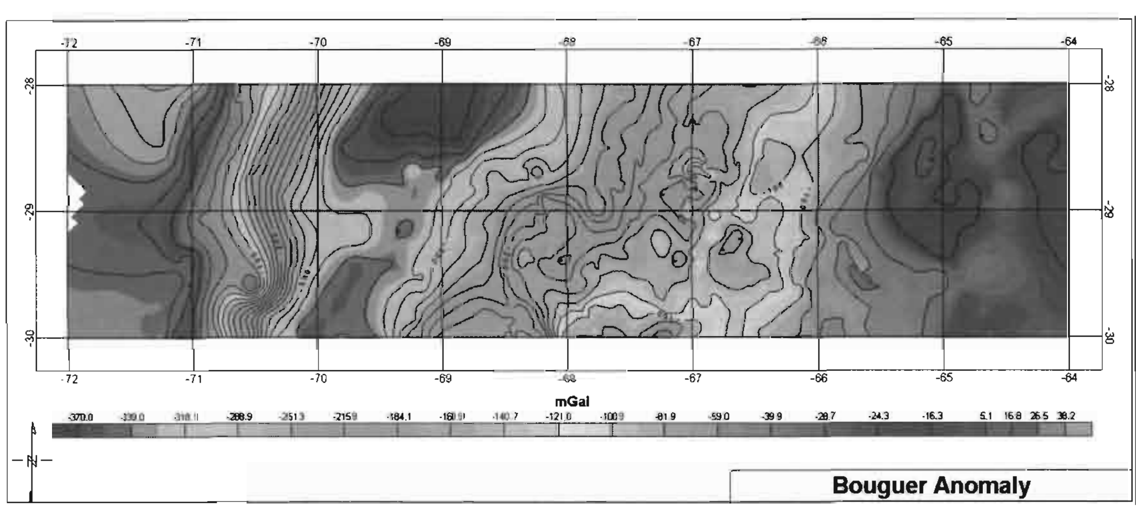

Figure 2: Bouguer anomalies map (after Martinez et al., 2000) enriched with more than 50 measure points in the zone near 29° South latitude. Windows between 28° and 30° South latitudes and between 72° and 64° West longitudes.

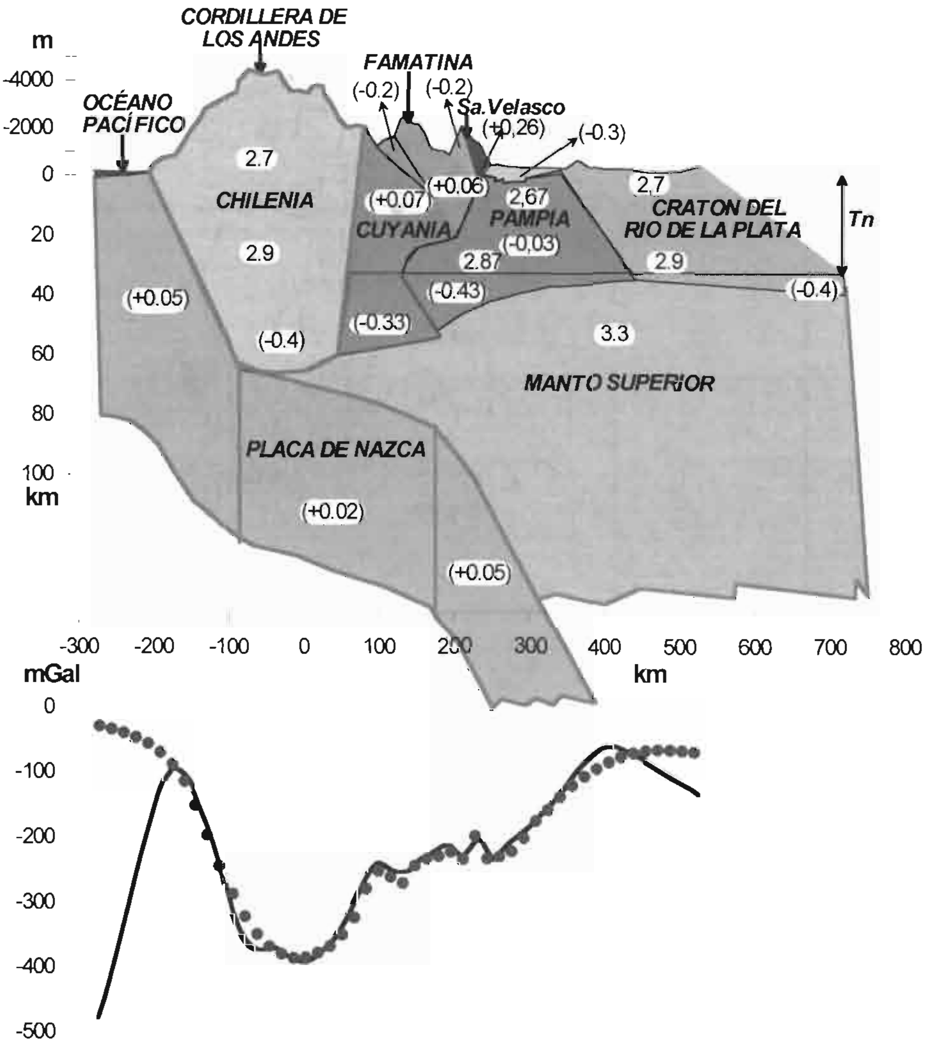

Figure 3: Crustal model with lateral variation of densities. Above: two-layer crustal model resembling the collision between the following terranes: Chilenia, Cuyania, Famatina System, Pampia and the River Plate Craton (inspired by the geologic model of Ramos et al., 2002). The numbers without parentheses are the densities considered for each terrane, and the numbers between parentheses are the differential densities used for the gravimetric calculation. Both are in gr/cm^3. Tn: normal crust thickness, 33 km. Below: Bouguer gravimetric anomaly. In full line, observed Bouguer anomaly corrected for the effect of the Nazca plate. In dotted line, calculated Bouguer anomaly.

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