GRAVITY FIELD AND GEOID AT THE SOUTH AMERICAN ACTIVE MARGIN (20° to 29° S)

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INTRODUCTION

From 1993 to 1996 the international MIGRA group with participants from Chile, Argentina and Germany has surveyed some 3.000 new gravity observations in an Andean geotraverse covering N-Chile and NW-Argentina between 64°- 71° W and 20° - 29° S. MIGRA is a Spanish acronym for "Mediciones Internacionales de GRavedad en los Andes" (Götze and Schmidt, 1993). Including reprocessed older data of Freie Universität Berlin, south American universities, oil and mining industry, there is now a data base of about 15.000 gravity values available, which can be used together with other geophysical and geological information for an interdisciplinary interpretation of the structure and evolution of the Central Andes (Götze et al. 1995, 1996).

In summer 1995 MIGRA took part in the "CINCA" offshore experiment of the german research vessel "Sonne" between the latitudes 20° S to 24° S. The offshore gravity data are connected with the on land survey to draw a complete gravity/geoid picture of this ocean-continent transition. Gravity data at sea were collected along continous survey lines (some 8.000 km). The average density of observational sites amounts to of about 15 observations per km. Gravity survey of cruise SO - 104 was tied to the Chilean National Gravity network of the "Departamento Geofísico, Universidad de Chile, Santiago" at reference stations in Valparaiso, Antofagasta and Iquique. The drift of the KSS31/32 onboard gravity sensor was very low and amounts to -0.048 mGal/day or - 1.44 mGal/month, respectively. The overall drift of the gravity meter was determined to be 0.47 mGal per 92 days.

For all gravity data we calculated gravity reductions within a radius of 200 km. Therefore anomalies calculated are "complete Bouguer anomalies". The data base which includes point data and 10 km * 10 km data grids of free-air-, different types of Bouguer- and isostatic-residual anomalies, are presented here in maps of isostatic residual fields along with a rough interpretation.

FIELD WORK AND REDUCTIONS

The investigated region covers a 900 km x 1.000 km area in the central part of the Andean orogenic system.

The young Andean orogen between 20° - 29° S comprises different structures which have evolved on a Precambrian-Paleozoic basement (e.g. Reutter et al., 1994). This belt of ancient rocks was also described as the border of the "Faja Eruptiva Occidental". Two of our gravity surveys obtained structural information with new stations covering the northern and southern edges of this belt, near Calama (Chile) and in the Southern Argentinean Puna respectively. The investigated area is characterized by its enormous topography and remoteness, by its aridity, low population density and limited infrastructure. Other difficulties limiting our field work were the lack of topographic maps and geodetic networks in some regions. The spacing of stations amounts to approximately 5 km along all passable tracks aside from some local areas with a higher station density . To complete this data base we included gravity observations from different sources. With the exception of some inaccessible regions in the "Eastern" and "Western Cordillera", the gravity coverage for the region is fairly uniform. All measurements are tied to the IGSN71 gravity datum at base stations in Oran/Argentina, Iquique/Chile and Tucumán/Argentina (Götze et al. 1994).

The large size of the area and the severe logistical problems did not always allow us to determine the drift of the gravity meters by repeating the measurements at each station. However, even when we used bad tracks, the drift of the LaCoste & Romberg instruments (model G) rarely exceeded 0.1 mGal per day. Only about 35% of the gravity sites could be tied directly to benchmarks, such as levelling lines or trigonometric heights, so we used altimeters for height determinations. To improve the quality of our barometric measurements, we calculated time-dependent drift corrections as it is usually done for gravity measurements, using as many benchmarks and repeated measurements as possible. Moreover, the profiles of several days were tied together in order to eliminate systematic errors. The scales of the barometers have been calibrated on levelling lines with an altitude difference of about 2.000 m. Error estimations showed that even in the worst case the accuracy was better than 20 m, giving an error in the Bouguer anomaly of about 4 mGal, which is less than 1% of the overall magnitude of more than 450 mGal.

For the terrain correction (up to 167 km around all stations), a method including calculations of the earth´s curvature developed for gravity investigations in the Alps was used, after adapting it to the special situation in the Central Andes. Reduction density was 2.67 g/cm^3 and the digital terrain model by Isacks (1988) was used to calculate a true 3D terrain correction..

GRAVITY ANOMALIES

Onshore the Bouguer anomaly drops down to a regional minimum of about - 450 mGal in the area of the recent volcanic arc, related to crustal thickening by isostatic compensation. The effect of isostatic compensation of topography was calculated assuming the model of Vening-Meinesz with the following parameters: density contrast of the earth´s mantle and crust dRHO = 0.35 g/cm^3, normal crustal thickness: 35 km and a flexural rigidity of 10^{23} Nm. The gravity effect of the isostatic compensation root was eliminated from the Bouguer gravity and the resulting anomaly serves as a residual field (Fig. 1). The most interesting features of this field are: (1) Positive values in the area of the forearc with isolated complexes parallel to the coastline. They are regionally caused by the presence of the dense subducting plate (gravity effect of about 50 mGal; density contrast: 0.05 g/cm^3) and locally by uplifted jurassic batholiths intruded into the "Formación La Negra". (2) The NNW-SSE striking positive anomaly from Calama (CAL) by the Salar de Atacama to southern Puna. We explain this gravity maximum by a highly metamorphic and high-density Paleozoic/Precambrian structure, the "Faja Eruptiva Occidental", which is oblique to the N-S orientation of the recent volcanic belt. (3) Local minima along the recent volcanic arc point to reservoirs of partly molten material at depths of 15 - 20 km. (4) Minima following a line from Ollagüe (OLL) to Calama (CAL) along 69° W, are caused by the Eocene volcanic arc with low-density volcanic material in the upper crust. (5) Alternating gravity highs and lows in the backarc region east of 67° W are observed in wide areas of the Argentine Puna and the Eastern Cordillera with a general NE-SW trend. The minima point to the position of mesozoic basins which are located in the Argentine Puna and extend northward to the territory of Bolivia. Gravity highs correlate with outcrops of Precambrian/Paleozoic basement in the Puna and Eastern Cordillera. 3D forward modelling of both gravity and gravity potential (geoid) can explain that most of the observed

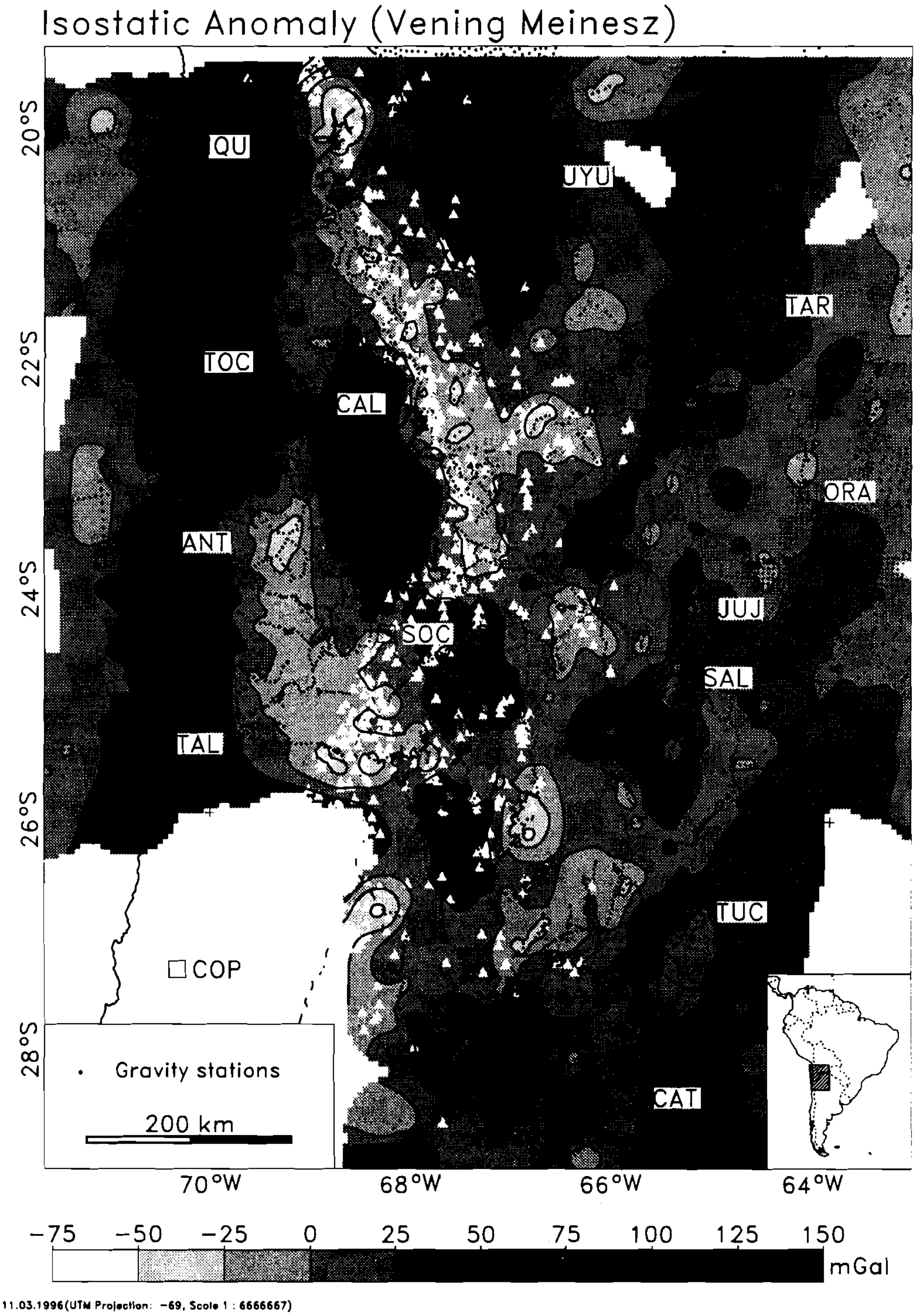

Figure 1: Residual gravity field of the Central Andes. Contour lines 10 mGal. Database is shown together with volcanos and other geographical features.

geoid anomaly (undulation) of 50 - 60 m is caused by Andean topography and isostatic roots. However, also density inhomogeneities in the downgoing slab and in the asthenospheric wedge contribute to undulations of the Earth's geoid in the Central Andes. All 3D density modelling has been proven by the results of refraction seismics (e.g. Wigger et al., 1994). Please, refer also to poster Kirchner, Götze, Lessel and Schmitz (this issu).

CONCLUSIONS

The updated gravity data base will play an important role in both local investigations of applied geophysics and regional interdisciplinary interpretations of pure geophysics. Andean gravity field seems to be a sensitive indicator which is linked to many processes contributing to the tectonic framework of the Nazca plate subduction zone.

MIGRA data sets are available via FTP for non commercial applications of universities and governmental agencies. You may contact H.-J. Götze at Freie Universität Berlin (Germany) under "hajo@zedat.fu-berlin.de" or refer to the "Gravity Research Group´s" Home page on the WWW for further information: - http://fub46.zedat.fu-berlin.de:8080/~wwwgravi.

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