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PRINCIPAL FACTS FOR GRAVITY DATA COLLECTED IN THE

SOUTHERN ALBUQUERQUE BASIN AND A REGIONAL COMPILATION,

CENTRAL NEW MEXICO

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by

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ABSTRACT

Principal facts for 156 new gravity stations in the southern Albuquerque basin are presented. These data fill a gap in existing data coverage. The compilation of the new data and two existing data sets into a regional data set of 5562 stations that cover the Albuquerque basin and vicinity is also described. Bouguer anomaly and isostatic residual gravity data for this regional compilation are available in digital form from ftp://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-00-490.

INTRODUCTION

The Albuquerque basin is one of the largest basins associated with the Cenozoic age Rio Grande rift. The basin is located in central New Mexico (Figure 1), and its ground-water resources are the focus of an assessment involving the cooperation of a number of organizations, referred to as the Middle Rio Grande basin study (http://rmmcweb.cr.usgs.gov/public/mrgb). Gravity data contribute to this effort by placing constraints on the thickness of basin fill and the locations of major basement faults, which are important for developing a three-dimensional view of the basin hydrogeology.

Regional-scale compilation of gravity data in the Rio Grande rift area began with Cordell and others (1982). Heywood (1992) compiled data for the State of New Mexico, and the University of Texas at El Paso (UTEP) maintains a database of the Rio Grande rift region. However, these compilations lacked coverage of a large area in the southwestern part of the Albuquerque basin. UTEP and the U. S. Geological Survey (USGS) collaborated in a field effort to acquire gravity data in this area in 1997, motivated by the need for improved gravity coverage for the Middle Rio Grande basin study. The purpose of this report is to present the new data, describe the data processing procedures, and explain how the data were incorporated with the previous compilations.

DATA COLLECTION

A field survey was undertaken during the summer of 1997 to fill in gaps in existing gravity data coverage in the southwestern Albuquerque basin as best as possible within the limitations of road and land accessibility (fig. 2). Gravity measurements were acquired by two teams consisting of two persons each using LaCoste-Romberg gravity meters G-376 and G-161. Locations were determined using dual-frequency Global Positioning System (GPS) units and differential measurements.

Information on observed gravity base stations in Albuquerque and Socorro were obtained from the Department of Defense Worldwide Reference Base station network. For convenience, a temporary gravity base station was established outside the new Belen Post Office by tying it to the two other base stations. The Socorro base station was approximately located because the marker was no longer intact due to construction at the old post office site. The Albuquerque base station is located in the Astronomy Building on the University of New Mexico campus. The separate teams took three trips to the Albuquerque and Socorro base stations to record gravity readings. The average value (979192.66 mGal) determined by the teams became the value for the Belen Post Office station. In a separate location within the gravity survey area, a base was established for the GPS survey by using differential measurements from nearby first-order benchmarks. The benchmark locations were obtained from the National Geodetic Survey (http://www.ngs.noaa.gov).

Once the GPS and Belen gravity base stations were established, the two teams repeated gravity readings at these stations daily in order to determine drift corrections for the gravity meters. The teams began each day by recording the gravity reading at the Belen Post Office. Next, they drove to the GPS base location, unloaded and assembled the stationary GPS unit, and recorded the gravity reading. From this location, the two teams separated to acquire data from new stations. At each new station, the team set up a rover GPS station to acquire location information. They also recorded an identification code for the station, time, gravity reading, and notes on inner-zone terrain relief on standard gravity field data sheets. At the end of the day, each team returned to the GPS base, recorded a gravity reading, then disassembled and loaded the GPS unit into the vehicles, returned to the Belen Post Office, and took a final gravity reading for the day.

In the evening, GPS data from each team were downloaded onto a laptop computer and an initial review of the data revealed whether the GPS units were recording properly. Standard manufacturer-supplied software was used to download and process the GPS data. The locations of the gravity stations (horizontal and vertical) are accurate to within about 5 cm. A total of 156 gravity stations were occupied in 5 days.

DATA REDUCTION

The gravity data were processed using standard reduction equations for free-air, Bouguer, and earth curvature corrections (Cordell and others, 1982) and a standard value of 2.67 g/cm^3 for the density of the Earth's crust. Corrections for the variation of gravity with latitude at each station were computed using the International Gravity formula of 1971 (Woollard, 1979). Inner-zone terrain corrections were calculated out to 895 m from each station using a standard Hammer technique (Hammer, 1939), in which average elevation estimates within circular zones surrounding the station are used to compute the gravity effect of each zone. Outer-zone terrain corrections for 0.895 to 167 km from each station were computed using the algorithm of Plouff (1977). This algorithm computes gravity effects based on digital elevation models having different sample intervals, taking advantage of decreased need for close sample spacings at great distances from the station. A digital elevation model with 15-arc-second sample interval was used closest to the station.

REGIONAL DATA COMPILATION

The 156 new gravity data points for the southern Albuquerque basin area were combined with previously collected data in order to check the integrity of the new data and to develop a better regional view of the Albuquerque basin and vicinity. The previously collected data were extracted for the study area from latitudes 34°N to 36°15'N and longitudes 107°30'W to 105°30'W from two sources: the compilation by Heywood (1991) for the state of New Mexico (Heywood data) and unpublished data supplied by G. R. Keller from the University of Texas at El Paso (UTEP data). Considerable overlap exists between these two data sets. Duplicates were detected by searching for stations with similar locations (within .01 decimal minutes of each other).

These stations were removed from the UTEP data set if the observed gravity values were less than .01 mGals of the corresponding value in the Heywood data set.

Because the UTEP data contained incomplete terrain-correction information, these data were examined and corrected separately before combination with the other data sets. First, the UTEP data set was split into three parts depending upon whether there was information for inner-zone and/or outer-zone terrain corrections (inner and outer TCs): (1) stations having inner TC's but no outer TC's; (2) stations having outer TC's but no inner TC's; and (3) stations having neither inner nor outer TC. All outer and inner (if required) TC's were computed using USGS in-house software based upon the original computer program of Plouff (1977) and 15-sec digital elevation models (digitized from 1:250,000 scale topographic maps) available from USGS National Mapping Division. Although inner TC's are best estimated by inspection of the area surrounding the gravity station rather than computing them from digital elevation data, the difference is considered negligible for the basin area due to the low relief. In addition, large errors in computed TC's could be recognized by comparing the resulting Bouguer values to neighboring stations, resulting in removal of the problematic stations from the data set. In a few cases, the computed inner TC gave results that were more compatible with neighboring stations than the original value. Throughout the data set there are negative TC's. Although TC's can be negative in large regions of low relief, these values are probably due to discrepancies between station elevation and digital elevation model. Because they are all very small in magnitude, they were left as is.

Some of the UTEP data also contained records with values that seemed problematic, such as stations that seemed mislocated with respect to neighboring stations and stations with similar identification codes that all had the exact same inner TC value. There were 11 such problematic stations that were subsequently discarded.

After the remaining UTEP data were terrain-corrected, they were combined with the Heywood data and data for the 156 new stations. Bouguer anomalies were computed with a reduction density of 2.67 g/cm^3 using in-house USGS software, following Cordell and others (1982) as before. Inspection of the Bouguer maps revealed quite a few stations that produced "bulls-eye" type anomalies and were considered bad stations. As a result, 29 problem stations were removed from the Heywood data and 2 from the UTEP data set. There are data for 5562 stations in the final compilation (fig. 2), 5262 from the Heywood data set, 144 from the UTEP data set, and 156 from the new data set. A color image of the Bouguer anomaly data is shown in figure 3.

ISOSTATIC RESIDUAL GRAVITY

In order to focus on density variations within the upper crust, a regional field is commonly removed from Bouguer gravity data. The regional field can be constructed in a number of ways, such as trend fitting, modeling, or wavelength filtering. However, a regional field that is based on an Airy isostatic model is most desirable because it is understandable in physical terms and easily repeated between studies. As discussed by Simpson and others (1986), the exact parameters of the isostatic model need not be accurate nor does the Airy mechanism of isostasy need be completely satisfied for construction of a useful regional field. However, they caution that the resulting maps should not be used as evidence for or against isostatic compensation.

The isostatic regional field for the Albuquerque basin area was computed out to a radius of 167 km using the program AIRYROOT by Simpson and others (1983). Regional field values farther away than 167 km were obtained from the isostatic model field computed by Karki et al. (1961) for the world. We chose the same parameters to model the isostatic regional field as those determined for the statewide compilation by Heywood (1992). These parameters are as follows: density of topographic load = 2.67 g/cm^3, depth of root at sea level = 20 km, and density contrast at bottom of root = 0.30 g/cm^3. In his report, Heywood discusses the choice and application of these parameters at length and presents maps of the regional and residual fields. AIRYROOT computes the regional field at sea level. This field was continued to the topographic surface of the study area using the chessboard method of Cordell (1985) before subtraction from the Bouguer anomaly value at each station location. After removal of the isostatic regional field from the Bouguer gravity value at each station, the results were gridded (Webring, 1981) and are displayed in figure 4 as an isostatic residual gravity map. The resulting isostatic residual gravity values are generally within 0.5 mGal of those computed by Heywood. The most noticeable difference between the Bouguer (fig. 3) and isostatic residual (fig. 4) gravity maps is that gravity lows in the isostatic residual gravity map are more comparable in value within the basin area from north to south. These anomaly maps are discussed by Grauch and others (1999).

DIGITAL FILES

There are two digital data files containing the principal facts for the regional compilation of the gravity data, including the 156 new stations. The file "hueboug.lis" lists the facts for the Bouguer anomaly in table format for readability. The file "huegrv.asc" lists the facts in sequence for computer program use and includes the isostatic residual gravity value as well as the Bouguer anomaly value. In the file names, the 3-letter code "hue" is a reference to Heywood-Utep-edited data. The 3-letter code "grv" refers to isostatic residual gravity and the 4-letter code "boug" refers to Bouguer anomaly data. Note that the values of observed gravity and station elevations are represented differently in the two files. In hueboug.lis, a constant of 900,000 has been subtracted from the observed gravity value; in huegrv.asc the constant subtracted is 980,000. The difference arises from the different requirements of the files: readability for the first file, numerical precision for the second file. Station elevations are listed in feet in hueboug.lis and in meters in huegrv.asc.

The FORTRAN format to read the sequential file huegrv.asc, after 3 lines of ASCII header information, is (a8,8x,9e16.8), an 8-character id and 9 channels of data. The data fields are described as follows.

Channel	FORTRAN Format	Description
N/A	a8,8x	identification string
1	e16.8	longitude in decimal degrees
2	e16.8	latitude in decimal degrees
3	e16.8	station elevation in meters
4	e16.8	observed gravity in mGals with a constant of 980,000 removed
5	e16.8	inner terrain correction (Hammer zones a-f) in mGals
6	e16.8	outer terrain correction (Hammer zones g-o) in mGals
7	e16.8	free-air gravity in mGals
8	e16.8	complete Bouguer anomaly (density=2.67 g/cm^3) in mGals
9	e16.8	isostatic residual gravity in mGals

There are 5562 stations in the file huegrv.asc, which extend somewhat beyond the study area in all directions. During the compilation procedure, blanks in the original id's for some stations were substituted with 0's. Data statistics are as follows.

Channel	Description	Minimum	Maximum	Mean	Standard Deviation
1	Longitude	-107.550	-105.450		
2	Latitude	33.95233	36.30		
3	Station altitude (m)	1388.090	3671.316	1954.981	313.716
4	Observed gravity (with a constant 980,000 removed)	-1150.250	-741.380	-839.3074	53.1898
5	Inner terrain correction zones a-f	0.0	5.150	0.1739	0.4565
6	Outer terrain correction zones g-o	-0.20	33.460	0.8901	1.6132
7	Free air gravity anomaly	-70.0864	184.9275	1.09551	35.25
8	Bouguer gravity anomaly	-269.9469	-154.9865	-218.0735	20.37
9	Isostatic residual gravity	-35.6787	51.6449	0.6207	15.92

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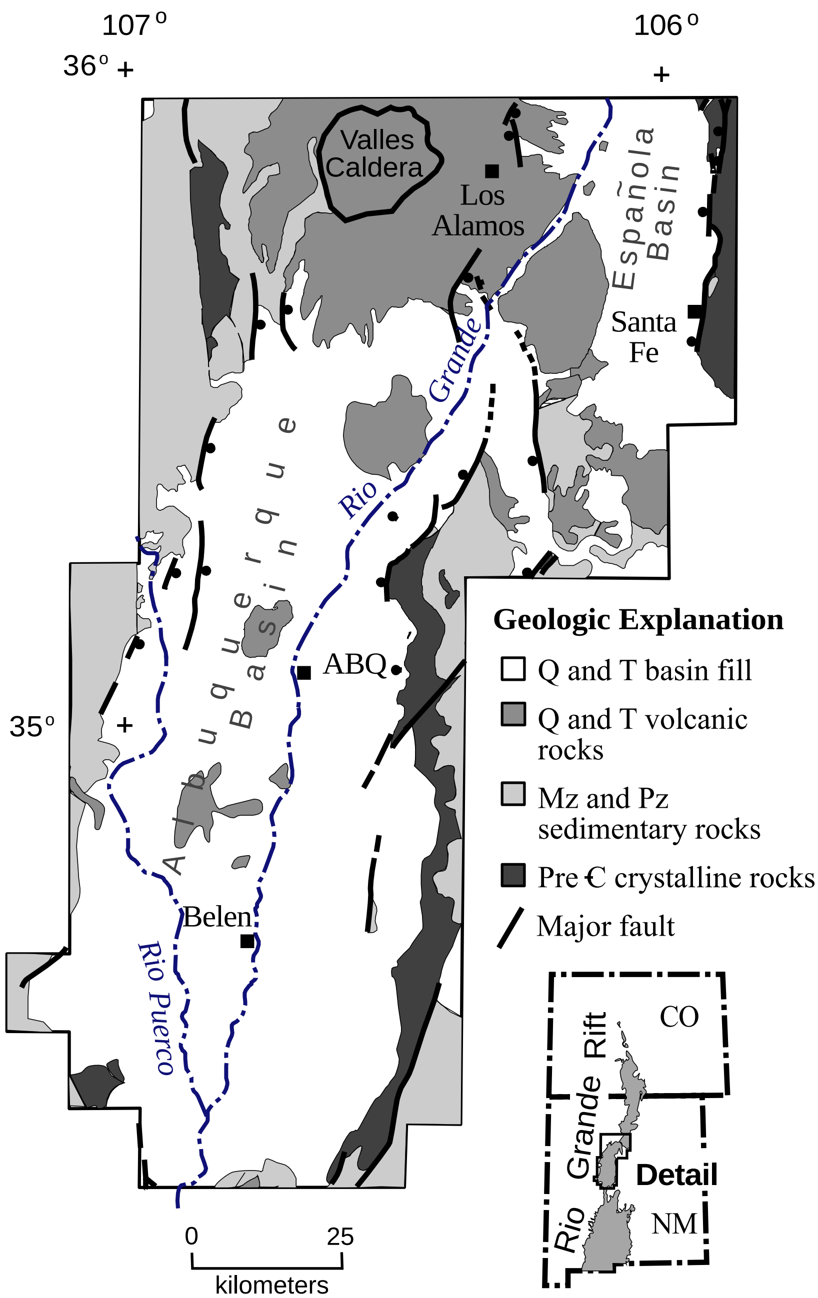

Figure 1. Index map showing regional geology of the Albuquerque basin area and its location within the Rio Grande rift. ABQ = Albuquerque. Geology generalized from Kelley (1977).

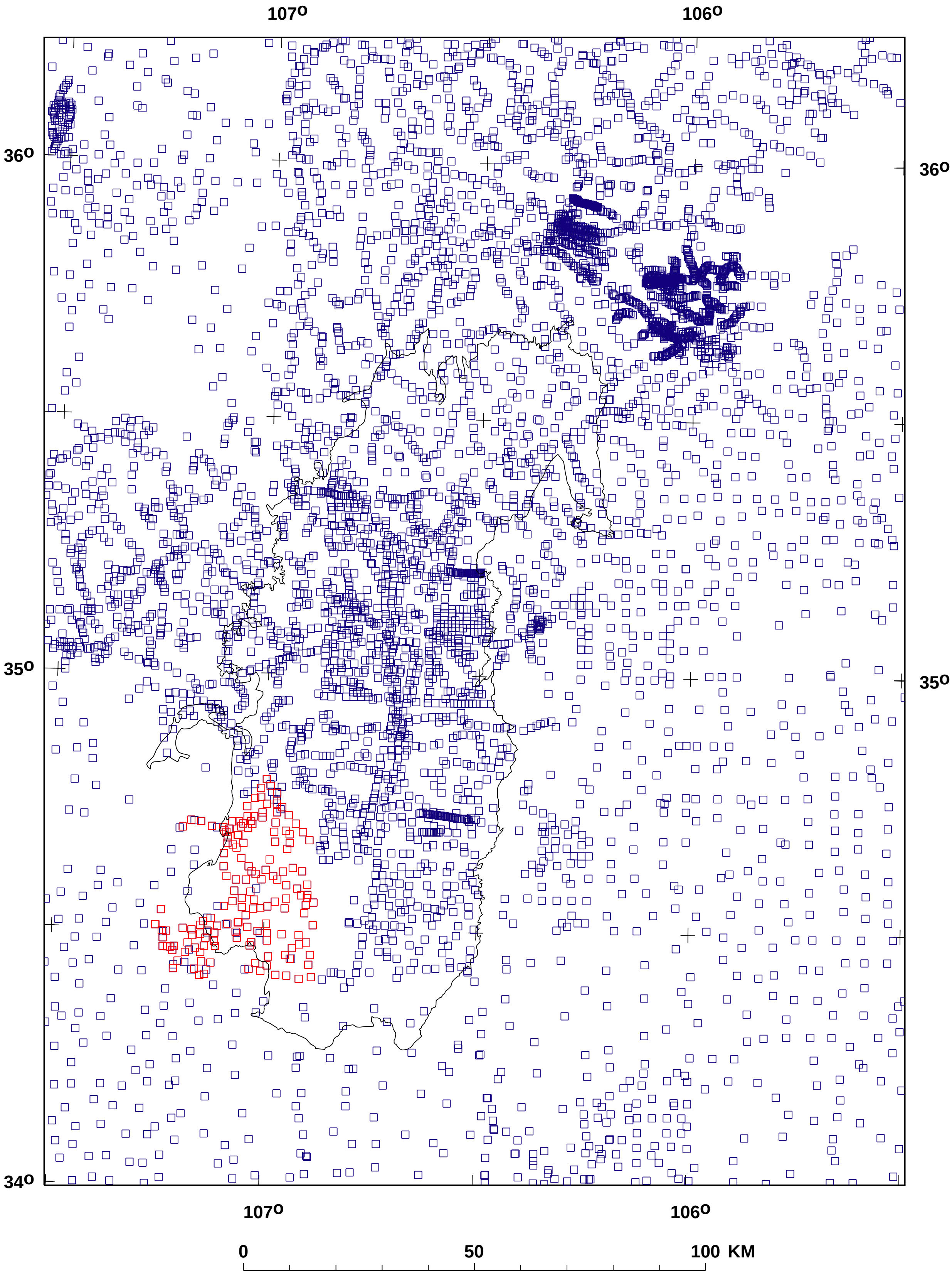

Figure 2. Location of stations for the regional compilation of gravity data. New data stations in the southern Albuquerque basin are indicated by red squares. Older data stations, from Heywood (1992) and The University of Texas at El Paso (UTEP) data files, are indicated by blue squares. The Albuquerque basin is outlined in black for reference.

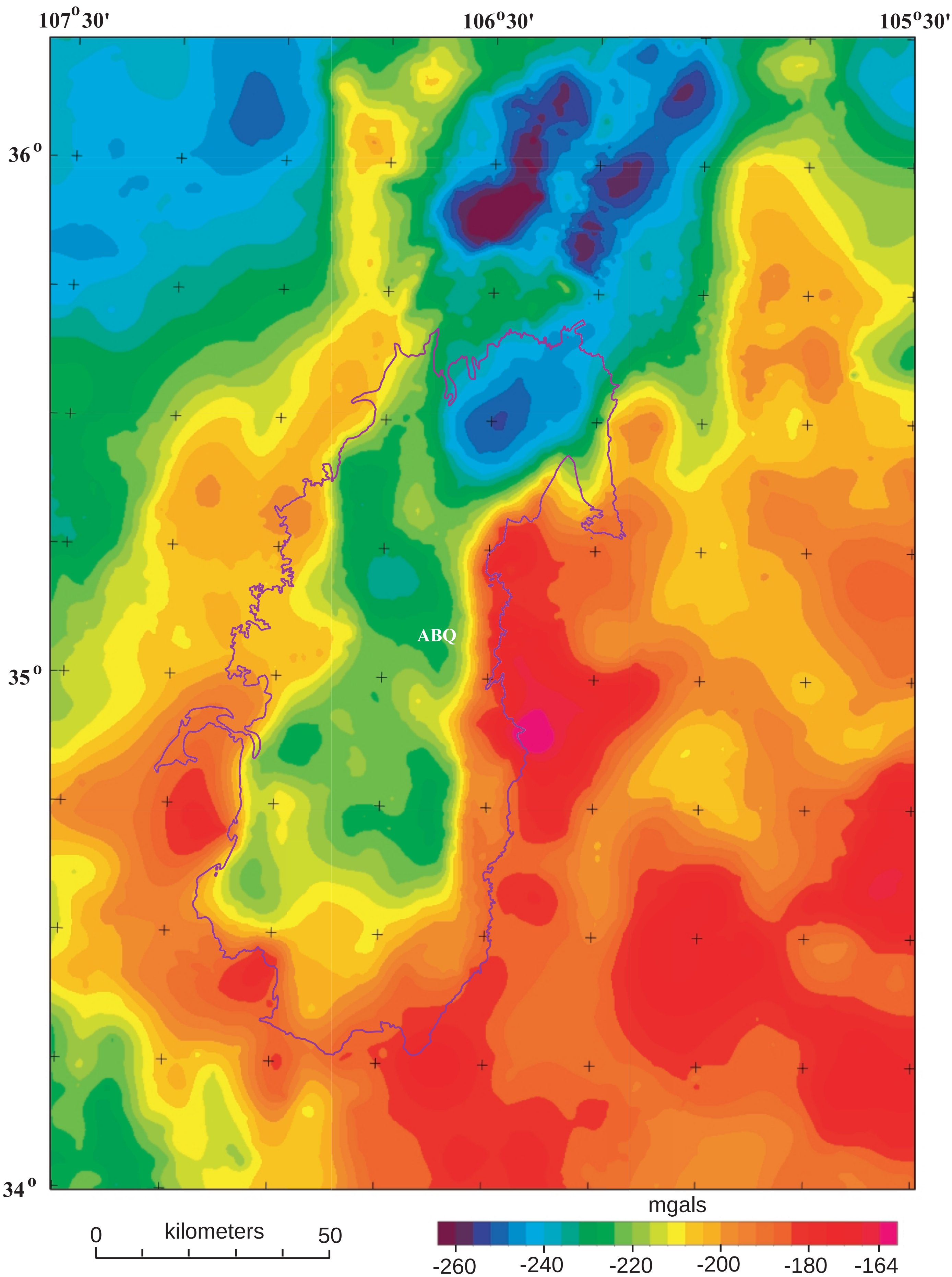

Figure 3. Bouguer gravity map of the Albuquerque basin area processed from the regional data compilation. ABQ = Albuquerque. The Albuquerque basin is outlined in purple for reference.

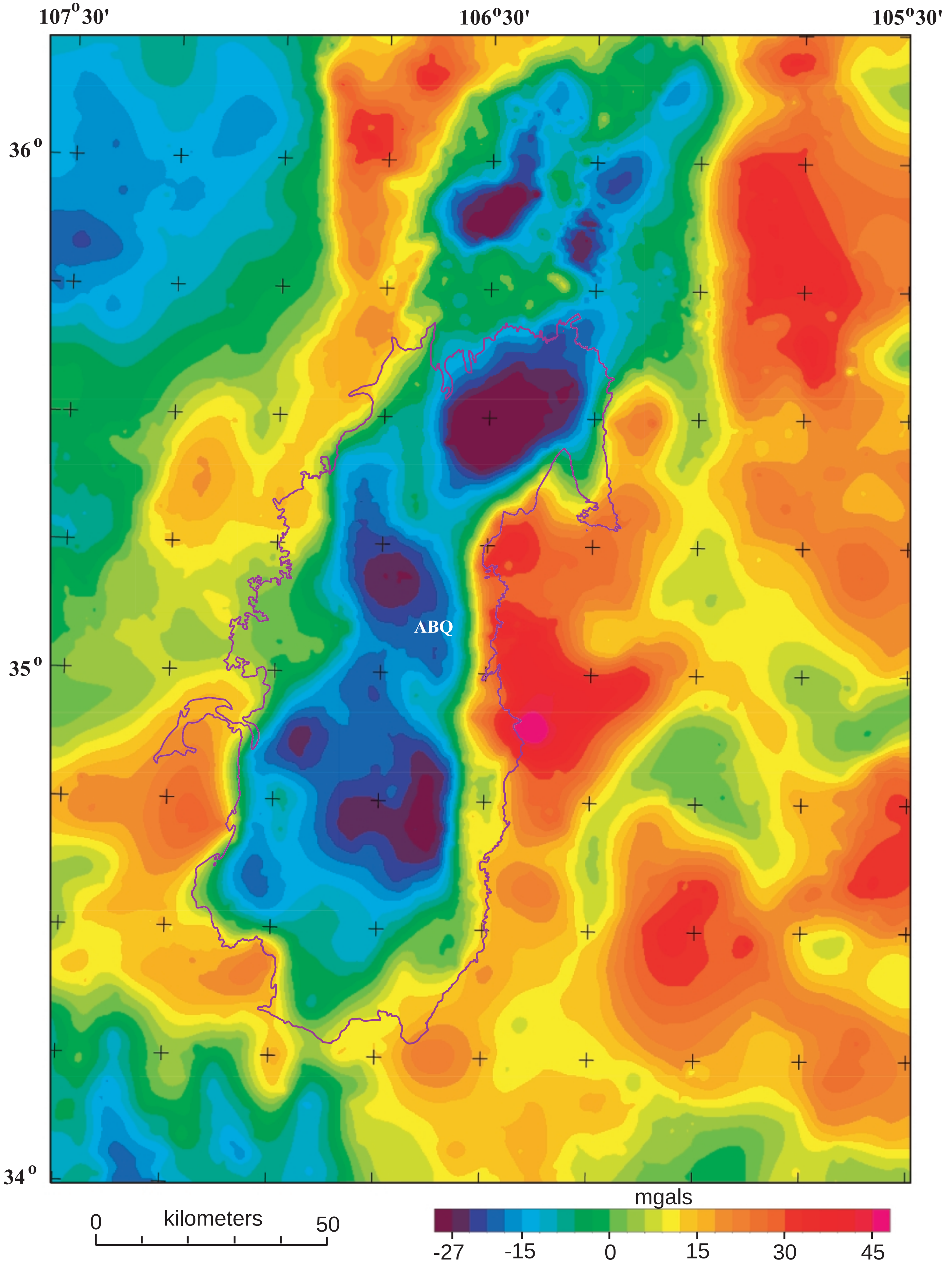

Figure 4. Isostatic residual gravity map constructed by removal of an isostatic regional field from the new Bouguer gravity data (Simpson et al., 1986; Heywood, 1992). ABQ = Albuquerque. The Albuquerque basin is outlined in purple for reference.