

GC Gravity Data: Lot of Bang for Buck*

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General comments

Gravity measurements are a simple and inexpensive source of information about the subsurface structure of an exploration target. These data require only some simple data reduction to be converted into interpretable anomaly values.

By “anomaly,” we mean departures from values that can be calculated for a simple model of the Earth, including compensation for the variations in gravity due to measurements being made at different elevations. The overall gravity field varies from about 978 gals (1 gal = 1 cm/s²) at the equator to about 983 gals at the poles. These variations easily can be accounted for by using the international gravity formula in which the predicted value of gravity varies with latitude.

We often find anomalies of a few milligals to be geologically significant, and the effect of changes in elevation alone is about 0.3 milligal/meter. Thus, a crucial consideration in gravity surveys is the measurement of the elevation where the measurement is made. In the case of land surveys, determining the elevation to an accuracy of a few centimeters involves a larger effort than making the actual gravity readings. Because of the large effects topography has on gravity measurements, correcting for these effects in mountainous regions poses a special challenge. However, the broad availability of digital elevation models worldwide, thanks to efforts such as the Shuttle Radar Topography Mission, and the ability of computers to handle massive data sets have brought this problem under control.

The specific type of anomaly that is usually employed in gravity studies is the Bouguer anomaly, which is called the Complete Bouguer anomaly if the reduction process includes terrain corrections. Much has been made of the fundamental ambiguity that gravity anomalies clearly reveal the presence of mass, but allow for an infinite combination of density-volume products to model a specific anomaly.

Given geologic constraints, drill hole data and supporting geophysical data, this ambiguity can be drastically reduced. Thus, these data are particularly useful in:

- Determining the regional structural setting of an exploration project.
- Helping optimize seismic data acquisition.
- Providing structural information in areas outside seismic data coverage or at depths that exceed the limits of seismic control.

Classic applications of gravity data that define prospects directly include:

- The detection of salt domes.
- The detection of ore bodies.

If one has a good geologic understanding of an area, the qualitative interpretation of gravity data is in fact quite straightforward. The key is thinking about density contrasts -- sediments (2.5 gm/cm³) versus basement (2.7 gm/cm³) -- that would produce a particular anomaly. For example, a gravity high could be due to a structural

uplift that has brought denser (older and more compacted or cemented) rocks near the surface, and a gravity low could be due to a sedimentary basin that contains rocks less dense than the surrounding geology.

Two-dimensional models are a more quantitative form of interpretation and should be derived in much the same way as the construction of a geologic cross-section in that the process should involve integration of all available information. Three-dimensional modeling also is often undertaken.

Gravity studies often begin with public domain regional scale data sets consisting of point measurements taken on land, track data recorded from ships or aircraft, or even data derived from satellites. Land and marine measurements recently have been compiled into a large database for the contiguous United States, and a North American database effort is well under way. These databases are the result of a cooperative effort by the U.S. Geological Survey, the National Geospatial-Intelligence Agency, NOAA/NGS (National Oceanic and Atmospheric Administration / National Geodetic Survey) and university groups.

Example: Rio Grande Rift

The current version of this database can be accessed at <http://paces.geo.utep.edu>, and an example of the data is available for the southern Rio Grande rift region (Figure 1). The Rio Grande rift is a major continental rift zone that is associated with a series of deep basins that both follow and cut across older features. The data shown in Figure 1 were gridded and contoured to produce the Bouguer anomaly map shown as Figure 2. This map is dominated by a strong regional increase of anomaly values (~100 milligals) from northwest to southeast that obscures the more local anomalies due to the basins.

This regional anomaly is primarily due to the crustal thinning across the Rio Grande rift and to a batholith that is found beneath the Datil-Mogollon volcanic field to the northwest. These effects illustrate a well-known problem in gravity studies; namely, the separation of the regional field from the more local anomalies in which we are interested.

In Figure 3, the regional field has been removed by applying a simple band-pass filter to the data, so that the gravity lows due to the basins become evident. The filtered map clearly shows the north-south trending basins associated with the Rio Grande rift and provides a quick outline of their geometry and relative depth.

The map's southern portion shows strong northwest trends that reflect Laramide uplifts.

Summary

- The analysis of gravity data is a very cost effective exploration tool.
- Regional data often are available from public domain sources and can provide a useful starting point.
- Many data brokers provide more detailed data at a reasonable price.

Any gridding and contouring software can be used to turn the gravity measurements at points into maps.

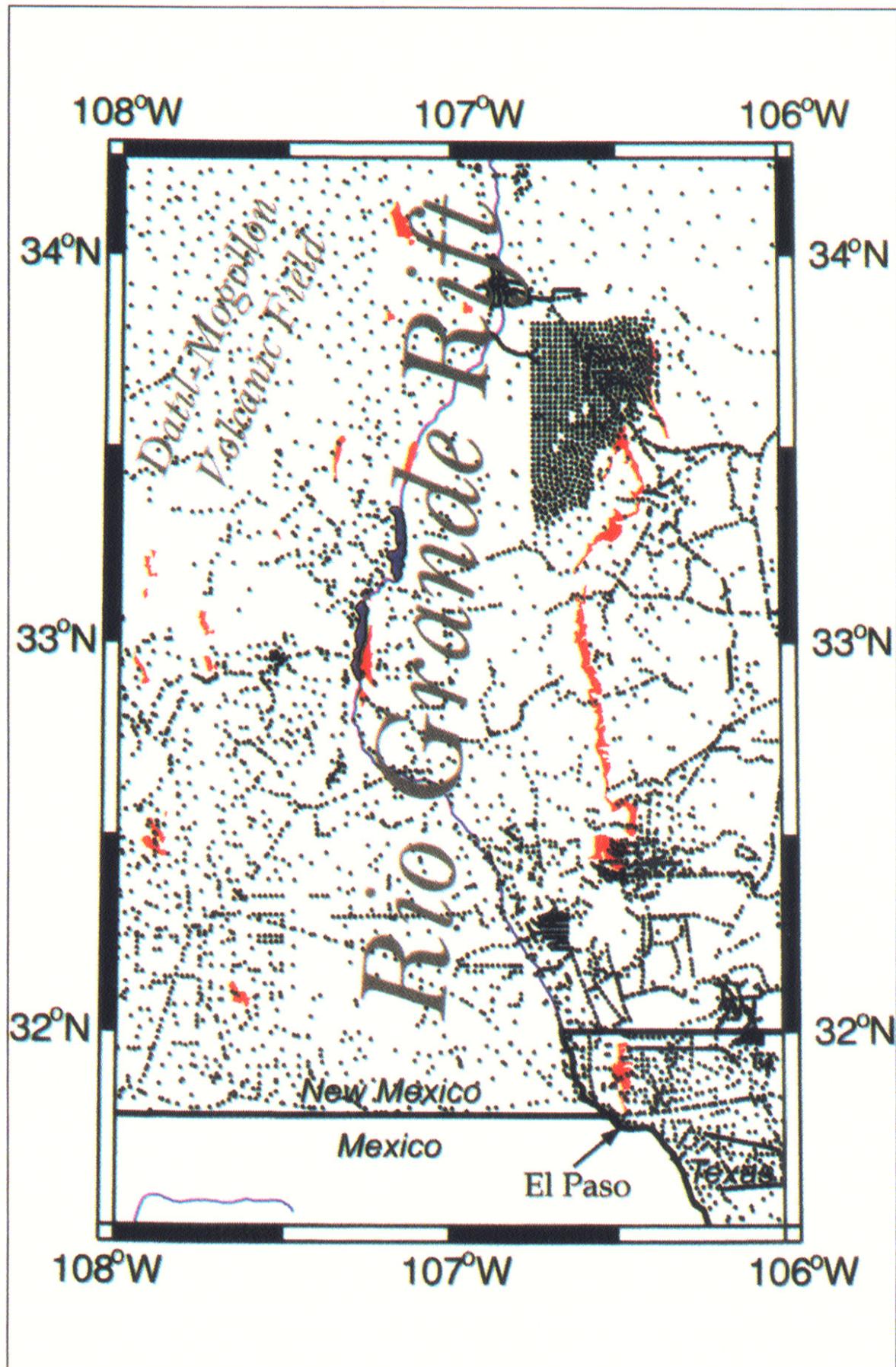


Figure 1. Index map showing the distribution of gravity readings available in the southern Rio Grande rift region (southern New Mexico and far west Texas).

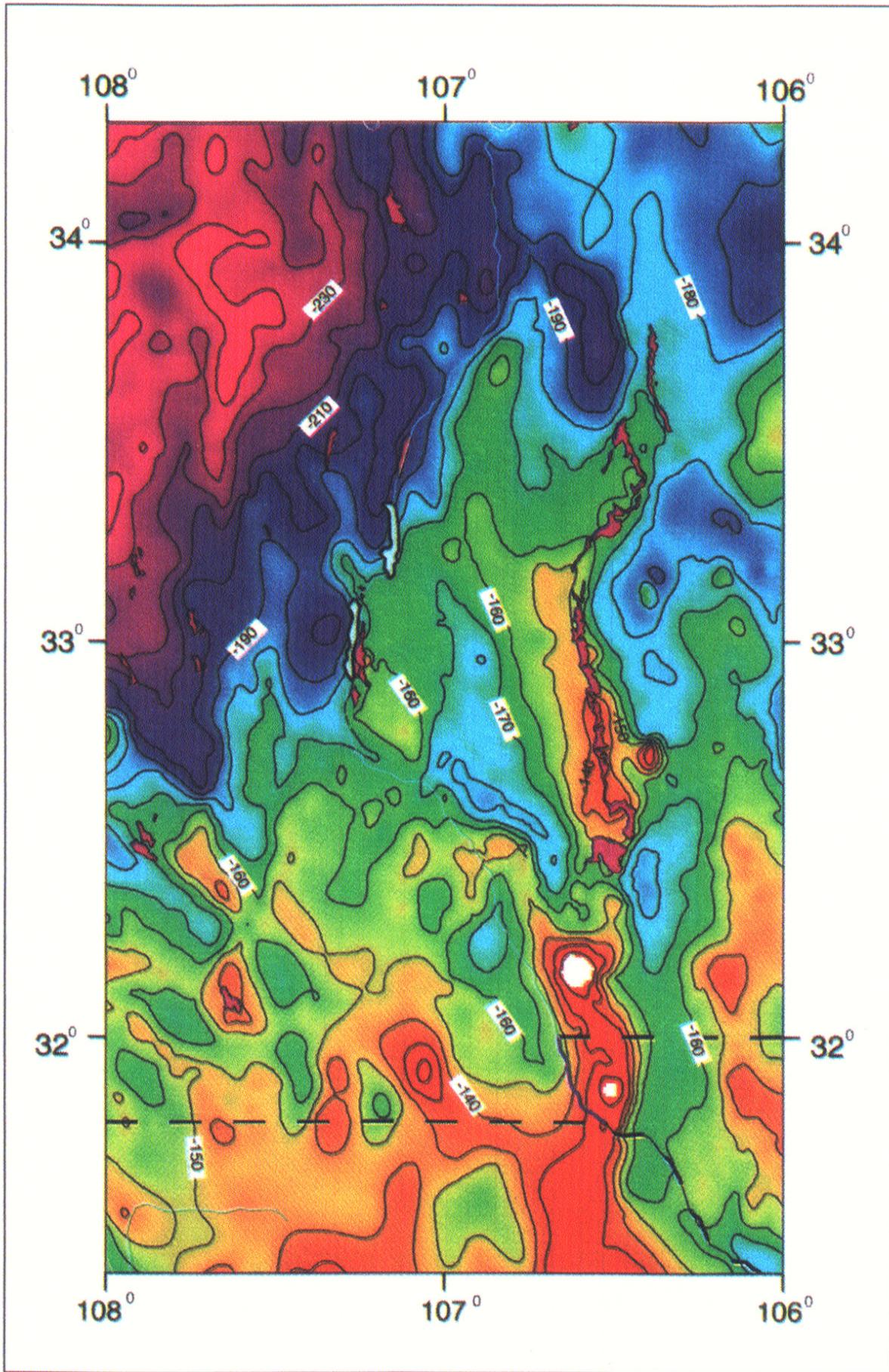


Figure 2. Bouguer gravity anomaly map of the southern Rio Grande rift. Contour interval is 10 milligals. Precambrian basement outcrops are shown in magenta.

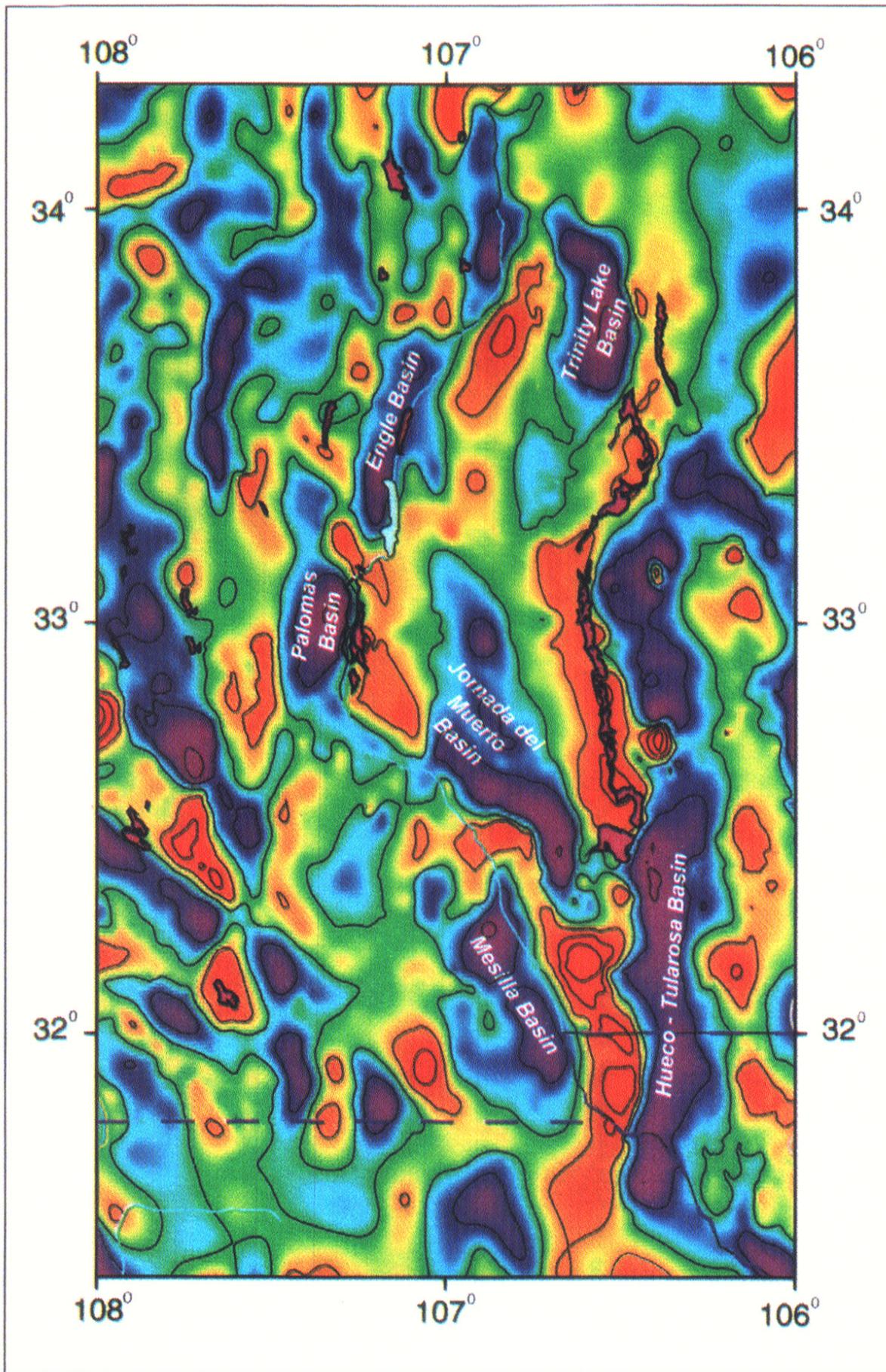


Figure 3. Filtered gravity map of southern Rio Grande rift in which only wavelengths between 10 and 75 km have been passed. Important basins are labeled. Contour interval is 10 milligals. Precambrian basement outcrops are shown in magenta.