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Geophysical anomalies in southwestern New Mexico

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GEOPHYSICAL ANOMALIES IN SOUTHWESTERN NEW MEXICO

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Abstract—Gravity and aeromagnetic data have been compiled for southwestern New Mexico and surrounding areas. A series of maps has been prepared using various filter parameters. These maps display many relationships of geological importance. The preliminary analysis reported here suggests that the Laramide Burro uplift was an extensive feature and that early and late Cenozoic structures can be differentiated on the basis of strike filtering.

INTRODUCTION

Southwestern New Mexico has experienced a complex tectonic history which is discussed elsewhere in this volume. The purpose of this paper is to employ geophysical data, primarily gravity measurements, to analyze the subsurface structure in southwestern New Mexico and adjacent areas (Fig. 1). The goal of this preliminary analysis is to shed light on the major tectonic events which have affected this area.

PREVIOUS STUDIES

Previous geophysical studies in southwestern New Mexico have focused primarily on the Rio Grande rift. Gravity and seismic measurements now provide a good picture of the crustal structure in the southern portion of the rift (Decker and Smithson, 1975; Ramberg et al., 1978; Daggett et al., 1986; Sinno et al., 1986). The long wavelength (>125 km) components of the gravity field in the southern rift correlate well with the seismic data and primarily reflect variations in crustal thickness (Fig. 2). The emphasis in this study is on upper crustal features and thus the shorter wavelength components of the gravity field. There have been several gravity studies of portions of the area which include investigations of southeastern Arizona (Aiken, 1978), northern Chihuahua (Aiken et al., 1981), the El Paso area (Wen, 1983), the Las Cruces-Truth or Consequences area (Gilmer et al., 1986) and the Cordilleran Overthrust belt (Lance et al., 1982).

GRAVITY AND AEROMAGNETIC DATA

The University of Texas at El Paso has been compiling gravity data in the area for over a decade. In addition to our own efforts, major sources of data have been the University of Texas at Dallas, the U.S. Geological Survey, the University of Wyoming, New Mexico State University and the Defense Mapping Agency. More than 16,000 gravity readings are available in the study area (Fig. 3) and the coverage is generally adequate for the analysis undertaken here. All gravity readings were reduced to complete Bouguer anomaly values using the reduction equations of Cordell et al. (1982) and the terrain correction technique of Plouff (1977).

A major effort in this study was the compilation of aeromagnetic data for the area. For New Mexico, the data of Cordell (1983) were employed. Data from the National Uranium Resource Evaluation program were used for west Texas. Data in Arizona are from Sauck and Sumner (1970), and data in northern Mexico are from Himes (1968). The individual data sets could be satisfactorily merged by simply adding or subtracting constants to create a match with adjacent values in New Mexico. Flight lines are shown in Figure 4, and the resulting data consist of over 86,000 total magnetic intensity values.

DATA PROCESSING

The gravity and magnetic anomaly data were first gridded at a 2-km interval using the minimum curvature technique (Swain, 1976). The next step was to produce the anomaly maps shown as Figures 5 and 6.

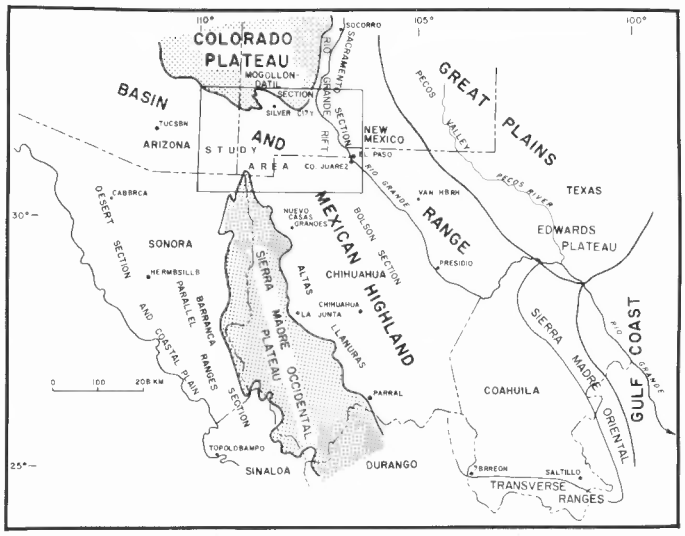


FIGURE 1. Index map of the study area.

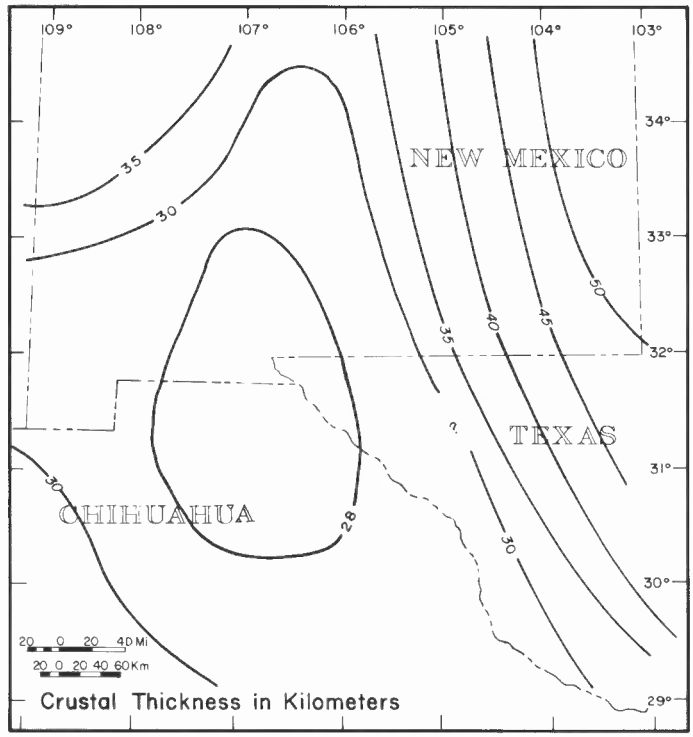


FIGURE 2. Contours of crustal thickness in the area. Contour interval = 2 km.

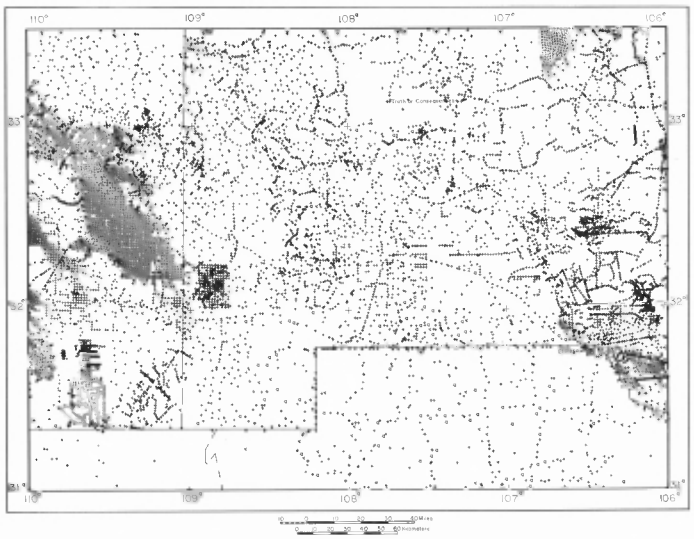


FIGURE 3. Distribution of gravity readings (+).

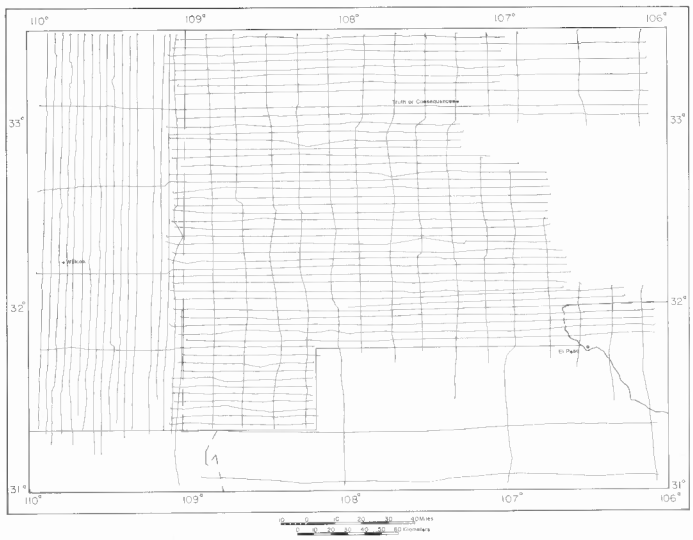


FIGURE 4. Aeromagnetic flight lines.

These and the other contour maps in this study were produced using the Surface II contouring routine (Sampson, 1978). In order to enhance anomalies and trends of interest, an algorithm (Coultrip, 1982; Peeples et al., 1986) that applies bandpass and strike filters to two-dimensional digital signals was applied to the gridded potential field data. Prior to filtering, a simple (second-order) polynomial surface was subtracted from the complete Bouguer anomaly field (Fig. 5) in order to avoid edge effects. Previous studies (Wen, 1983; Daggett et al., 1986) concluded that the regional gravity field in the area can be represented by anomalies with wavelengths greater than 125 km. In addition, all anomalies with wavelengths less than 15 km were considered to be of little interest in this regional analysis. Therefore, the gravity map of primary interest from the standpoint of interpreting upper crustal features was constructed by applying a 15–125 km bandpass filter to the residual anomalies with respect to the second-order surface. The total regional field removed is shown as Figure 7. This whole process ultimately consists of substracting values on the surface in Figure 7 from the corresponding Bouguer anomaly values to produce the map shown as Figure 8. This filtered gravity map is the major result used in the interpretations discussed below. The same bandpass filter was applied to the magnetic data to produce the map shown in Figure 6.

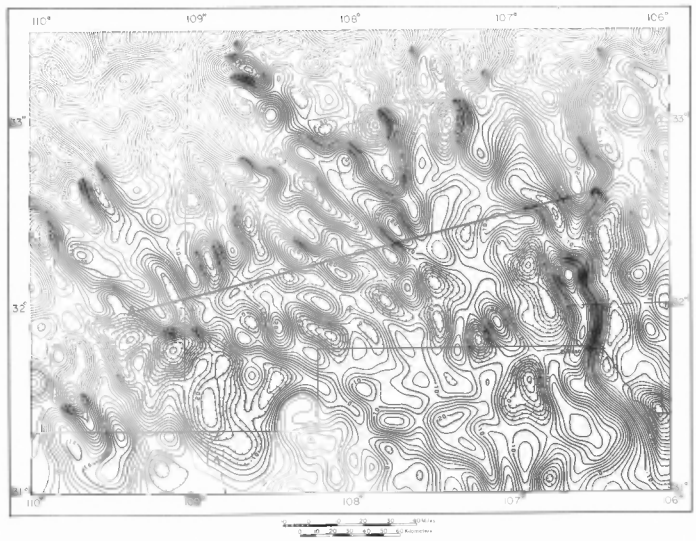


FIGURE 5. Residual gravity anomaly map in which a second-order polynomial surface was subtracted from the Bouguer anomaly values. Reduction density for Bouguer correction = 2.67 gm/cc. Contour interval = 2 milligals. A sea-level datum was used for the Bouguer correction. A–A′ is the profile modeled in Figure 10.

DISCUSSION

Two distinct trends are evident when viewing the filtered anomaly map in Figure 8. The western portion of the map is dominated by northwest-trending anomalies while the eastern area shows north–south trends. A disjointed northwest-trending gravity high dominates the center of the map. This feature correlates with the Burro uplift and roughly follows the northern margin of the Cordilleran "overthrust" belt of Drewes (1978). This belt is bounded by the Pedregosa basin to the southwest and Colorado Plateau to the north. The area of the Pedregosa basin contains a series of gravity lows which is in part due to the sediments in this basin. The Mesozoic Bisbee basin (Bilodeau, 1982) is also located in this area. To the far east lie the north–south-trending Rio Grande rift structures. This north–south trend is dominant through most of the Hueco bolson which is deflected abruptly to the southeast near El Paso. The northwest–southeast-trending Texas lineament (Muehlberger, 1980) generally coincides with this structural deflection.

Several northwest-trending positive anomalies are found in southwest New Mexico. The most prominent of these correlates with the Burro uplift (Lance et al., 1982). The width and lateral extent of these anomalies (Fig. 8) suggests that the Laramide Burro uplift (Seager and Mack, 1986) may be an extensive structural high crossing almost the entire central portion of the area. The aeromagnetic data (Fig. 6) qualitatively agree with this interpretation because sharp, positive anomalies are generally found in this same area. The computer modeling discussed below indicates the majority of the residual anomalies in the central portion of the study area are primarily due to thick sequences of Cenozoic sediments and associated locally uplifted fault blocks.

Although many local complications (for example, intrusions) exist, we feel the strike-filtered (N-S reject) map of Figure 9 accentuates the signatures of Laramide (Seager and Mack, 1986) and early Rio Grande rift (Seager et al., 1984) structures which seem to dominate much of the study area. The rejection of north–south-trending anomalies attenuates the strong influence of the youngest Rio Grande rift features. This approach may give improved estimates of the lateral extent of "overprinted" Laramide basins and uplifts. For example, the Mesilla and Jornada del Muerto basins are associated with both north–south- and northwest–southeast-trending anomalies. We feel that the strike-filtered map, in a general sense, separates the effects of the Laramide Love Ranch and Potrillo basins from the younger Cenozoic features.

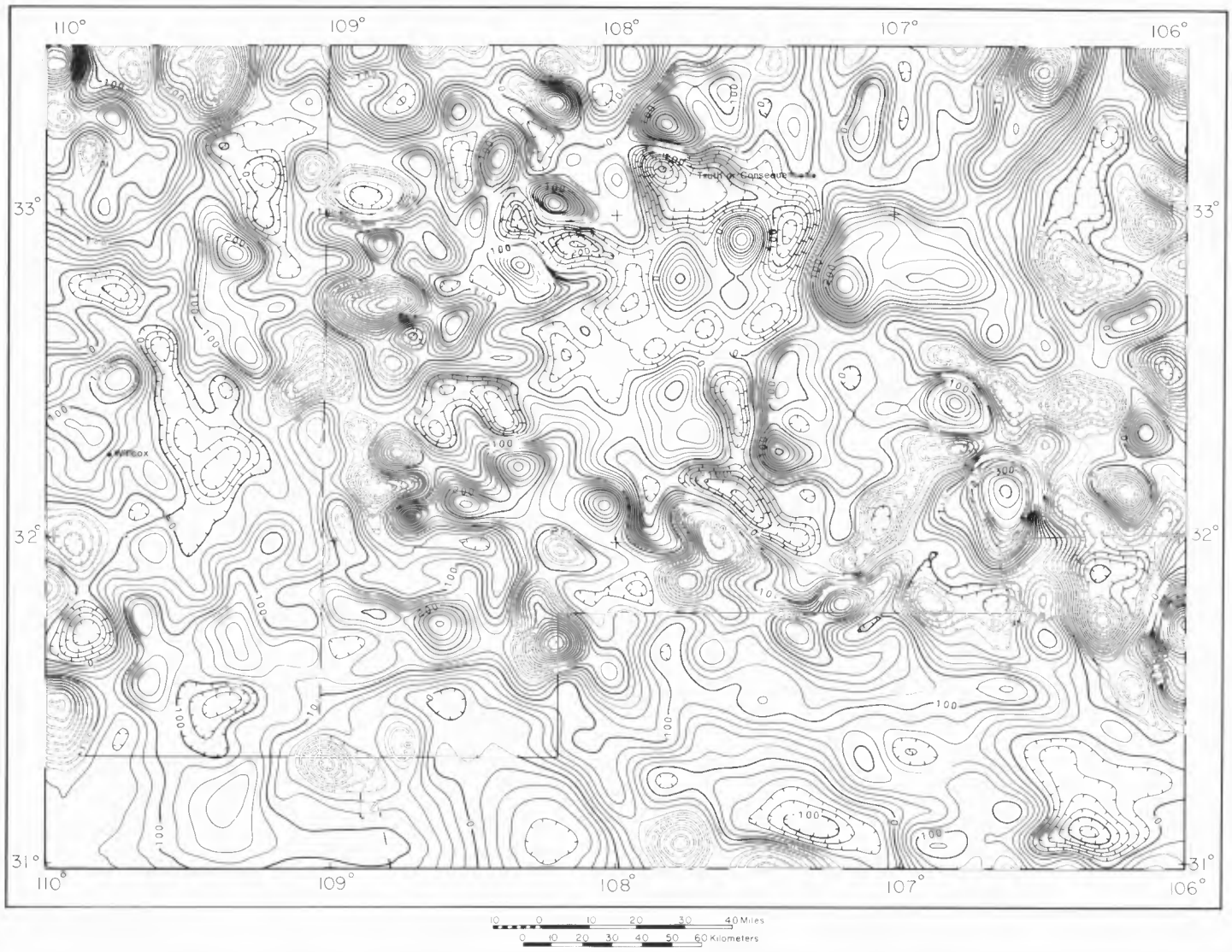


FIGURE 6. Bandpass-filtered (15–125 km) magnetic anomaly map. Contour interval = 20 gammas.

GRAVITY MODELING

As an aid to interpreting gravity data, a cross-sectional model was constructed across the area (Fig. 5). The profile is constrained by available well data and surface geology. As a first approximation, a two-body model (Fig. 10) was employed. Basinal fill was assigned a density value of 2.35 g/cc (Daggett et al., 1986). Basement features, composed of Precambrian and pre-Laramide rocks, were assigned a density of 2.7 g/cc. This approach does not discriminate between Laramide, "early rift," and "late rift" sediments. Such a discrimination is probably not possible using only the gravity data. The easternmost valley on the profile, the Jornada del Muerto basin, has the largest negative gravity anomaly associated with the profile. The magnitude of its amplitude (–18 milligals) indicates the presence of a substantial thickness (2.8 km) of Cenozoic sedimentary rocks. Other notable valley systems are the San Simon and Animas systems of southeastern Arizona and southwestern New Mexico, having Cenozoic fill thicknesses of 1.8 and 1.5 kilometers, respectively. The entire profile can be satisfactorily modeled using geologically reasonable variations in the thickness of Cenozoic sedimentary rocks.

CONCLUSIONS

Gravity and magnetic anomalies in southwestern New Mexico reflect the area's complex tectonic history. Northwest trends predominate which

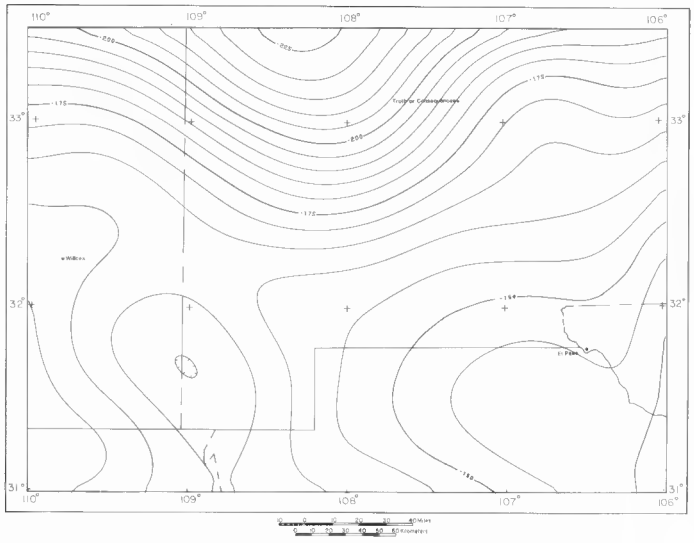


FIGURE 7. Regional gravity surface representing all anomalies greater than 125 km in wavelength. Contour interval = 5 milligals.

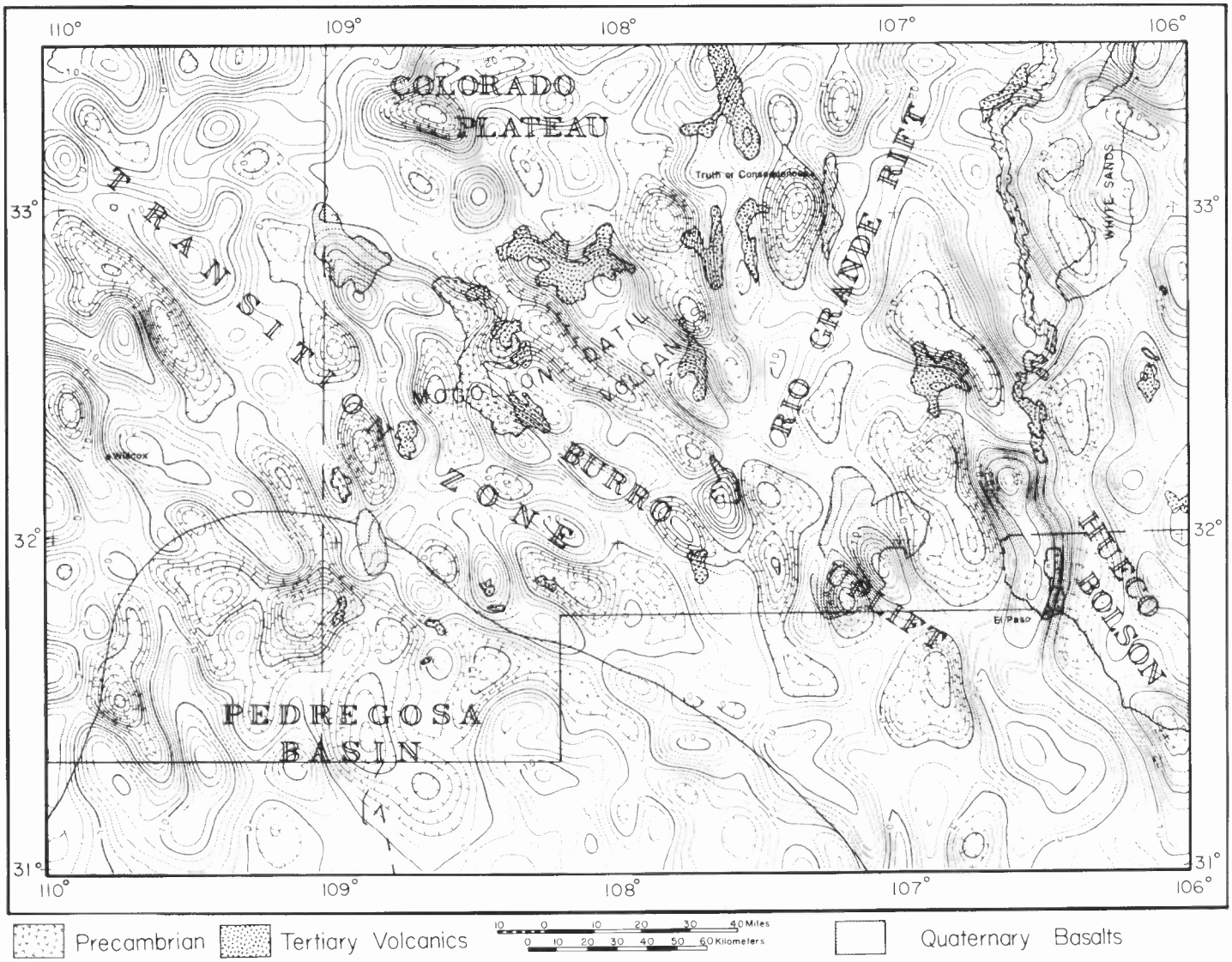


FIGURE 8. Filtered gravity anomaly map with geologic features as an overlay. A 15–125 km bandpass filter was applied to the values shown on Figure 5. Contour interval = 2 milligals.

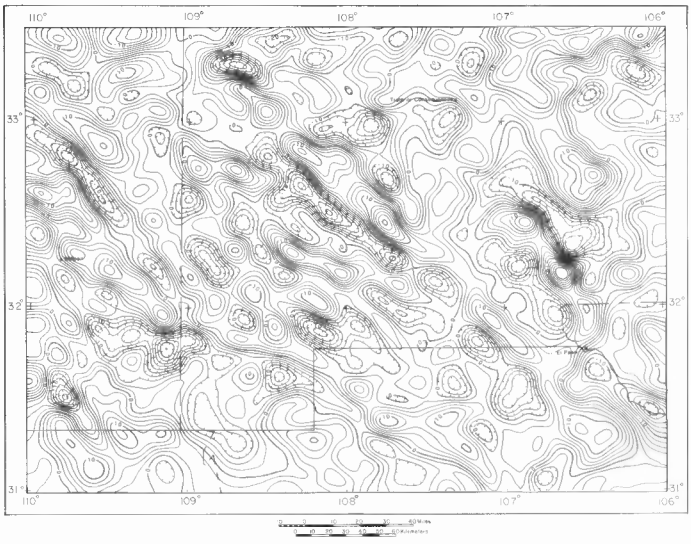


FIGURE 9. Strike-filtered residual anomaly map. Contour interval = 2 milligals. North–south-trending anomalies were rejected.

may date from Precambrian time but reflect the signatures of Laramide compression and early Rio Grande rift extension. An extensive Laramide Burro uplift is one possible interpretation of the northwest-trending gravity highs in the area.

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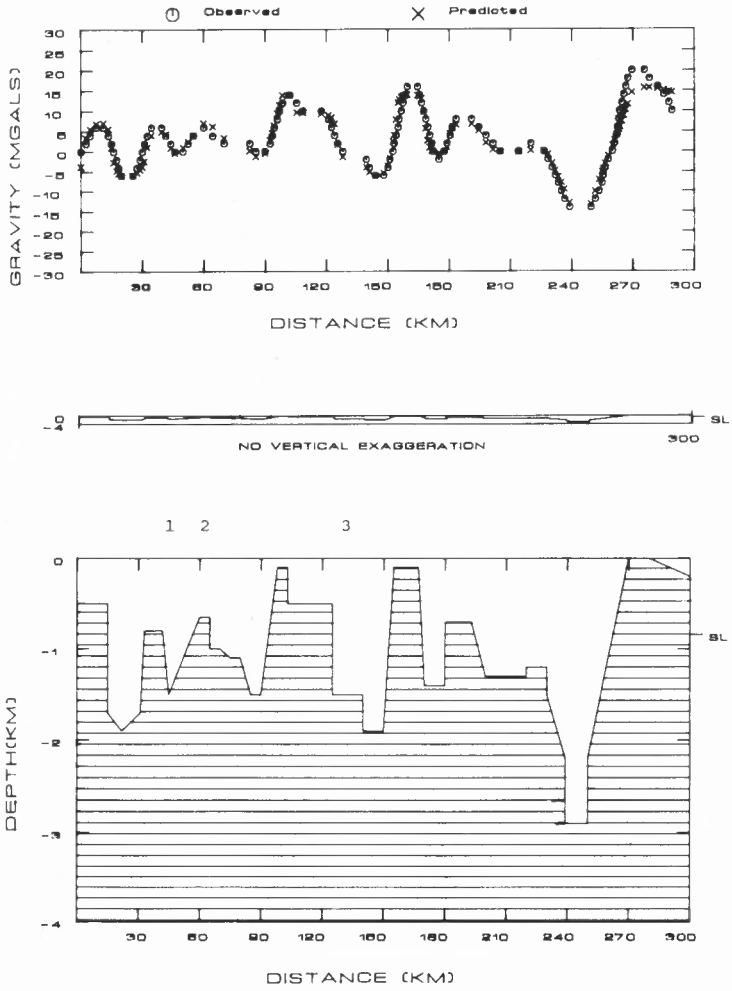


FIGURE 10. Computer model for gravity profile A–A′. The horizontal lined area is the basement (pre-Cenozoic). Wells used as constraints are numbered 1, 2 and 3, corresponding to Cockrell No. 1 (Pyramid Fed.), Cockrell No. 1 (Coyote State), and Cockrell No. 1 (State-1349), respectively. Subsurface data from Thompson (1982).

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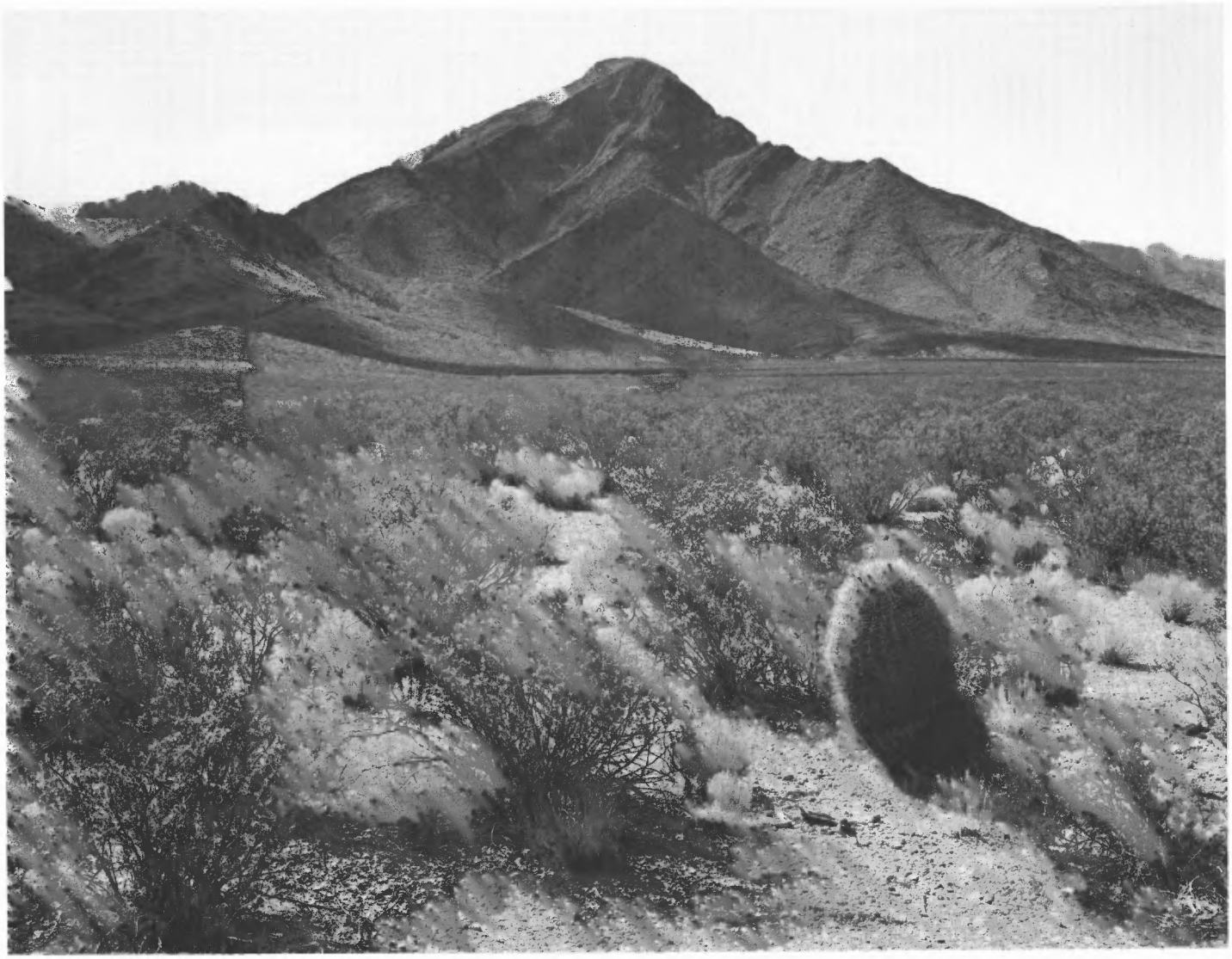
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East side of Gym Peak, Florida Mountains. View is N47°W. Gym Peak is capped by Fusselman Dolomite thrust to right over steeply-dipping El Paso and Montoya formations. Prominent inverted V-ridge in center contains about 450 m of Fusselman disconformable between underlying Montoya and overlying Oñate and/or Percha shales. In middleground to left of the Fusselman ridge, Percha is overlain by Mississippian Rancheria Formation and Lower Permian Hueco Formation. Slope in top left corner is underlain by Upper Cambrian granite south of the south Florida Mountains fault. In the foreground and middle distance the piedmont surface is a desert pavement composed of granules and pebbles. Principal shrubs are creosote and mariola. A lonely barrel cactus, rare in the Florida Mountains, is at right. Camera station is in SE¼, sec. 17, T26S, R7W. Altitude about 1305 m. W. Lambert photograph No. 87L12. 18 July 1987, 4:46 p.m., MDT.