ISOSTATIC RESIDUAL GRAVITY ANOMALIES OF NEW MEXICO

By Charles E. Heywood

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CONTENTS

Page

Abstract 1

Introduction 1

Bouguer gravity anomaly map 2

Isostatic residual gravity anomaly map 2

Isostatic correction 9
Sensitivity analysis 15
Isostatic residual anomalies 15
Uncertainty estimation 25

Summary and conclusions 25

References cited 26

FIGURES

Figure 1. Map showing locations of gravity measurements 3

2. Map showing Bouguer gravity anomalies of New Mexico and surrounding areas 4

3. Map showing topography of New Mexico and surrounding areas 6

4. Plot showing Bouguer gravity anomalies versus altitude for selected stations in New Mexico 8

5. Diagram showing the geometry of the Airy-Heiskanen compensation model 10

6. Map showing far-field isostatic correction for New Mexico 12

7. Map showing near-field isostatic correction for New Mexico 13

8. Map showing total isostatic correction for New Mexico 14

9. Map showing isostatic residual gravity anomalies of New Mexico and surrounding areas 18

10. Plot showing isostatic residual gravity anomalies versus altitude for selected stations in New Mexico 21

11. Map showing generalized geology of New Mexico 22

12. Map showing depth to top of Dakota Sandstone and isostatic residual gravity anomalies of the San Juan Basin area 23

TABLES

Page

Table 1. Sensitivity of crustal thickness to model properties 16

2. Sensitivity of near-field isostatic correction to model properties 17

CONVERSION FACTORS AND VERTICAL DATUM

1 milligal = 0.001 centimeter/second/second

Multiply	By	To obtain
	Length	
centimeter	0.3937	inch
meter	3.281	foot
kilometer	0.6214	mile
	Mass	
gram	0.03527	ounce, avoirdupois
gram	0.002205	pound, avoirdupois
	Area	
square kilometer	0.386	square mile
	Volume	
cubic centimeter	0.06102	cubic inch

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

About 50,000 gravity measurements were used to construct Bouguer and isostatic residual gravity anomaly maps of New Mexico. The Bouguer gravity anomaly map indicates a strong regional gradient due to changing crustal thickness, which obscures the anomalies of geologic interest. To facilitate quantitative modeling of these high-frequency anomalies, a correction was made for the gravitational attraction of the crustal root, assuming local Airy isostatic compensation. The resulting isostatic residual gravity anomaly map contains anomalies attributable to density variations from intracrustal sources.

INTRODUCTION

Anomalies in the Earth's gravitational acceleration can be useful for inferring subsurface geologic structure in areas where there is a density contrast between the constituent lithologies. Alluvial basins typically contain unconsolidated rocks of appreciably lower density than that of the underlying crystalline or carbonate rocks, hence gravimetry is particularly well suited to their study. It is possible to estimate the depth of a sedimentary basin from its associated gravity anomaly when the density contrast between the basin-fill sediments and the surrounding rocks is known. Quantitative estimates of the thickness and geometry of basins are possible if the densities and distribution of contrasting lithologies are constrained.

The theoretical basis of gravimetry, aspects of data processing, and practical application to geologic studies may be reviewed in standard geophysics texts such as Eaton (1974), Dobrin (1976), Nettleton (1976), Telford and others (1976), or Milsom (1989). Intermediate level treatments using potential theory may be found in Heiskanen and Vening Meinesz (1958), Garland (1979), and Torge (1989).

The gravitational acceleration measured at a point on the Earth's surface is a resultant of centrifugal acceleration and gravitation from the Earth's and celestial masses. It is a function of the altitude, latitude, and surrounding terrain configuration associated with an observation point, all of which may be uniquely determined and suitable corrections applied. Gravitational acceleration is temporally dependent on the relative locations of celestial bodies, which can be accounted for as a tidal correction. It is also dependent on the internal density distribution of the Earth's mass, which is not uniquely determined and hence is the property we wish to constrain when studying geologic structure.

A gravitational anomaly is the difference between the gravity measured at a point and that calculated from the composite of effects for a particular Earth model. The Bouguer correction accounts for the effects of altitude, latitude, and topographic mass (for an assumed density between sea level and the topographic surface) surrounding an observation point. The Bouguer gravity anomaly represents the vertical component of the anomalous gravitational field due to subsurface lateral density inhomogeneities. If the Earth's internal structure can be further constrained, the residual field will more closely reflect the gravitational effect of the mass not accounted for that we wish to quantify. The isostatic residual anomaly is the result of such a refinement. This investigation, a cooperative project with the New Mexico State Engineer Office, is part of an effort to quantify the usable ground water in selected alluvial basins throughout New Mexico. The results of the investigation may also be useful to those interested in geologic structure for other mineral assessments or tectonic studies.

This report describes a statewide gravity data coverage that is appropriate for modeling the structure and depth of large alluvial basins in New Mexico. The gravity-contour, topographic-contour, and geologic maps were developed from an associated digital data base. For purposes of detailed studies and modeling efforts, appropriate data can be extracted from the digital data base.

A specific density distribution or geologic structure may be inferred from these gravity data alone, but will be non-unique in the sense that other models will determine the same anomaly pattern. It is therefore essential to constrain any interpretation with other available geologic or geophysical data.

The author wishes to express his gratitude to Randy Keller of the University of Texas at El Paso for providing a significant portion of the raw gravity observations. Mike Webring of the U.S. Geological Survey offered technical advice.

BOUGUER GRAVITY ANOMALY MAP

Approximately 50,000 gravity measurements (location, altitude, and observed gravity) in New Mexico and a 45-minute surrounding halo were extracted from data bases of the Defense Mapping Agency and the University of Texas at El Paso. About 200 new gravity measurements were made in central and southwest New Mexico. All data are referenced to the International Gravity Standardization Net (IGSN) of 1971 (Morelli and others, 1974). The locations of the observations are plotted in figure 1 and indicate the relative density of coverage in various parts of the State. The gravitational effect of topographic mass was corrected for each measurement by computing a digital terrain correction with the algorithm of Plouff (1977). Free-air and Bouguer anomalies were calculated for all stations using a reduction density of 2.67 grams per cubic centimeter by the equations outlined by Cordell and others (1982). Computed Bouguer gravity anomalies, contoured using a 5-milligal interval, are plotted in figure 2.

The Bouguer gravity map shows a strong regional gradient becoming generally more negative from the southeast toward the northwest. This gradient tends to obscure local anomalies of geologic interest and complicates the quantitative modeling in large sedimentary basins and in areas of significant vertical relief. Figure 3 is a contour map of the surface topography of New Mexico. Comparison of figure 3 with figure 2 shows that increases in altitude tend to correlate with increasing Bouguer anomalies. This is further illustrated in figure 4, which is a plot of Bouguer gravity anomalies versus altitude for gravity of stations on pre-Quaternary rock. The regression line indicates a negative correlation of altitude with Bouguer gravity of 0.11 milligal per meter. A similar relation was observed by Mabey (1960, 1966) in Idaho and Nevada and is attributable to the existence of compensating crustal mass beneath topographic loads (Airy, 1855; Heiskanen and Vening Meinesz, 1958; Woolard, 1959).

ISOSTATIC RESIDUAL GRAVITY ANOMALY MAP

Although the Bouguer reduction process removes the gravitational effect of topography to sea level, the effect of the compensating mass at depth is not accounted for and hence a correlation with topography still exists. To enhance the signal due to intracrustal density contrasts, it is desirable to make a correction to remove this effect.

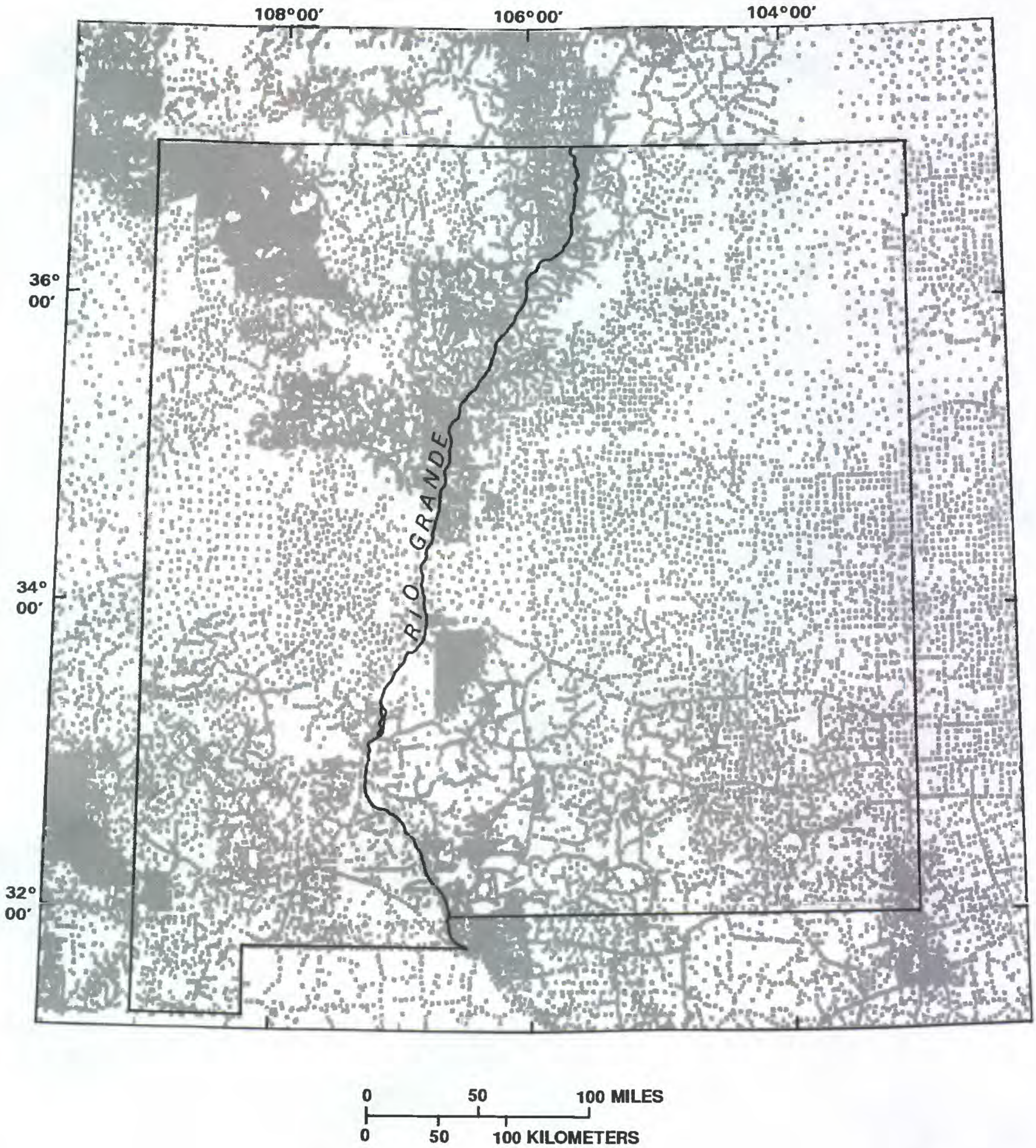

Figure 1.--Locations of gravity measurements.

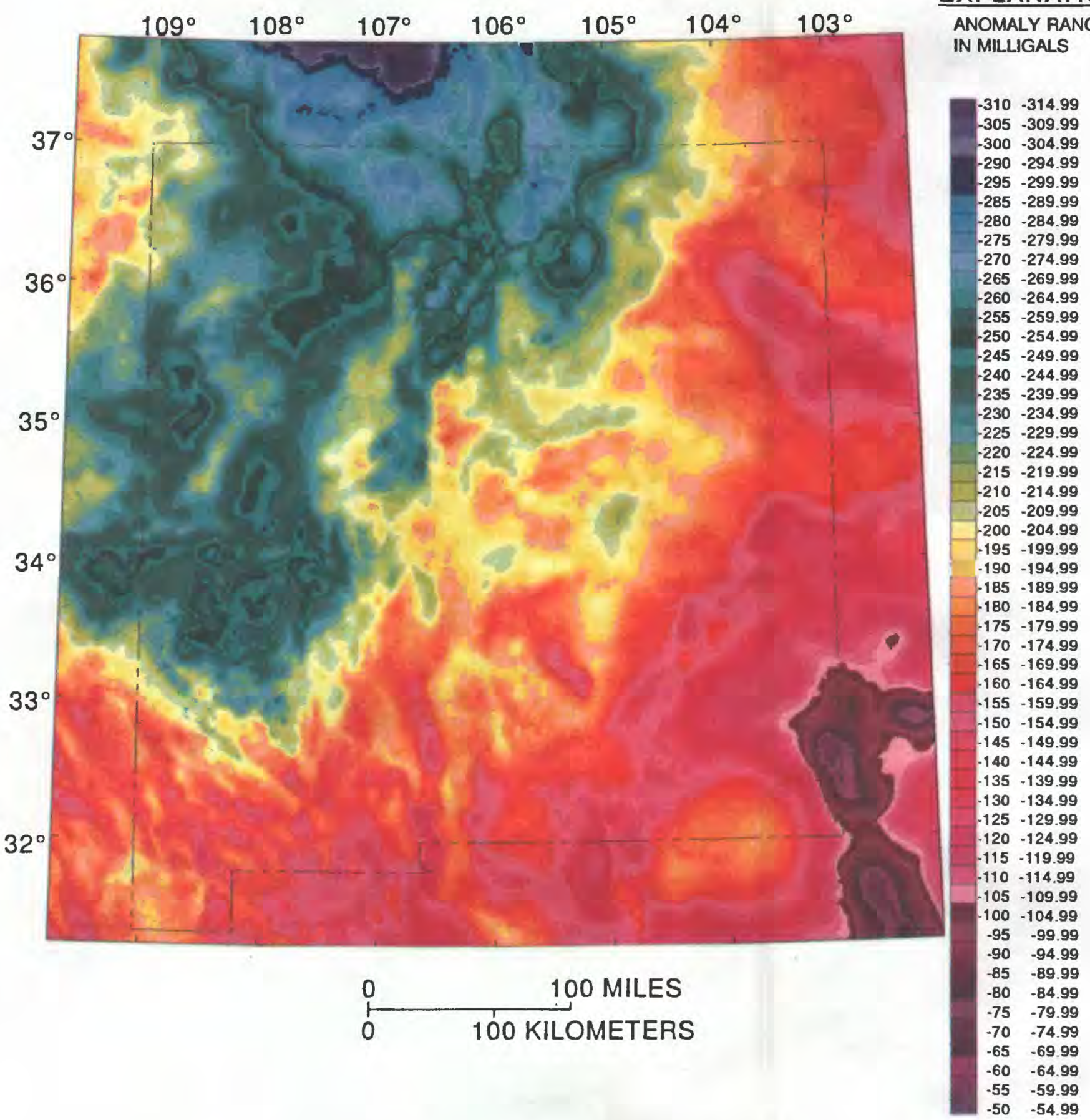

Figure 2.--Bouguer gravity anomalies of New Mexico and surrounding areas.

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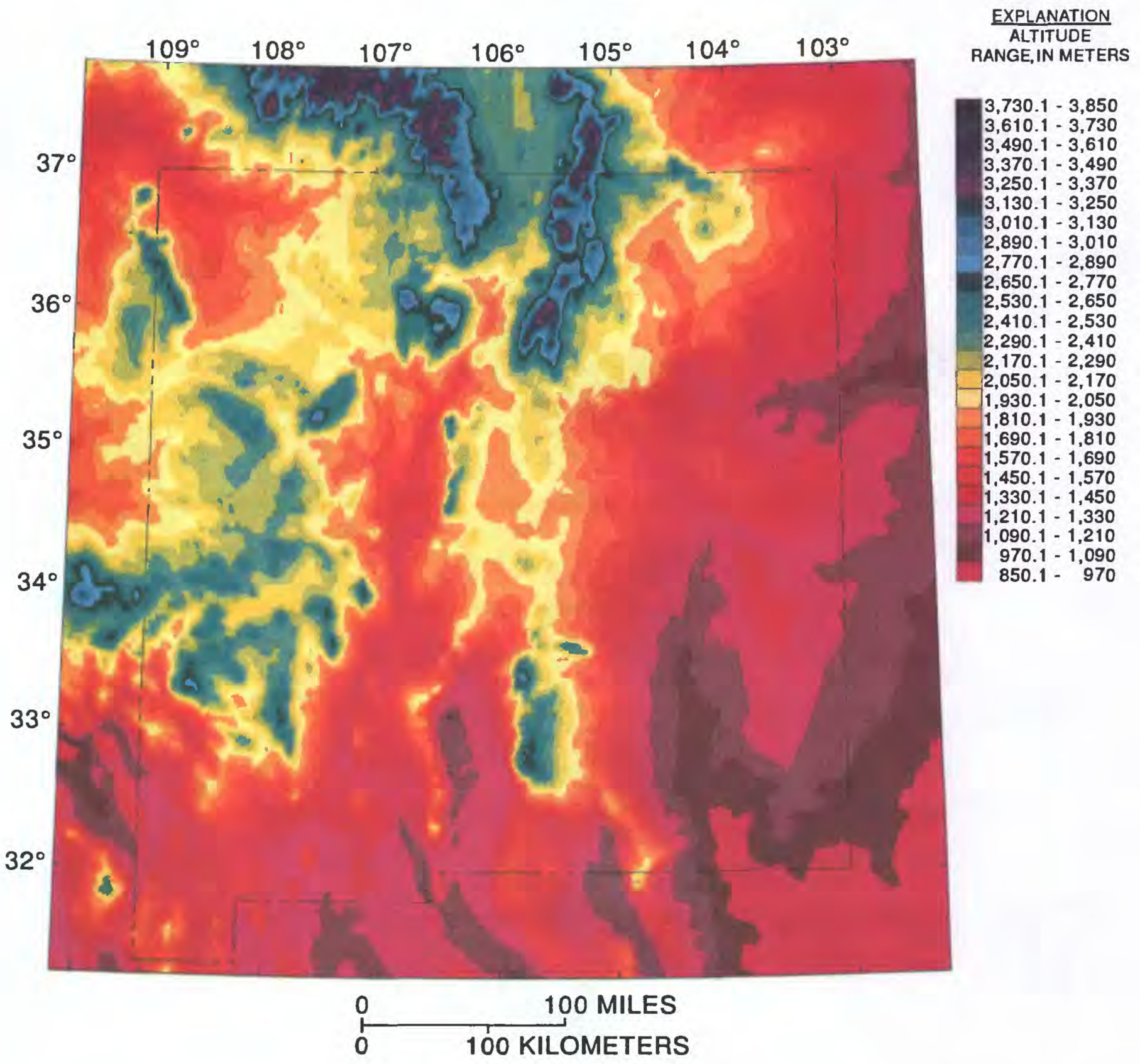

Figure 3.--Topography of New Mexico and surrounding areas.

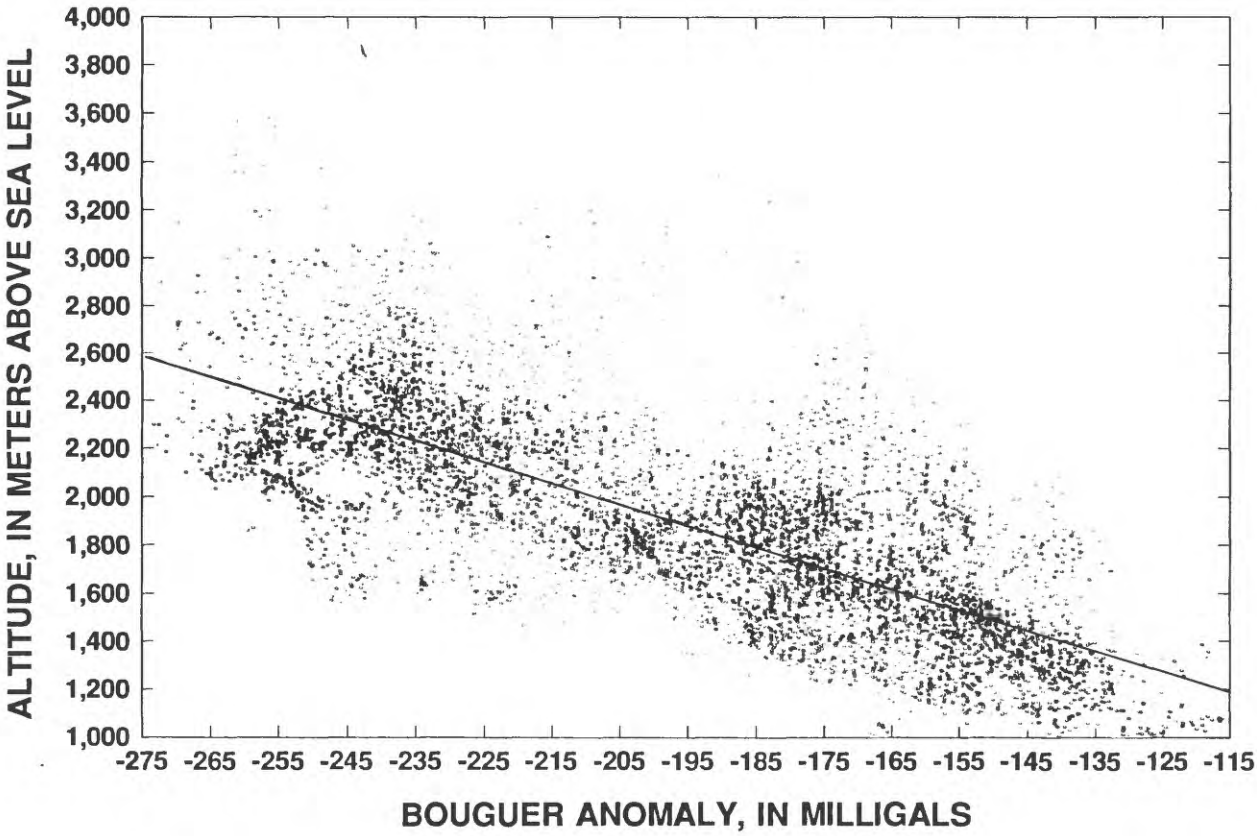

Figure 4.--Bouguer gravity anomalies versus altitude for selected stations in New Mexico.

Isostatic Correction

Several methods of removing the topography-induced regional gravity gradients were tested. Because these gradients tend to be long in wavelength, they can be separated and removed by wavelength filtering or by subtraction of an appropriately fitted polynomial surface (Wen, 1983). Such techniques have the disadvantage of potentially removing long-wavelength signals from intracrustal sources of geologic interest. Alternatively, a correction may be applied based upon a smoothed version of topography. Such smoothing suppresses high-frequency topographic variations, resulting in a model of isostatic compensation of the regional topographic load. By designing a smoothing function related to the expected depth of compensation and applying an appropriate factor for conversion from a topographic load to a gravitational field, one may produce a regional gravitational field that correlates with topography and can be used as a correction.

This approach was tested by applying an upward continuation filter (essentially an exponential smoothing function) to a gridded representation of topography with the program FFTFIL (Hildebrand, 1983). A continuation distance of 30 kilometers was used, which is the approximate crustal thickness in southwest New Mexico (Daggett and others, 1986). By assuming a density of 2.67 grams per cubic centimeter, the gravitational effect of this mass was estimated and approximates that due to a smooth compensating crustal root. For the region of southwest New Mexico to which this correction was applied, the topographic correlation was effectively removed from the residual gravitational field. This approach, however, uses the assumption of planar input to the upward continuation filter, which is not rigorously valid. Furthermore, a single continuation distance is not appropriate for the entire State, where the crustal thickness changes markedly. This approach was therefore abandoned in favor of the isostatic model to be described next. For the region in which this approach was tested, the resulting regional field agreed very well with that calculated by the isostatic model. It may well be that this is a useful short-cut technique for removal of regional gradients in localized studies or in areas of relatively homogeneous deep crustal structure.

A general philosophy in geophysical modeling is to correct for known effects as accurately as possible to isolate anomalies that are due to unknown sources. Because some isostatic mechanism undoubtedly exists for the Earth's crust, an isostatic model was used to correct for the topographically related regional field. A model was chosen that defines the gravitational effect of compensating crustal mass to a topographic load according to the Airy hypothesis for local isostatic compensation. Local compensation assumes that the compensating mass is directly beneath the crustal load. This assumption is only an approximation because the lithosphere retains finite flexural rigidity even in extensional environments (Weissel and Karner, 1989) that may distribute compensation regionally. The assumption has the advantage, however, of requiring a minimum of model properties, and deviations from the assumption may be evaluated in terms of the resultant anomalies. Moreover, local compensation is a good approximation for the Western United States, where the isostatic response function has been determined to be essentially local in nature (McNutt, 1980). This approximation may be particularly valid in central and southwestern New Mexico where the Rio Grande rift and basin and range morphology illustrate crustal thinning and weakness (Eaton, 1979). Furthermore, as pointed out by Simpson and others (1986), differences between most reasonable isostatic models tend to be long in wavelength and small in amplitude. Because the focus of this study is on short-wavelength residual anomalies, these differences between isostatic models do not justify making the additional assumptions of crustal elastic properties needed for a distributed compensation model.

The geometry and properties of the Airy-Heiskanen compensation model are depicted in figure 5. The topographic load may be defined by an altitude above sea level (e) and a topographic density (ρ_t). The normal crustal thickness (d_s), or compensation depth, is that which exists below a land surface at sea level. The crustal thickness (d) below sea level at any point is uniquely defined by the topographic load above sea level, the normal crustal thickness (d_s), and the density contrast at depth across the crust/mantle interface ($\Delta\rho$) according to the equation:

$$d = d_s + e\left(\frac{\rho_t}{\Delta\rho}\right) \tag{1}$$

The anomalous gravitational field at sea level due to the crustal root of varying thickness (d) within a specified horizontal radius may then be calculated. Upward continuation of this field to the altitude of the gravity measurement then defines the isostatic correction to be applied to the Bouguer anomaly.

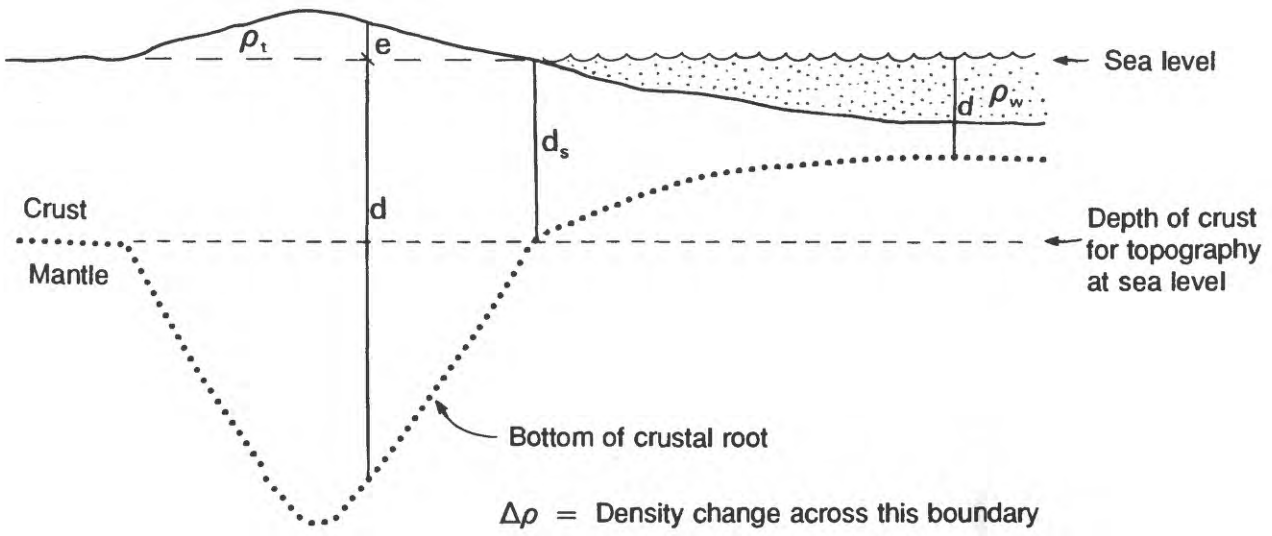

Figure 5.--Geometry of the Airy-Heiskanen compensation model (modified from Simpson and others, 1983).

For computational convenience, the isostatic correction was split into two components, which are termed "near-field" and "far-field" in this report. The near-field correction is the computed gravitational effect of compensating mass within a cylinder 166.7 kilometers in radius. The far-field correction is the computed combined gravitational effect of topography and compensating mass from 166.7 kilometers to the antipode. Karki and others (1961) calculated the far-field effect for the world according to the Airy-Heiskanen compensation model. They used a normal crustal thickness (d_s) of 30 kilometers, a topographic density (ρ_t) of 2.67 grams per cubic centimeter, and a density contrast at depth ($\Delta\rho$) of 0.6 gram per cubic centimeter. This far-field isostatic correction is contoured at a 2-milligal interval and presented in figure 6. The negative north-northwest gravitational gradient is largely due to the Rocky Mountains. The model properties used in this calculation are not optimal for New Mexico, but the gravitational effect of the difference between these and the optimal properties is small for this far-field calculation compared to the near-field calculation.

The program AIRYROOT (Simpson and others, 1983) was used to calculate the gravitational attraction at sea level of the crustal root out to a radius of 166.7 kilometers. This program employs the algorithm of Parker (1972), which uses a fast Fourier transform technique to calculate the gravitational field anomalies on a flat Earth to infinity. For this near-field calculation (within 166.7 kilometers), the effects of earth curvature are negligible and the flat Earth approximation is accurate. Computational details may be found in Blakely (1981). The gravitational field from 166.7 kilometers out to infinity is then calculated by numerical integration of a Bessel function. The difference between these two calculations is the attraction of the root inside a cylinder of 166.7 kilometers in radius. Data requirements for the program are a gridded altitude set and a density to define the topographic load, a normal crustal thickness, and the density contrast at depth. The program was tested on a sample data set by comparing output from an independent program, ISOCOMP (Jachens and Roberts, 1981), which computes an isostatic correction by directly calculating and summing the gravitational effect of a set of mass prisms. Agreement between the two programs was within 0.5 milligal. AIRYROOT was favored for the near-field calculation because its computational algorithm is much more efficient, allowing rapid experimentation with the model properties for sensitivity analysis.

For the near-field calculation, a normal crustal thickness of 20 kilometers and a density contrast at depth of 0.3 gram per cubic centimeter were chosen. Surface topography was assigned the Bouguer reduction density of 2.67 grams per cubic centimeter. This combination of model properties produced the best fit for overall crustal thicknesses determined from seismic and gravity observations for southern New Mexico and the Colorado Plateau (Daggett and others, 1986; Sinno and others, 1986; Mooney and Braile, 1989). The effect of uncertainty in this choice of properties is discussed in the section on sensitivity analysis. For input altitudes, digital topography at a 3-arc-minute spacing for the southwestern United States and Mexico was projected to a grid with a 5-kilometer spacing. Areas of Mexico for which 3-arc-minute data were not available were interpolated to a 3-arc-minute interval from a 5-arc-minute data set (R.W. Simpson, U.S. Geological Survey, written commun., 1990). A 250-kilometer margin of digital topography around the study area was required by the model to calculate the root gravity effect out to 166.7 kilometers and to prevent edge effects in calculating a Fourier transform. The overall grid dimensions of 1,270 kilometers by 1,400 kilometers encompass 1,778,000 square kilometers centered on New Mexico. The computed near-field isostatic correction at sea level is contoured at a 10-milligal interval and plotted in figure 7. This represents the gravitational field due to the crustal root within a horizontal radius of 166.7 kilometers.

The near-field correction (fig. 7) was added to the far-field correction of topography and compensating crustal root (fig. 6). The resultant total isostatic correction is contoured at a 10-milligal interval and plotted in figure 8.

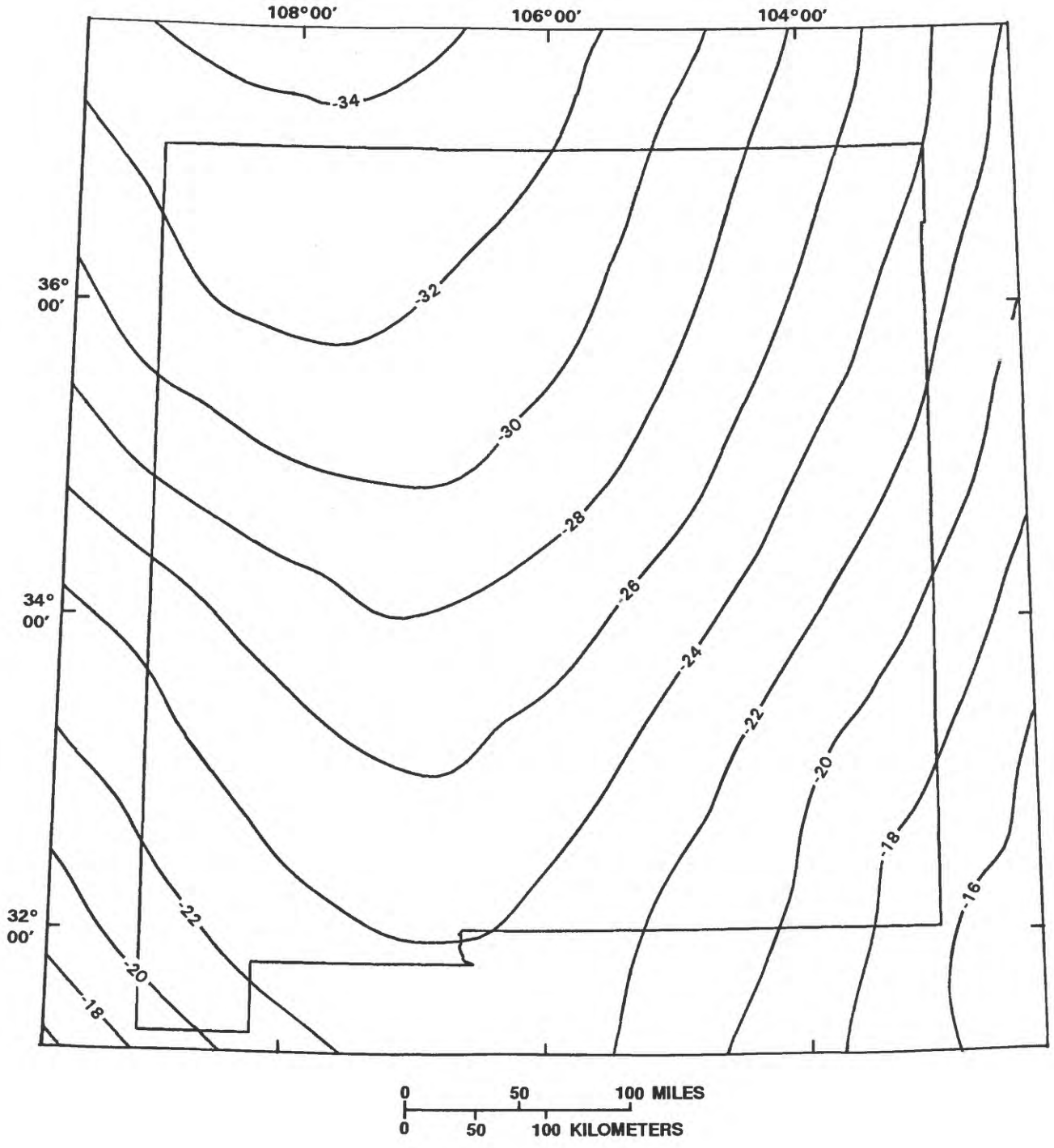

Figure 6.--Far-field isostatic correction for New Mexico (data from Karki and others, 1961).

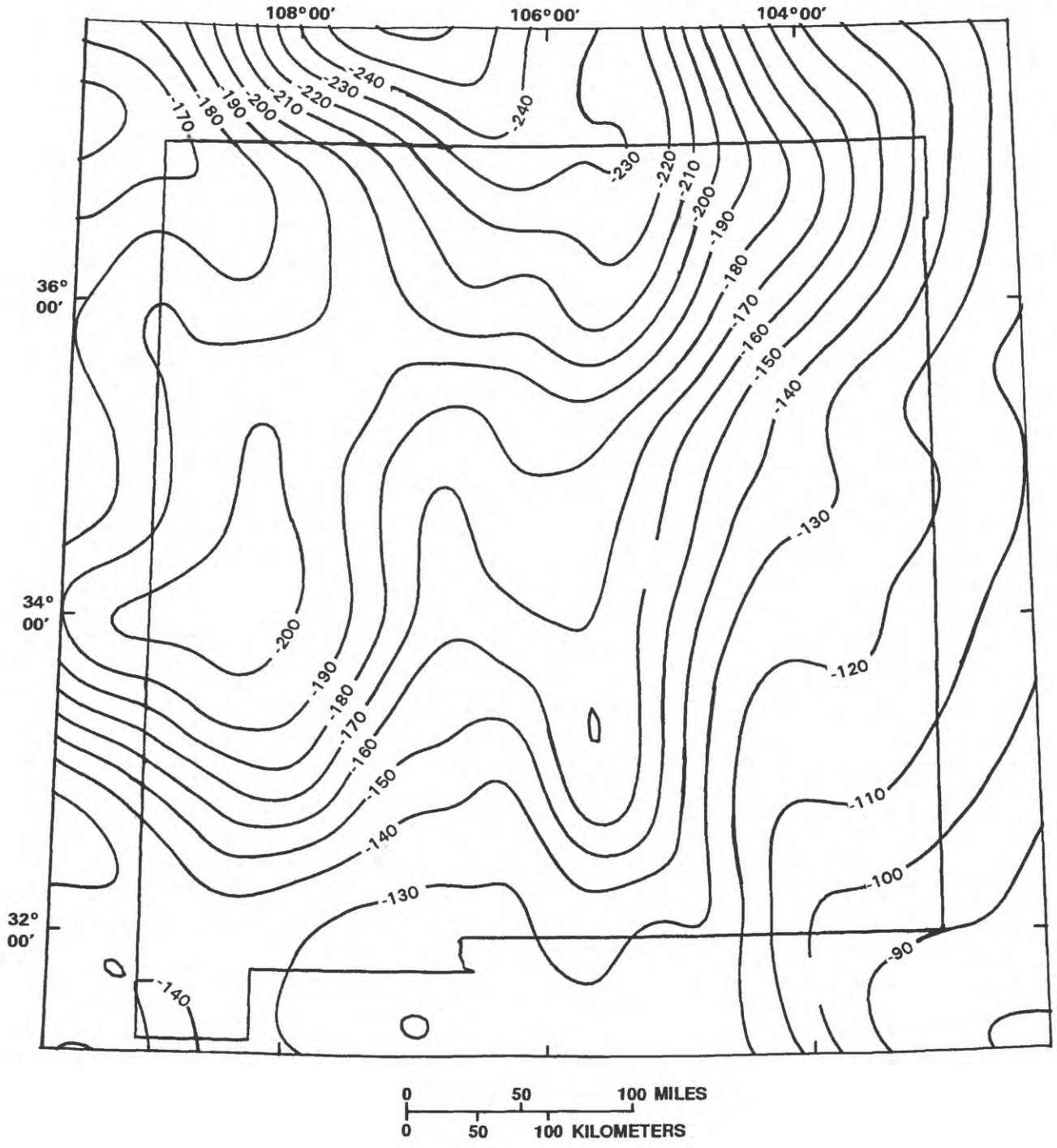

Figure 7.--Near-field isostatic correction for New Mexico.

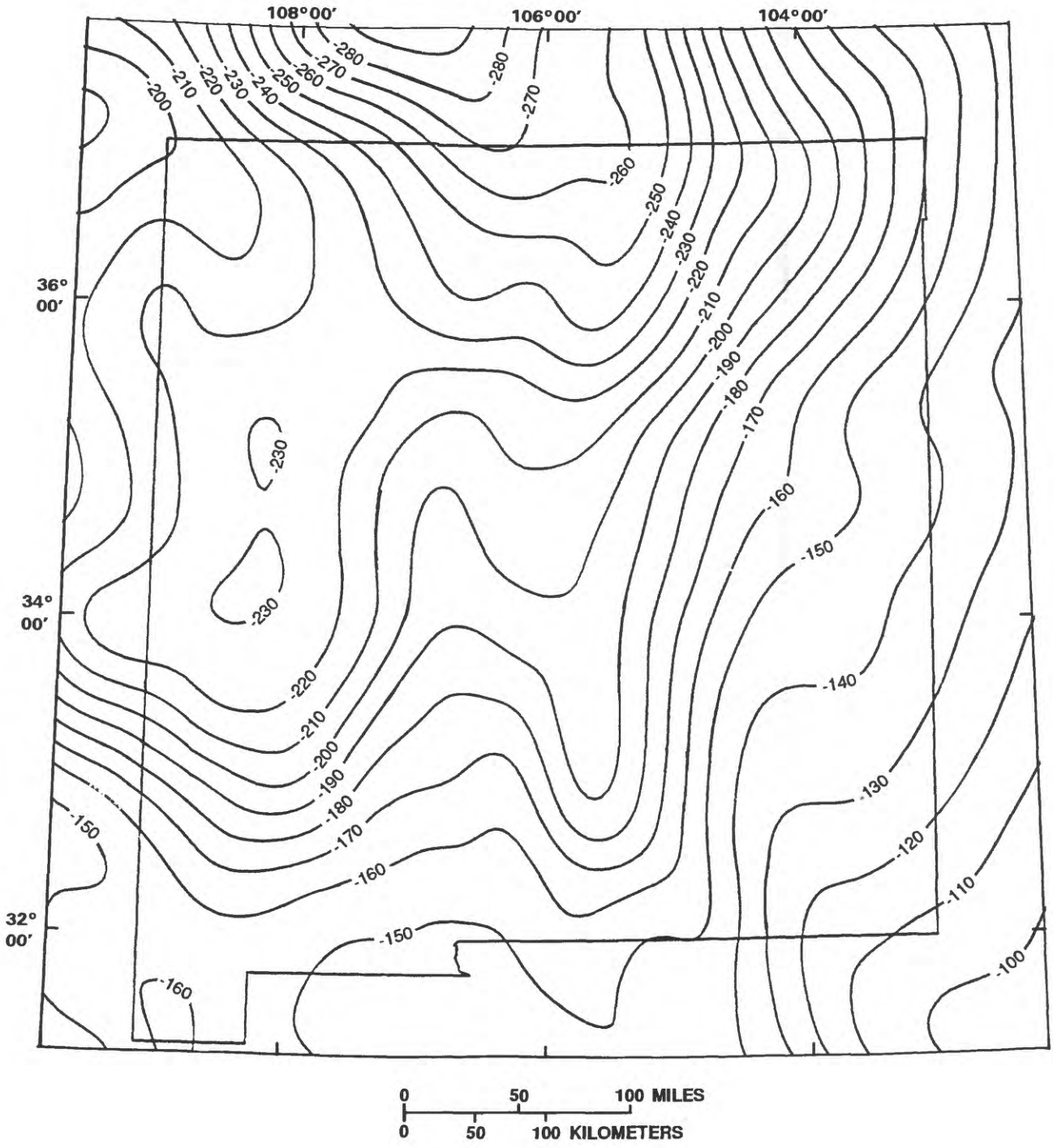

Figure 8.--Total isostatic correction for New Mexico.

Sensitivity Analysis

To test the sensitivity of the computed near-field isostatic correction to the model input properties of normal crustal thickness (d_s) and density contrast across the crust/mantle interface ($\Delta\rho$), 25 separate program runs were made with different combinations of these two properties. The topographic load was held fixed for all runs by retaining the Bouguer reduction density of 2.67 grams per cubic centimeter as the topographic density.

The effect of these model properties on the crustal thickness (d) computed by equation (1) is presented in table 1. For each combination of model input properties, maximum, median, average, and minimum crustal thickness (d) values are presented. The maximum value represents a crustal thickness beneath the central Colorado Rocky Mountains. The median and average values are representative of crustal thicknesses beneath alluvial basins in southwest New Mexico. The minimum value represents an oceanic crustal thickness in the Gulf of California. As mentioned in the previous section, $\Delta\rho$ equaling 0.3 gram per cubic centimeter and d_s equaling 20 kilometers gave the best fit of computed crustal thickness to that measured in the various tectonic provinces in New Mexico. The maximum and minimum computed crustal thicknesses for this choice of properties are also realistic for oceanic crust and a thick root beneath a mountain chain (Garland, 1979).

The effect of different combinations of model properties on the computed near-field isostatic correction is presented in table 2. For each combination of model input properties, a maximum, average, and minimum near-field isostatic correction is presented. The maximum value corresponds to the near-field isostatic correction above oceanic crust in the Gulf of California. The average value is typical of a correction for southwest New Mexico. The minimum value represents the correction in a broad region of high altitude, the central Colorado Rocky Mountains.

Deviations in the values of d_s and $\Delta\rho$ of as much as 5 kilometers and 0.05 gram per cubic centimeter, respectively, from the utilized best-fit values may still give reasonable values of crustal thicknesses. For average topography in New Mexico, this amounts to an uncertainty in the near-field isostatic correction of 2 to 5 milligals. The difference between model properties used for the far-field (fig. 6) and near-field (fig. 7) components of the isostatic correction results in a mismatch of about 4 milligals in most areas, or about 12 percent of the far-field component. The far-field component is generally about 15 percent of the total isostatic correction in New Mexico, thus this error amounts to less than 2 percent of the total isostatic correction. Because this is a long-wavelength error, its effect on analysis of the isostatic residual anomalies is negligible.

Isostatic Residual Anomalies

To calculate the isostatic residual anomaly associated with each gravity measurement, the total isostatic correction at sea level (fig. 8) was upward-continued as a potential field to altitudes of 2 and 4 kilometers. The geographic location of each measurement was interpolated within these three grids to determine the appropriate isostatic correction at each grid altitude. The isostatic correction at the actual station altitude was then found by linear interpolation between these values, or extrapolation for station altitudes greater than 4 kilometers. This isostatic correction was then subtracted from the corresponding Bouguer anomaly (fig. 2) for that measurement to yield the isostatic residual gravity anomaly. Because a terrain correction out to 166.7 kilometers was performed in the Bouguer reduction process, this isostatic residual anomaly has complete topographic and isostatic correction. These isostatic residual anomalies were contoured with a 5-milligal interval and plotted in figure 9.

Table 1.--*Sensitivity of crustal thickness to model properties*

Crustal thickness for sea-level altitudes (d_s), in kilometers below sea level	Density contrast across crust/mantle interface ($\Delta\rho$), in grams per cubic centimeter				
	0.20	0.25	0.30	0.35	0.60
	Computed crustal thickness (d), in kilometers				
10.0					
Maximum	61.30	51.04	44.20	39.31	27.10
Median	31.15	26.02	22.73	20.91	16.36
Average	25.86	22.67	20.55	19.04	15.25
Minimum	1.00	1.00	1.25	2.50	5.63
15.0					
Maximum	66.30	56.04	49.20	44.31	32.10
Median	34.09	30.27	27.73	25.91	21.36
Average	30.83	27.64	25.52	24.01	20.22
Minimum	1.88	4.50	6.25	7.50	10.63
20.0					
Maximum	71.30	61.04	54.20	49.31	37.10
Median	39.09	35.27	32.73	30.91	26.36
Average	35.81	32.62	30.50	28.98	25.20
Minimum	6.88	9.50	11.25	12.50	15.63
25.0					
Maximum	76.30	66.04	59.20	54.31	42.10
Median	44.09	40.27	37.73	35.91	31.36
Average	40.77	37.60	35.49	33.97	30.18
Minimum	11.88	14.50	16.25	17.50	20.63
30.0					
Maximum	81.30	71.04	64.20	59.31	47.10
Median	49.09	45.27	42.73	40.91	36.36
Average	45.74	42.56	40.45	38.94	35.16
Minimum	16.88	19.50	21.25	22.50	25.63

Table 2.--*Sensitivity of near-field isostatic correction to model properties*

Crustal thickness for sea-level altitudes (d_s), in kilometers below sea level		Density contrast across crust/mantle interface ($\Delta\rho$), in grams per cubic centimeter				
		0.20	0.25	0.30	0.35	0.60
		Computed near-field isostatic correction, in milligals				
10.0						
	Maximum	67.70	84.04	94.96	92.04	85.84
	Average	-133.66	-135.70	-137.08	-138.07	-140.58
	Minimum	-272.60	-283.57	-291.60	-297.72	-315.33
15.0						
	Maximum	87.59	82.54	79.58	77.65	73.40
	Average	-129.15	-131.17	-132.54	-133.52	-136.00
	Minimum	-261.44	-271.60	-279.02	-284.71	-300.68
20.0						
	Maximum	73.59	70.10	68.01	66.63	63.55
	Average	-124.73	-126.72	-128.06	-129.02	-131.46
	Minimum	-250.76	-260.30	-267.21	-272.46	-287.08
25.0						
	Maximum	62.95	60.41	58.87	57.84	55.50
	Average	-120.39	-122.33	-123.65	-124.59	126.99
	Minimum	-240.59	-249.51	-255.96	-260.85	-274.29
30.0						
	Maximum	54.51	52.59	51.41	50.63	48.79
	Average	-116.13	-118.02	-119.31	-120.24	-122.59
	Minimum	-230.84	-239.21	-245.23	-249.79	-262.24

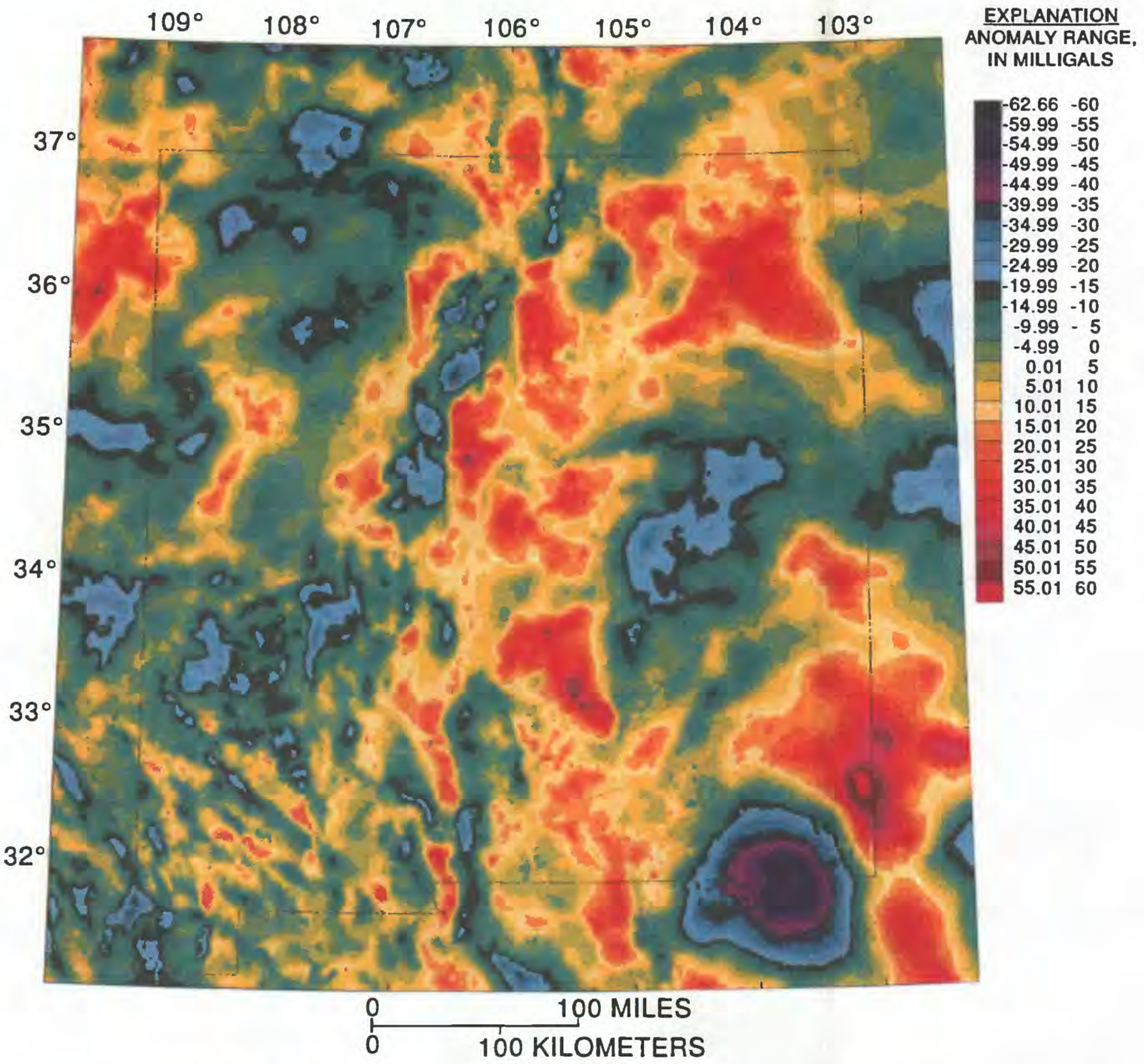

Figure 9.--Isostatic residual gravity anomalies of New Mexico and surrounding areas.

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Comparison of figure 3 with figure 9 reveals that the regional correlation with altitude that was present in the map of Bouguer gravity (fig. 2) has been removed. Individual anomalies may still be associated with topographic features because geologic structure is frequently expressed topographically. Figure 10 is a plot of isostatic residual gravity anomalies versus altitude for the same sampling of data stations as in figure 4. The lack of correlation between the isostatic residual anomalies and altitude and the tighter magnitude range of the isostatic anomalies compared to the range in Bouguer anomalies in figure 4 illustrate the effectiveness of the isostatic correction in removing the gravitational effect of deep crustal mass. Short-wavelength (less than 160 kilometers) isostatic residual anomalies in figure 9 are the result of density inhomogeneities due to geologic structure within the crust. Longer wavelength anomalies due to inhomogeneities in the upper mantle or regional changes in gross crustal composition may be present as well.

Figure 11 is a generalized map of the surficial geology of New Mexico. Comparison with the isostatic residual gravity anomalies map (fig. 9) reveals that isostatic residual anomaly highs often are related to structural highs composed of crystalline basement and Paleozoic carbonates, and to mafic volcanic units. Isostatic residual anomaly lows usually are associated with sedimentary basins and thick sequences of low-density, felsic, volcanic rock. These anomalies may be used to model the thickness of alluvial deposits in the sedimentary basins. Such calculations are useful for making quantitative estimates of stored ground water and for developing three-dimensional ground-water flow models.

Gravity anomalies frequently reveal geologic features not evident from examination of surficial geology alone. The prominent "bulls-eye" negative anomaly in southeast New Mexico (fig. 9) delineates the Permian Delaware Basin, which contains thick sequences of low-density evaporites and clastic rocks (Oriel and others, 1967). The positive anomaly to the east (fig. 9) corresponds to the location of the Capitan reef complex, which contains high-density carbonate rocks, and may also reflect a high-density mafic intrusion within the basement (Keller and others, 1980).

Figure 12 is a plot of isostatic residual gravity anomalies and depth to the top of the Cretaceous Dakota Sandstone in the San Juan Basin area in northwestern New Mexico and southwestern Colorado. The San Juan Basin contains primarily Pennsylvanian to Tertiary consolidated sedimentary rocks. These strata have a sufficient thickness and density contrast with adjacent rocks to produce a significant gravitational anomaly. Because there are sufficient well data to provide good structural control in this basin, this is a good opportunity to demonstrate the gravimetric expression of a sedimentary basin. The contour lines of depth to the Cretaceous Dakota Sandstone reflect both topography and the areal extent and shallow structure of the basin, which deepens to the north-northeast as an asymmetric synform. The negative values of isostatic residual gravity within the basin reflect the presence of thick sequences of low-density sedimentary rock. Although the depth to the Dakota Sandstone and thickness of post-Upper Cretaceous sediments increases fairly uniformly toward the north-northeast, several sizeable isostatic residual anomalies in the south and west-central parts of the basin reflect structure beneath the Dakota Sandstone. The large negative anomalies labeled A and B in figure 12 may be the gravimetric signature of basement depressions filled with Cambrian to Jurassic sedimentary rock. Alternatively, there may be zones within the Precambrian basement composed of quartzite or felsic metavolcanic rocks (Cordell and Grauch, 1987). Such rock types have a density less than that of typical basement granites, and would therefore produce a negative gravitational anomaly. The anomalous residual gravity high labeled C in figure 12 spatially correlates with a magnetic anomaly (Cordell and Grauch, 1987) and may represent a mafic intrusion within the sedimentary superstructure beneath the Dakota Sandstone. Such a large intrusive structure as well as basement depressions would influence deep fluid migration patterns within the basin.

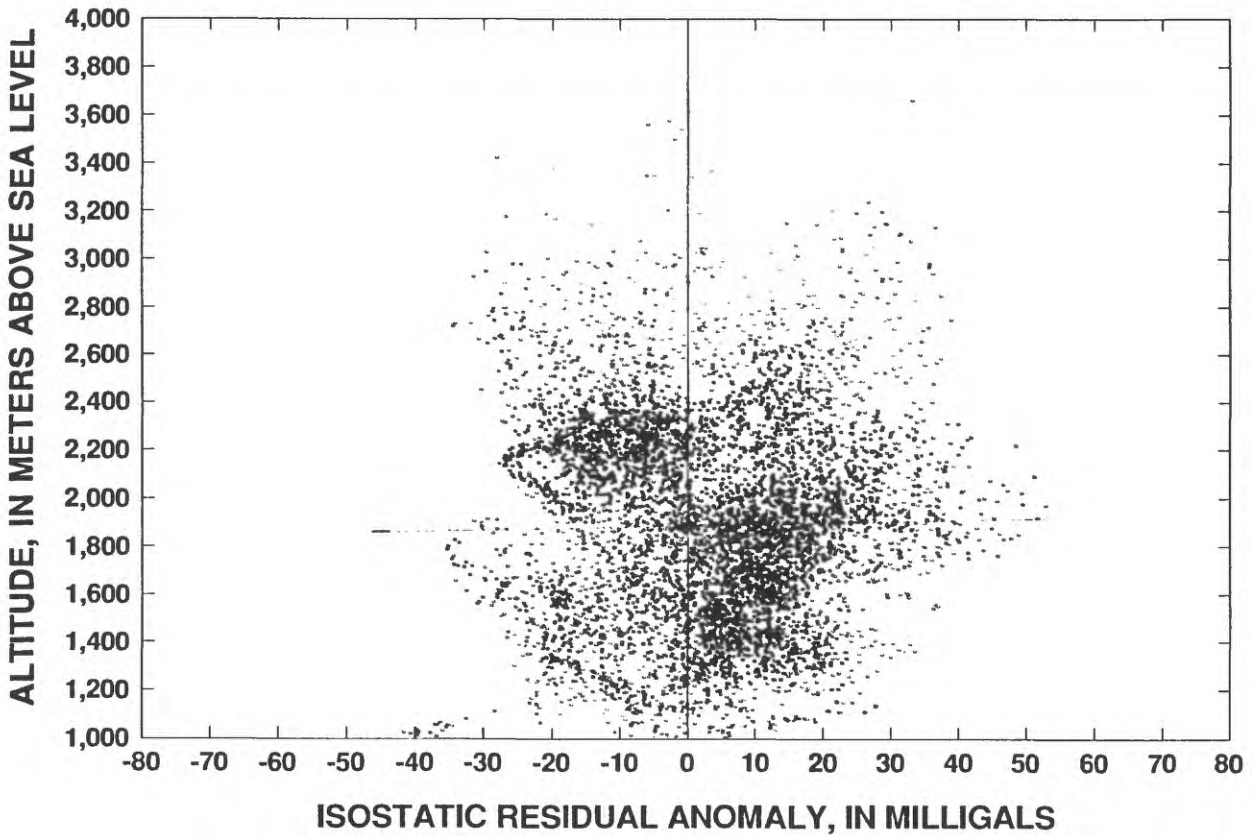


Figure 10.--Isostatic residual gravity anomalies versus altitude for selected stations in New Mexico.

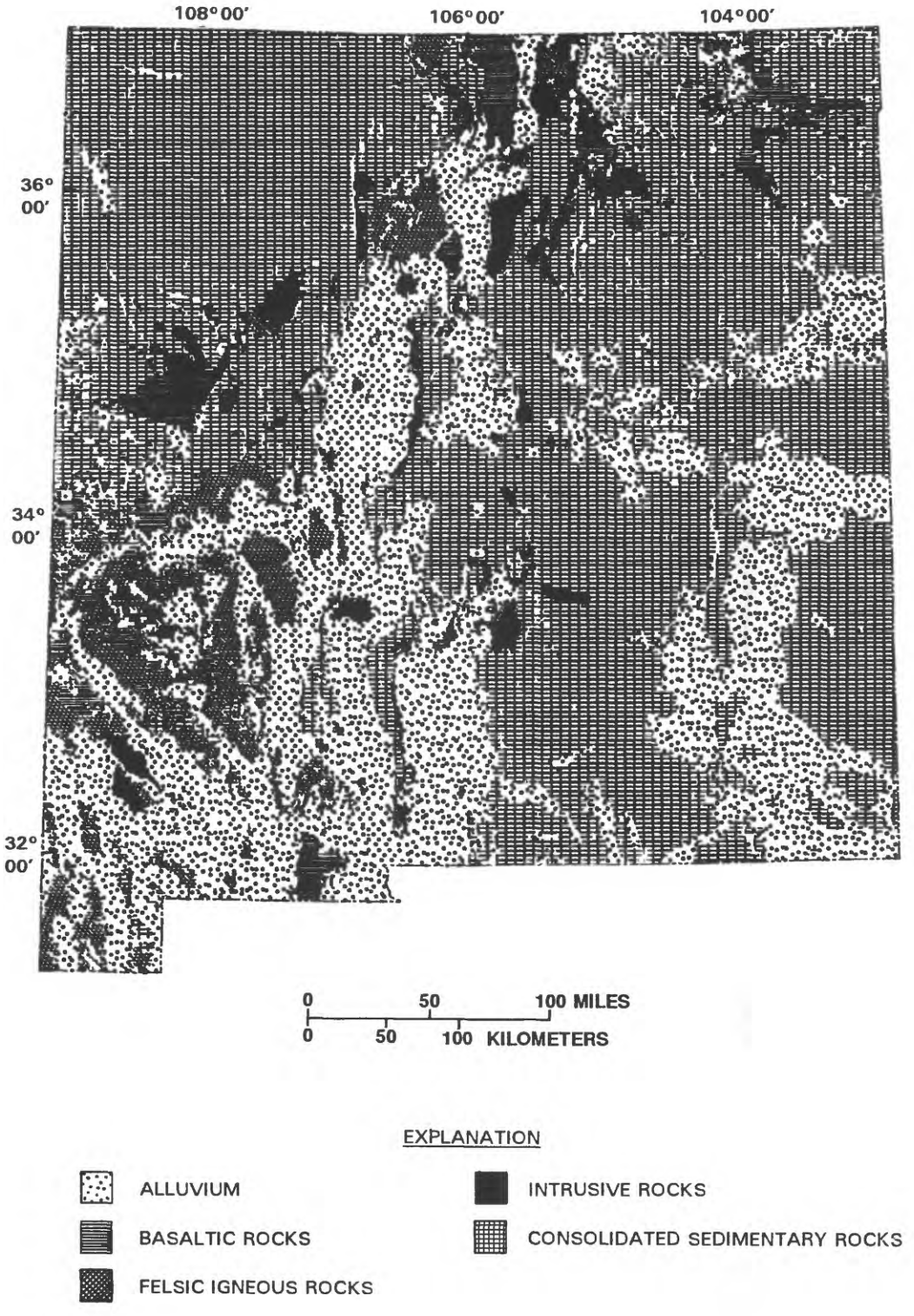
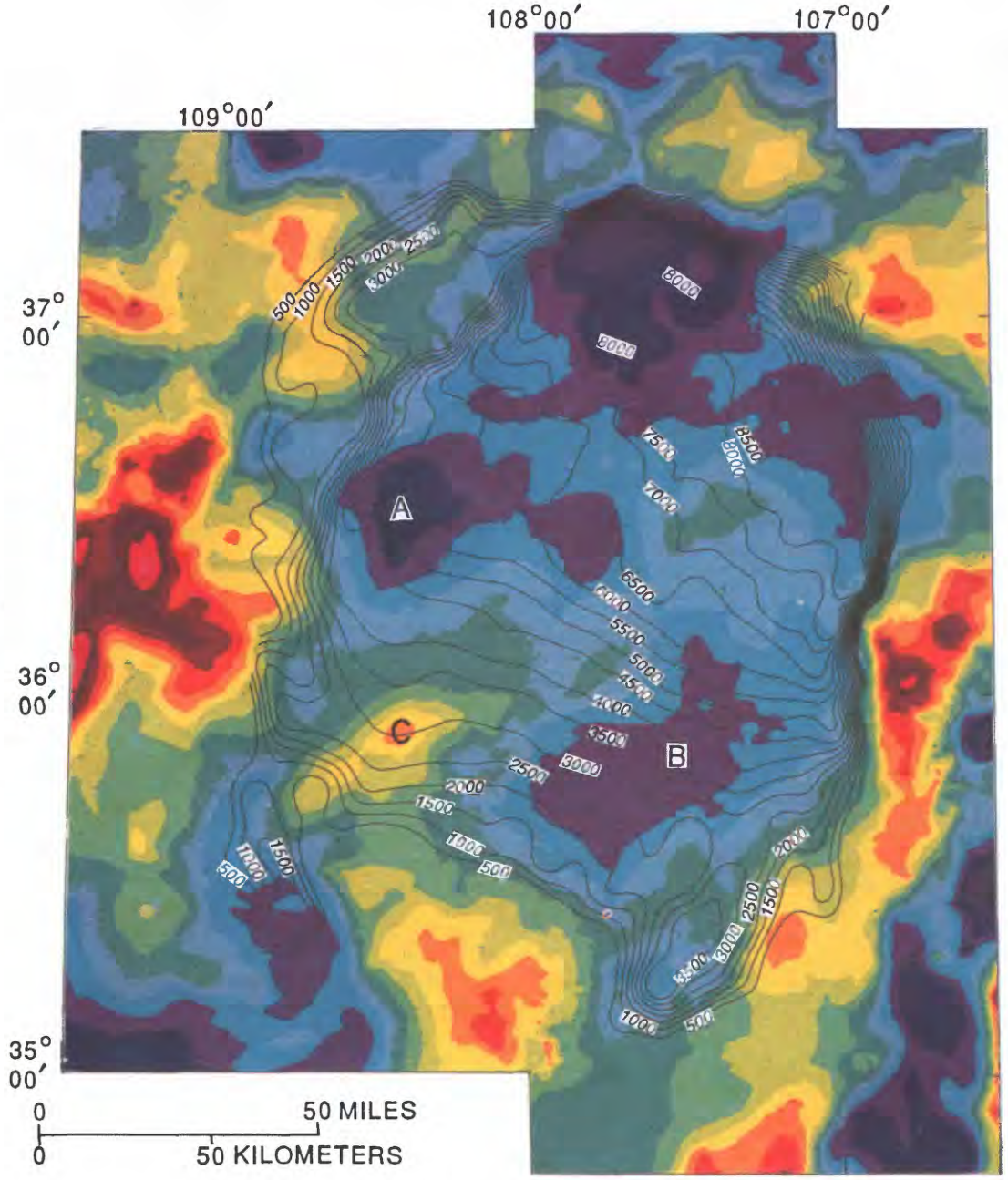


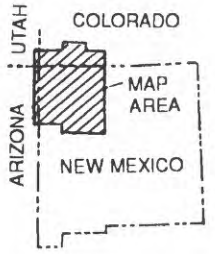
Figure 11.--Generalized geology of New Mexico (modified from Dane and Bachman, 1965).



EXPLANATION

ANOMALY RANGE, IN MILLIGALS

-35	-39.99
-30	-34.99
-25	-29.99
-20	-24.99
-15	-19.99
-10	-14.99
-5	-9.99
0	-4.99
5	0.01
10	5.01
15	10.01
20	15.01
25	20.01
30	25.01
35	30.01
40	35.01



—2000— LINE OF EQUAL DEPTH TO TOP OF DAKOTA SANDSTONE--Interval 500 feet. Datum is land surface

Figure 12.--Depth to top of Dakota Sandstone and isostatic residual gravity anomalies of the San Juan Basin area (depth from Craigg and others, 1989).

(PAGE 25 FOLLOWS)

Uncertainty Estimation

Uncertainties in the isostatic residual anomaly values are of two types. Short-wavelength errors are associated with individual stations and arise from field measurement and the Bouguer reduction process. They are due to uncertainties in station altitude, location, terrain correction, and observed gravity measurement. These errors combined may total 2 milligals for some stations but, on the basis of the smoothness of the contoured version of the data, 99 percent of the stations are believed to be accurate to within 1 milligal. Long-wavelength errors arise from the calculation of the isostatic correction. They may be due to inaccurate assumptions in the isostatic model, calculation errors, or a mismatch in model properties for the near-field and far-field isostatic corrections. For most of the study area the combined long-wavelength error is estimated to be less than 3 milligals. For most geologic modeling, a long-wavelength error of this magnitude is negligible because anomalies of geologic interest are of relatively short wavelength.

SUMMARY AND CONCLUSIONS

Gravity anomalies are useful for inferring the geologic structure and depth of deep sediment-filled basins that contain ground water. Quantitative interpretation of the Bouguer anomaly is complicated (in tectonically complex New Mexico) by the existence of regional trends due to changing crustal thickness. A model of crustal thickness based on isostatic compensation of topographic load can be used to correct for the anomalous gravitational effect of deep crustal mass. In the Airy-Heiskanen model for local isostatic compensation, the defining Earth properties most appropriate for New Mexico as a whole are a density contrast across the crust/mantle interface of 0.3 gram per cubic centimeter and a normal crustal thickness of 20 kilometers. Density of the topographic load was fixed to the Bouguer reduction density of 2.67 grams per cubic centimeter. Subtraction of this isostatic correction from the Bouguer gravity field effectively removes the regional trends and results in a superior gravity data set for sedimentary-basin analysis.

This statewide coverage of isostatic residual gravity is the data base for three-dimensional gravity models of alluvial basins being assessed for quantity of stored ground water. These models are being used to calculate the volume of saturated alluvial sediment within the respective basins.

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