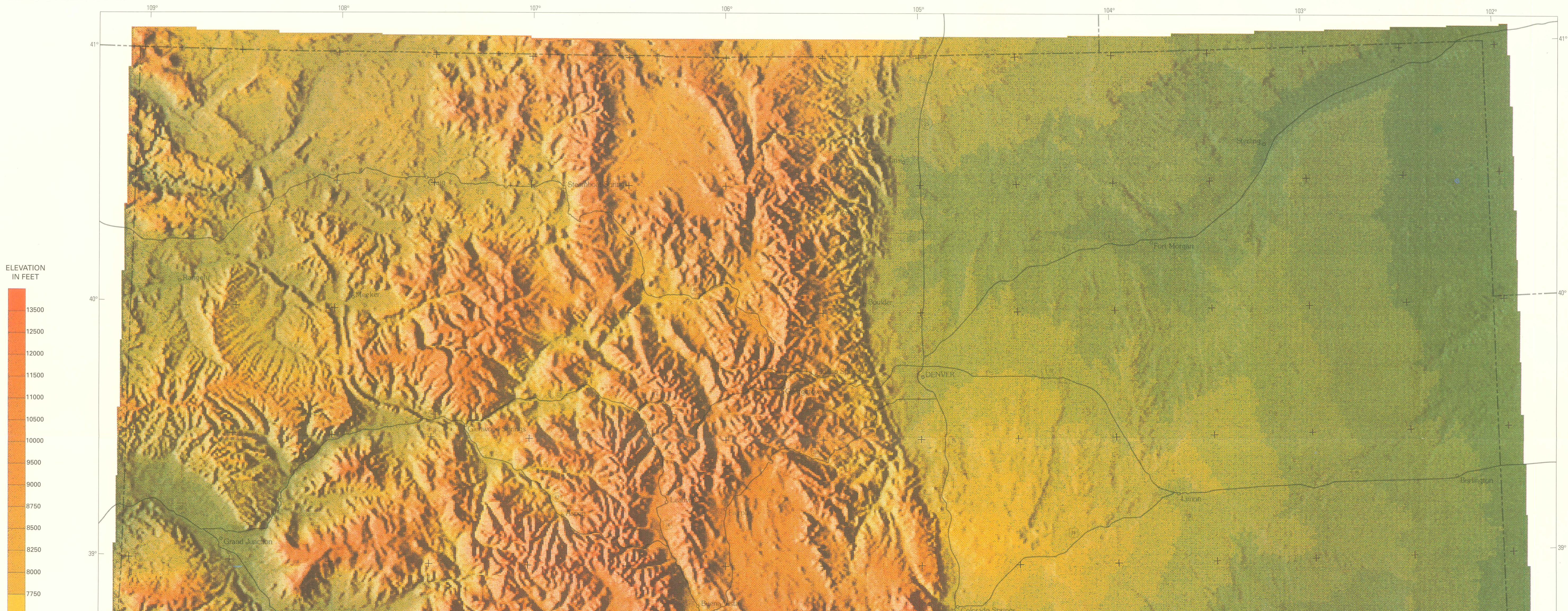
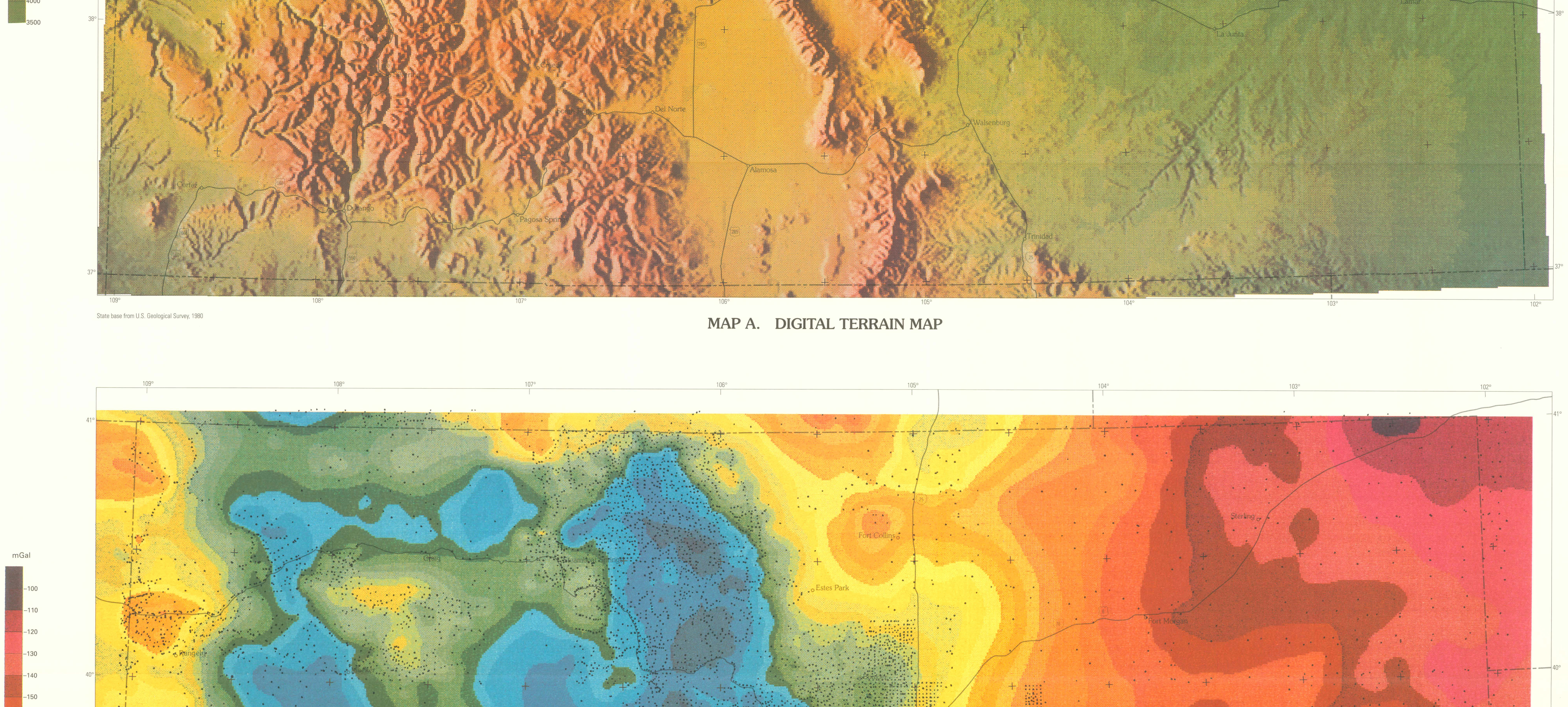


MAP A. DIGITAL TERRAIN MAP



SCALE 1:1 000 000

CONVERSION FACTORS		
Multiply	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

Edited by Michael T. Garrison
Color design by Virginia D. Scott
Graphic design by Larry J. Preisendorf

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MAP B. COMPLETE BOUGUER GRAVITY ANOMALY MAP WITH GRAVITY STATIONS (DOTS)

COMPLETE BOUGUER GRAVITY ANOMALY, ISOSTATIC-RESIDUAL GRAVITY, HORIZONTAL GRADIENT, AND TERRAIN MAPS OF COLORADO

By
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1994

INTRODUCTION

As part of the National Mineral Resource Assessment Program (NAMRAP), gravity measurements in the state of Colorado were processed to show complete Bouguer gravity anomalies, isostatic residual gravity anomalies, and horizontal gravity gradients from the isostatic gravity data. Also, a color-shaded-relief map of the 3-minute digital terrain data of Colorado was prepared for reference (map A). Color contour maps (1:1,000,000 scale) of the Bouguer gravity anomalies (map B) and isostatic-residual gravity anomalies (map C), and a color shaded-relief map of the horizontal isostatic gravity-anomaly gradients (map D) were prepared to assist in ongoing studies to assess the mineral resource potential and tectonic setting of the state. All of the color maps were prepared on a CalComp 5845 XP color electrostatic plotter using CalComp proprietary plotting software.

Behrendt and Bajwa (1974a, 1974b) prepared a Bouguer gravity-anomaly map of Colorado using data obtained from approximately 12,000 gravity stations. Since that time, many additional gravity measurements have been made by the U.S. Geological Survey (USGS). and other institutions and universities. This latest compilation of gravity data (Abrams, 1993) was obtained from 28,735 stations. The distribution of gravity stations is shown on map B.

Measurements of the gravitational field at the Earth's surface are sensitive to the density of the crustal rocks beneath the measurement sites. Areal measurements of the gravity field provide a means of detecting lateral variations in the density of crustal rocks, which can be interpreted in terms of lithological variations and (or) geological structures that juxtapose rocks of differing density. Before the gravity measurements can easily be used for geologic applications, however, corrections are made to account for physical differences in the measurement sites, such as elevation, mass above sea level, and irregularities in the topography. After data reduction, the reduced gravity measurements show positive anomalies (highs) and negative anomalies (lows) that can be interpreted as indicating the distribution of high-density and low-density rocks, respectively. The patterns of these anomalies often provide clues to the location and nature of geologic structures. Long-wavelength variations in the gravity-anomaly data are chiefly produced by sources at great depth; short-wavelength variations are usually produced by shallow or surficial rocks and small geologic structures. Gravity lows correspond to masses of low-density rocks or sediments, such as sedimentary basins, caldera fill, salt and granitic masses, and sediment-filled grabens; gravity highs are often identified with uplifts, horst blocks, and dense mafic rock masses.

TERRAIN MAP

Colorado can be divided into three physiographic zones (Thornbury, 1965, fig. 1; and map A). The eastern or high plains zone covers about 40 percent of the state and rises from an elevation of about 3,300 ft (1,000 m) near the Nebraska and Kansas border to 6,500 ft (1,980 m) near the mountain front. Elevations in the Rocky Mountain zone range [illegible]

BOUGUER GRAVITY ANOMALY MAP

[illegible] Geodesy and Geophysics, 1971). Cordell and others (1982) described gravity-reduction equations and approximations used by the program BOUGUER.

The complete Bouguer gravity anomaly data were projected on the Lambert conformal system with a central meridian of 106° W. and a base latitude of 38° N. The values were then gridded to an interval of 2 km using a minimum-curvature algorithm (Briggs, 1974; Webring, 1981). The actual data interval varies widely; there is a close distribution along roads and a sparse distribution in remote areas (see gravity station locations on map B). The grid spacing has an effect on the nature of the resulting map: calculations made using a smaller grid spacing emphasize shorter wavelength anomalies, whereas those using a larger grid spacing emphasize broader wavelength anomalies. The actual data spacing also strongly influences the wavelength of anomalies and, hence, the size of the features that can be identified; sparse data do not allow resolution of smaller features. Even when great care is used in selecting the gridding interval, some of the isolated anomalies on map B may be artifacts of the data-reduction procedure or inaccuracies in the field measurements and may not represent true crustal-density variations. The data were plotted as 5- or 10-mGal color-contour slices with red indicating gravity highs and purple indicating gravity lows (map B). The Bouguer gravity anomaly values range from a low of –310 mGal to a high of –106 mGal. The locations of the gravity stations on map B show the actual spacing of the gravity measurements.

ISOSTATIC-RESIDUAL GRAVITY ANOMALY MAP

Isostasy (a term first used by C.E. Dutton in 1889) is the principle by which topography is supported by variations in density of the earth's crust. Bouguer gravity anomalies have a strong inverse correlation with topography because the density variations of the compensating masses have not been accounted for in the Bouguer reduction. In general, areas with high topography have negative Bouguer anomalies and areas with low topography, such as ocean basins, have positive Bouguer anomalies. The isostatic residual gravity map (map C) was created to eliminate these long-wavelength correlations. The program AIRYROOT (Simpson and others, 1983) was used to calculate the isostatic effects in Colorado; the use of isostatic corrections is explained in Simpson and others (1986). An isostatic regional grid was calculated using the 5-minute grid of terrain elevations for the United States and the following parameters: a root depth of 30 km for topography at sea level, a density contrast (at depth) of 0.35 g/cm^3, and a surface load density of 2.67 g/cm^3. These are the same values used by Simpson and others (1986) to calculate the isostatic residual gravity field of the conterminous United States. The regional grid of isostatic corrections was then subtracted from the Bouguer gravity anomaly grid to remove the long-wavelength effects of the deep crustal structures. Consequently, the isostatic residual gravity map mostly shows lateral variations of density within the upper crust. The isostatic residual values at a 2-km interval were plotted as color-contour slices with red indicating high values and purple indicating low values (map C). The contour interval is not linear; the color intervals were chosen for ease of comparing map C with map B. The contour intervals are 0.3 and 0.6 mGals.

HORIZONTAL GRADIENT MAP OF THE ISOSTATIC GRAVITY FIELD

Map D shows the horizontal gradient (rate of change) of the isostatic gravity field calculated using techniques discussed in Grauch and Cordell (1987). Maximum gradients occur at inflections in the gravity field and can be interpreted as locations of steeply dipping boundaries between rocks that have distinct density contrasts. To highlight steep gradients, gradient maxima are located and plotted as lines (Blakely and Simpson, 1986) representing density boundaries between crustal materials, such as contrasting lithological units juxtaposed by a fault.

The color shaded-relief map was illuminated from the southwest, causing anomalies trending northwest and southeast to be emphasized and the southwest-northeast-trending anomalies to be subdued. This illumination angle was chosen because of the numerous structures that have northwestward trends, including most salt-cored anticlines in the Paradox basin and the major Laramide uplifts in the Rocky Mountains.

Mapping the horizontal gradient of the isostatic gravity and determining where gradient maxima occur aids the interpretation of gravity data by locating patterns and features that might not be apparent on other geological or geophysical maps.

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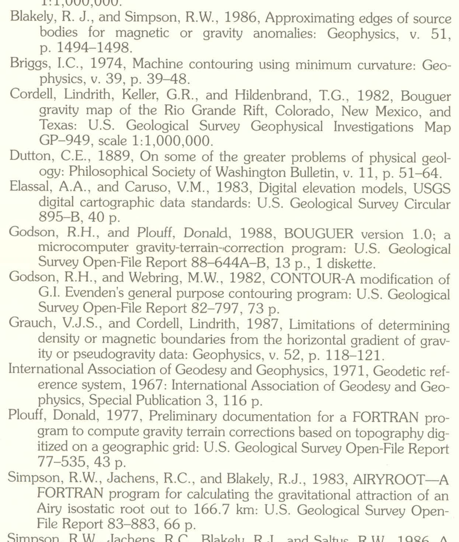

Figure 1. Location of major tectonic and geographic features

For sale by U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225