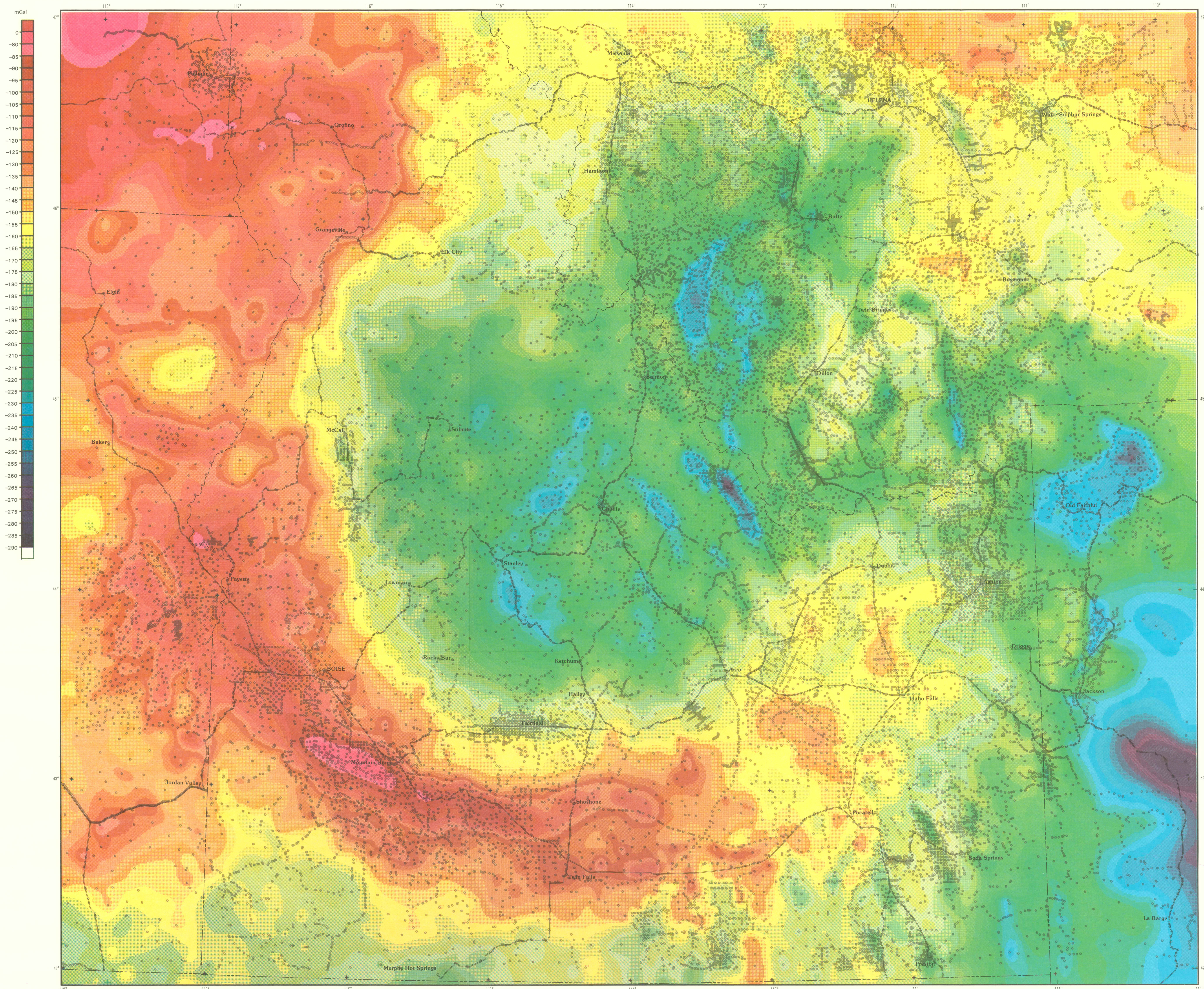
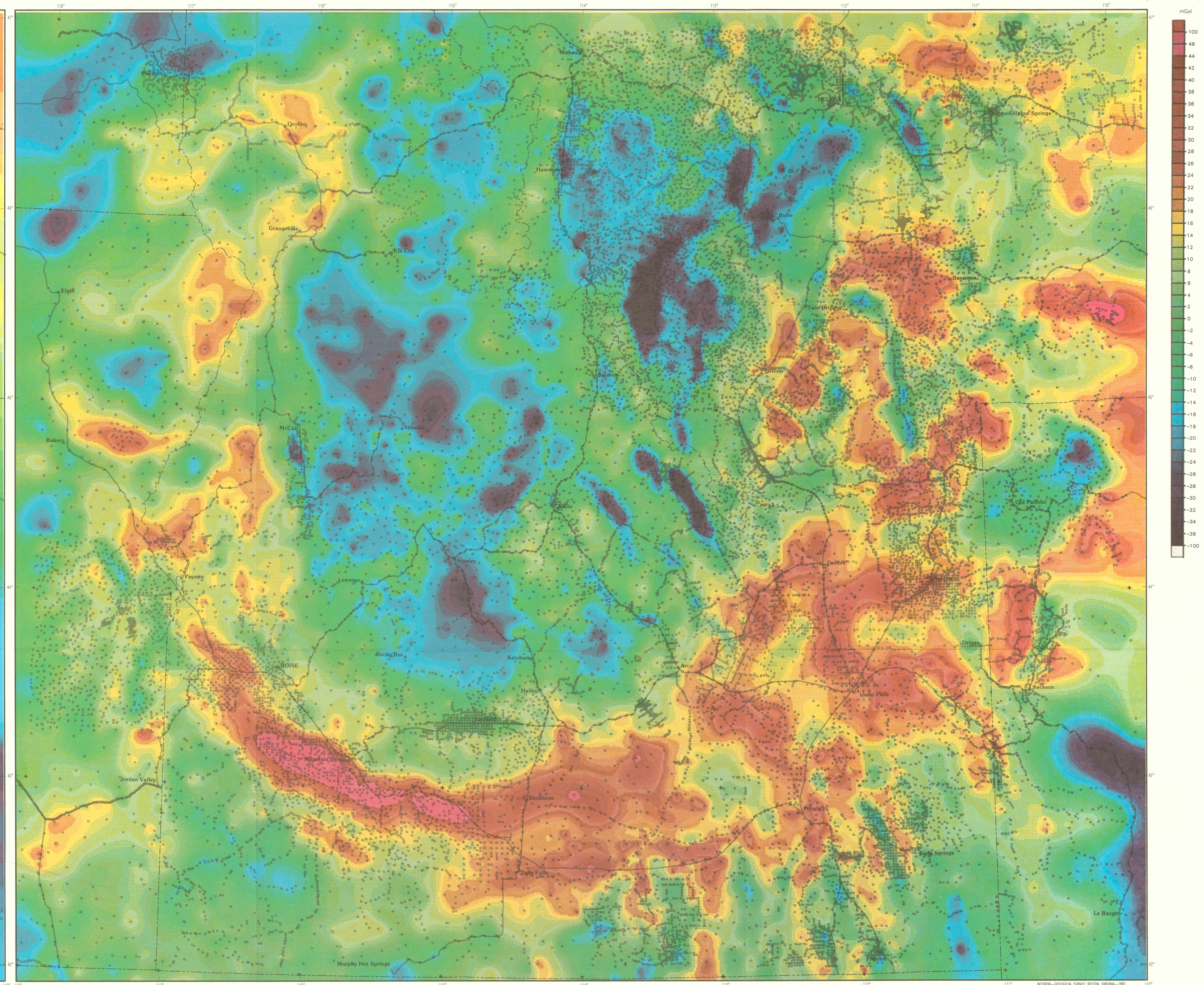
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOPHYSICAL INVESTIGATIONS
MAP GP-995 (SHEET 1 OF 2)




SCALE 1:1 000 000

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

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MAP A. COMPLETE BOUGUER GRAVITY MAP (5-MILLIGAL CONTOUR INTERVAL; CIRCLES, GRAVITY-STATION SITES).

MAP B. ISOSTATIC RESIDUAL GRAVITY MAP (2-MILLIGAL CONTOUR INTERVAL; CIRCLES, GRAVITY-STATION SITES).

## INTRODUCTION

A complete Bouguer gravity map and related geophysical maps were made for integrated geological-geochemical-geophysical mineral-resource appraisals in Idaho. This report is part of a series of maps showing the topography (Cady, 1992), gravity field (this report), and aeromagnetic field (McCafferty, 1992) of a large region (figure 1) centered on the Idaho batholith and Challis volcanics. Related geophysical maps include an isostatic residual-gravity map, a map showing magnitude of the horizontal gradient of the isostatic gravity field, and a density terrace map of the isostatic gravity field. Gravity maps are used to delineate density changes within the Earth and to interpret subsurface geology and structural features that could be related to mineral-resource potential. Simpson and Jachens (1989) reviewed gravimetric methods used in regional studies; the reader desiring a more detailed explanation is referred to their description of reduction processes and theories.

## PREPARATION OF MAPS

The complete Bouguer gravity map (map A) was compiled using data obtained from 32,152 stations. These data were extracted from the gravity data base of the State of Idaho (Bankey and others, 1985) and include additional data from U.S. Geological Survey (USGS) gravity surveys, the Defense Mapping Agency gravity data base, and data collected for university theses and dissertations. Observed gravity data relative to the IGSN-71 datum (International Association of Geodesy, 1974) were reduced to the Bouguer anomaly, using the 1967 gravity formula (International Association of Geodesy, 1971) and a reduction density of 2.67 g/cm$^3$. Standard USGS reduction equations and related expressions are given in Cordell and others (1982). Terrain corrections were calculated radially outward from each station to a distance of 167 km using a method developed by Plouff (1977). The map has a Lambert conformal projection with a central meridian of long 114° W. The data were converted to a 2-km grid using a computer program developed by Webring (1981) based on minimum curvature (Briggs, 1974). The gridded data were contoured at a 5-milligal interval using color-plotting software.

An isostatic residual-gravity map (map B) was calculated using the ISOCOMP program (Jachens and Roberts, 1981), which is based on the Airy-Heiskanen model of local compensation (Heiskanen and Vening Meinesz, 1958, p. 135–137). This map was created by removing from the Bouguer gravity field a model of the gravity expression caused by deficiencies in mass (compensating mass) that support topographic loads. The resulting isostatic residual anomalies (map B) do not imply either local isostatic compensation or imbalances. Instead, they reflect corrections that are the result of removing a predicted gravity response (the attraction of compensating mass) and are similar to other corrections made by removing predicted gravity responses from the observed gravity data, such as free-air and Bouguer adjustments. The use of isostatic corrections is further explained in Simpson and others (1986). For this study, the calculation of the isostatic residual gravity field used averaged digitized topography, a crustal thickness of 30 km, a crustal density of 2.67 g/cm$^3$, and a density contrast between the crust and upper mantle of 0.35 g/cm$^3$. These values were used by Simpson and others (1986) to calculate the isostatic residual gravity field of the conterminous United States. After the isostatic correction was applied at each gravity station, the data were gridded using a 2-km spacing and contoured using the same parameters as map A.

The gray-shade map (map C) shows the magnitude of the horizontal gradient of the isostatic gravity field. This map was calculated from the gridded isostatic gravity data using the method developed by Cordell (1979) and a computer program written by Blakely and Simpson (1986). Maximum values are delineated by darker shades of gray; lines indicate locations of calculated maximum gradients. These linear or sinuous patterns of maximum gradients follow boundaries between geologic units of different densities, such as lithologic contacts, abrupt facies changes, and contrasting units juxtaposed by a fault. The method best displays the surface projection of vertical boundaries between shallow units. Displacements of the gradient maxima from the surface projections of density boundaries are produced by unit boundaries that have dips less than 90°, by interference from neighboring gravity sources, and by terrain effects. These inaccuracies are less prominent at regional scales (Grauch and Cordell, 1987). Because the gradient is calculated from the gridded gravity data rather than the original station data, this map shows gradients in areas of sparse data that may not be accurate. Comparison with the location of gravity data is important to confirm that enough data exist in an area to define a relevant gradient.

Map D is a density-terrace map of the isostatic gravity field. It shows the results of a terracing operation (Cordell and McCafferty, 1989; J.D. Phillips, 1990, unpub. data) that was performed on the gridded isostatic residual-gravity data. The terrace method transforms the smoothly varying gravity field into a stepped field of uniform domains separated by discontinuous boundaries. The result is a physical-property (density) map that mimics a geologic map by theoretically outlining geologic structures and terranes associated with gravity anomalies. This method can also be applied to magnetic data (McCafferty, 1992). To emphasize the edges of density units, the density-terrace map is augmented by lines along the maxima of the horizontal gradient. Both methods were designed to enhance measurable density contrasts caused by lithologic contacts, abrupt facies changes, or structural breaks. The terrace method mathematically minimizes minor changes internal to each uniform domain in order to emphasize regional patterns in the gravity field.

The density values presented in map D are relative to each other, with warm colors showing dense or shallow sources and cool colors showing less dense or deeper sources. The values are uncalibrated because they are not corrected for depth to sources or thickness of sources causing density contrasts. Calibration can be done by statistical correlation of the terrace map with density data from measured rock samples or by using density models calculated from topographic data. Earlier studies (McCafferty and others, 1989) represented the density model used in calibration by a slab with constant thickness and flat top. Such density models cannot be applied to this study area, where depth and thickness of gravity sources are widely varying.

## DATA AVAILABILITY

Gravity data for the complete Bouguer gravity, isostatic residual gravity, and density-terrace maps in this folio area available as 2-km USGS standard-format grids on a 9-track magnetic tape from the EROS Data Center, U.S. Geological Survey, Sioux Falls, South Dakata, 57198. Principal facts for gravity stations used to create the gridded data are also included on the magnetic tape.

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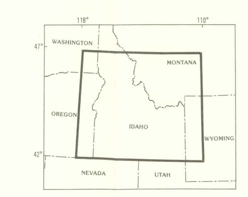
## EXPLANATION

o Gravity station location

## CONVERSION FACTORS

| Multiply | By | To obtain |
|---|---|---|
| centimeters (cm) | 0.3937 | inches (in) |
| meters (m) | 3.281 | feet (ft) |
| kilometers (km) | 0.6214 | miles (mi) |




Index map showing location of study area

# COMPLETE BOUGUER GRAVITY, ISOSTATIC RESIDUAL GRAVITY, AND RELATED GEOPHYSICAL MAPS CENTERED ON THE IDAHO BATHOLITH AND CHALLIS VOLCANIC FIELD, NORTHWESTERN UNITED STATES

By
Viki Bankey
1992