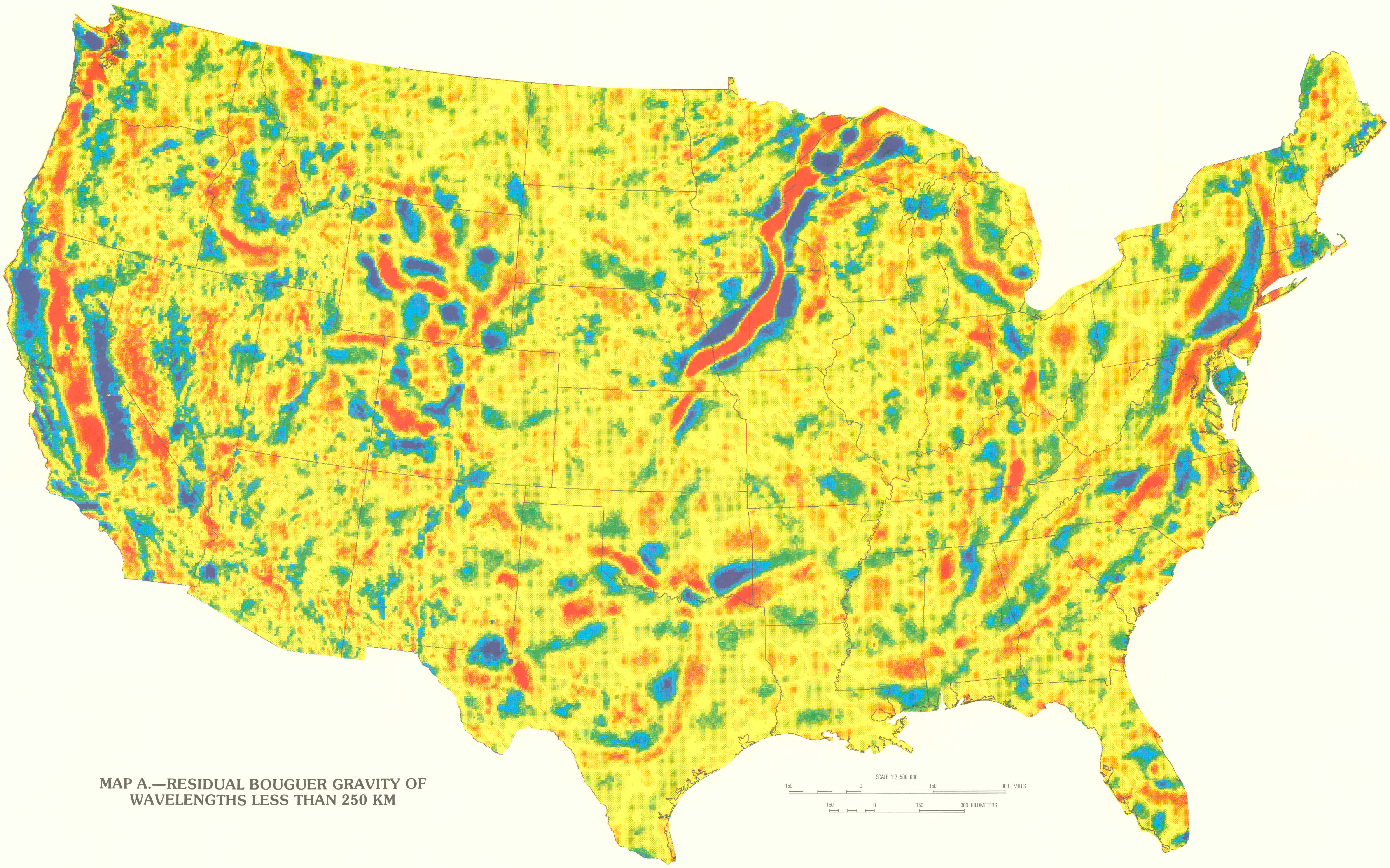
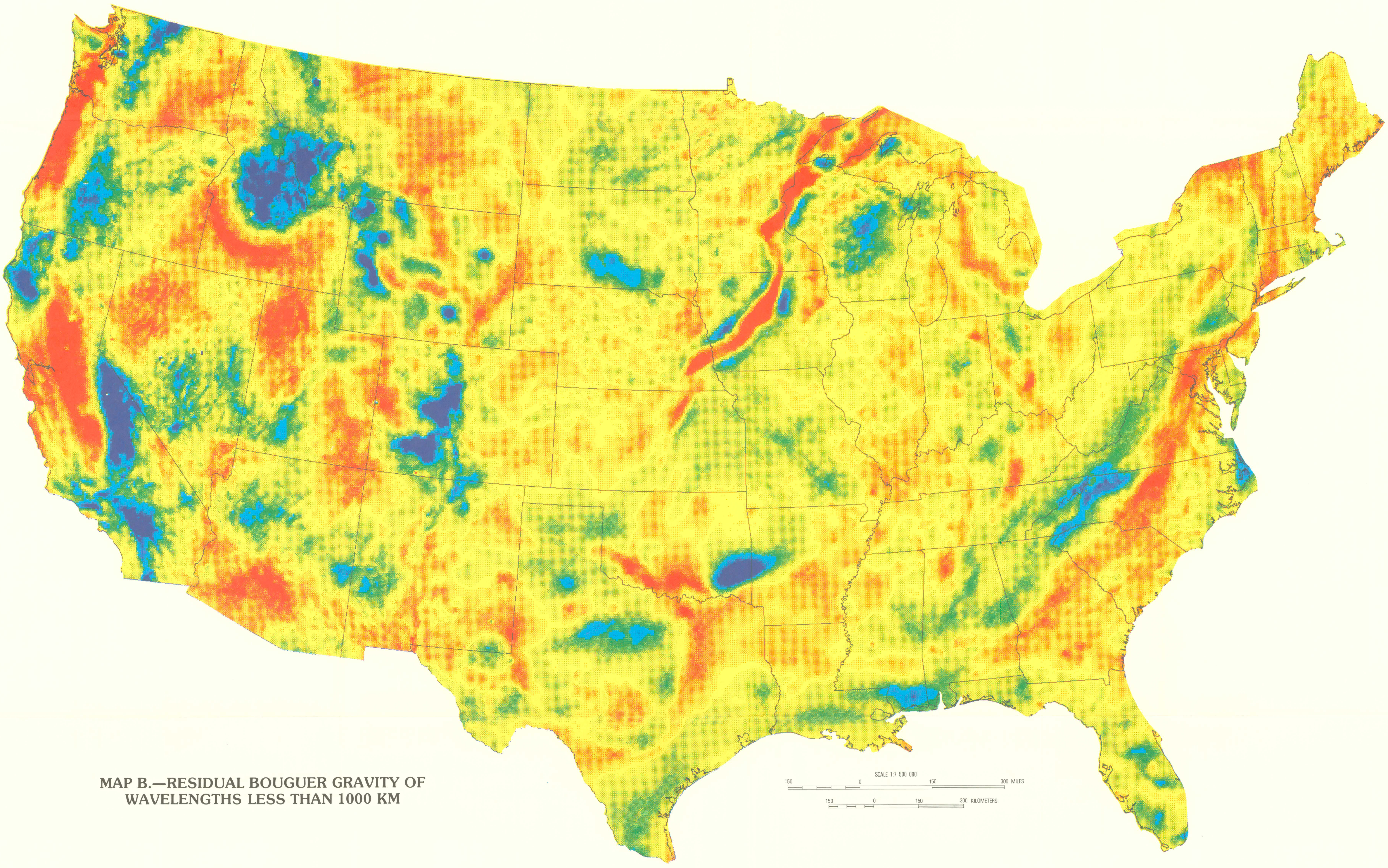
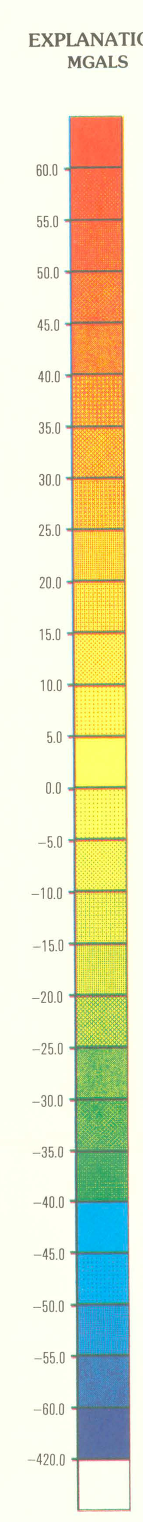


MAP A.—RESIDUAL BOUGUER GRAVITY OF WAVELENGTHS LESS THAN 250 KM



MAP B.—RESIDUAL BOUGUER GRAVITY OF WAVELENGTHS LESS THAN 1000 KM



Data gridded at a spacing of 6 km; on Albers Equal Area projection with 96° west as central meridian

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INTRODUCTION

These maps were prepared from data obtained primarily from data files maintained by the Defense Mapping Agency of the Department of Defense and the Canadian Gravity Data Centre of the Earth Physics Branch of the Department of Energy, Mines, and Resources (Canada). The maps have been used in studies relating to earthquake/reactor hazards, geothermal energy, and nuclear repository site programs of the U.S. Geological Survey. Those shown here (maps A–D) are part of a series of digital gravity and terrain maps of the United States currently being developed by the authors.

A gravity-anomaly map exhibits the effects of geological bodies of distinctive density, which may have varying shapes, dimensions, and burial depths. In any region the gravity field is usually caused by the superposition of the overlapping gravitational effects of many bodies whose individual anomalies may be difficult to separate. The terms "residual" and "regional" are arbitrary with respect to scale but are used to make a distinction between anomalies arising from local, near-surface masses and those arising from larger and usually deeper features, respectively. There are many methods for preparing regional and residual maps (Grant, 1972). For our study we chose a general wavelength (or frequency) filtering method to obtain a separation of long wavelength anomalies (regional), that are typically associated with deep-crustal or subcrustal features, from short wavelength anomalies (residual) that are associated with shallow features. We are aware, however, that the separation is not complete and that in particular, some long wavelength anomalies can be caused by broad shallow features. The short wavelengths on the residual maps bring out and emphasize small features, but in some cases the anomaly amplitudes may be distorted by the removal of the long wavelengths.

The validity of the wavelength filtering process in calculating regional-residual gravity fields is dependent on the assumption that the cut-off wavelength of the filter and maximum depth of source are related. Preliminary analyses suggest that the maximum source depth is roughly equal to the cut-off wavelength divided by a factor ranging from 6 to 12, depending on the geometry of the source. Thus the residual gravity map composed of wavelengths of 250 km and less (map A), exhibits anomalies which most probably are associated with sources that lie above a depth of between 21 and 42 km; the effects of broad shallow sources such as low-density sedimentary strata, however, are not present on this map. We conclude, therefore, that map A contains anomalies associated with anomalous mass distributions residing primarily in the crystalline portion of the Earth's crust. Conversely the complementary 250 km wavelength low-pass map (map C) represents the effects of deeper sources, such as the shape of the crust-mantle boundary and anomalous masses in the mantle, and presumably those of any broad shallow masses that may be present. Similarly, maps prepared with the 1000 km wavelength cut-off filter (maps B and D) show anomalies that are most likely a result of density contrasts lying above (residual) or below (regional) a depth of about 125 km.

DATA REDUCTION

Principal facts (observed gravity, elevation, latitude, and longitude) from approximately 500,000 gravity stations were assembled for processing. The resulting data set was screened to select one station within a 4 x 4 km area. Bouguer gravity anomaly values were computed using the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3; the equations and related expansions are given by Cordell and others (1982). Terrain corrections were made by computer (Plouff, 1977) for the region extending radially from 0.895 to 167 km from the station. The terrain corrections omitted from the inner zone (0.0 to 0.895 km) are estimated to be small, generally less than 2 mgal., but may be larger for stations located in deep canyons or on steeply sloping terrain.

A data set on a 6 km grid was derived from the irregularly spaced Bouguer anomaly values by means of a minimum curvature interpolation formula (Webring, 1981). The gridded data were transformed to the frequency domain by fast Fourier transform and then were low-pass filtered. The low-pass filter (Hildenbrand, T. G., unpub. data, 1979) is a simple rectangular window, modified so that the gain drops from one to zero along a ramp centered at the cut-off wavelength. The ramp was located between 300 km and 200 km for the 250 km wavelength cut-off filter and 1100 km and 900 km for the 1000 km wavelength cutoff filter. The regional (low-pass) field was calculated by taking the inverse Fourier transform of the product of the low-pass filter and the Fourier transformed Bouguer gravity field. Residual fields were calculated by subtracting the computed regional fields from the unfiltered gravity field. The maps were then made using an Applicon* color plotter.

DISCUSSION

Both the residual and the regional gravity maps reveal features that are not readily apparent on an unfiltered Bouguer gravity map. Many of the these gravity features have been discussed previously in the literature, but some either have not been noted previously or are shown here with much greater clarity and precision

RESIDUAL GRAVITY MAPS

The 250 km wavelength residual map (map A) allows one to compare across the entire conterminous United States, for the first time, anomalies originating primarily in the Earth's crust. The 1000 km wavelength residual map (map B) shows a much altered appearance beacuse the added long-wavelength components (250 km to 1000 km), believed to be generated primarily by lower crust or upper mantle sources, are added to the shorter wavelength anomalies of crustal sources; in some regions it may indicate where mantle features have a direct influence on crustal tectonic systems. Both residual maps exhibit a wide variety of anomaly patterns and trends, suggesting that the Earth's crust has been disrupted by many profound discontinuities or fracture systems that have formed highly contrasting lithologies.

Highlighted with particular clarity on both residual gravity maps is the system of midcontinent gravity anomalies, which extend from western Lake Superior to central Oklahoma. Geologic and geophysical evidence (King and Zietz, 1971) indicates that the anomalies are expressions of an ancient (Keweenawan) rift system with layered, mafic volcanic rocks.

REGIONAL GRAVITY MAPS

The regional gravity maps exhibit anomalies that are believed to be associated with sources originating primarily at the crust-mantle boundary or within the mantle. The 250 km wavelength regional map (map C) may also show the effects of broad shallow sources; for example, the gravity effect of the laterally extensive sedimentary strata of the Appalachian region is included in the regional field.

When these regional gravity maps are compared with a regional terrain map (Godson, 1981), it can be seen that they are nearly mirror images. The observed similarities substantiate the theory of isostasy, which states that anomalous mass loads such as mountain ranges are supported by nearly equal mass deficiencies at depth, whereas relative mass deficiencies in crustal material such as those of thick, sedimentary accumulations in basins are compensated by relatively denser mass at depth. Anomalously low density upper mantle material and (or) thicker crust are thought to be responsible for the lows over the Basin and Range Province and Rocky Mountains of the west and, to a lesser extent, the Appalachians of the east.

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*Use of commercial trade names is for descriptive purposes only and does not imply endorsement by the U. S. Geological Survey.

DIGITAL COLORED RESIDUAL AND REGIONAL BOUGUER GRAVITY MAPS OF THE CONTERMINOUS UNITED STATES WITH CUT-OFF WAVELENGTHS OF 250 KM AND 1000 KM

By

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1982

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