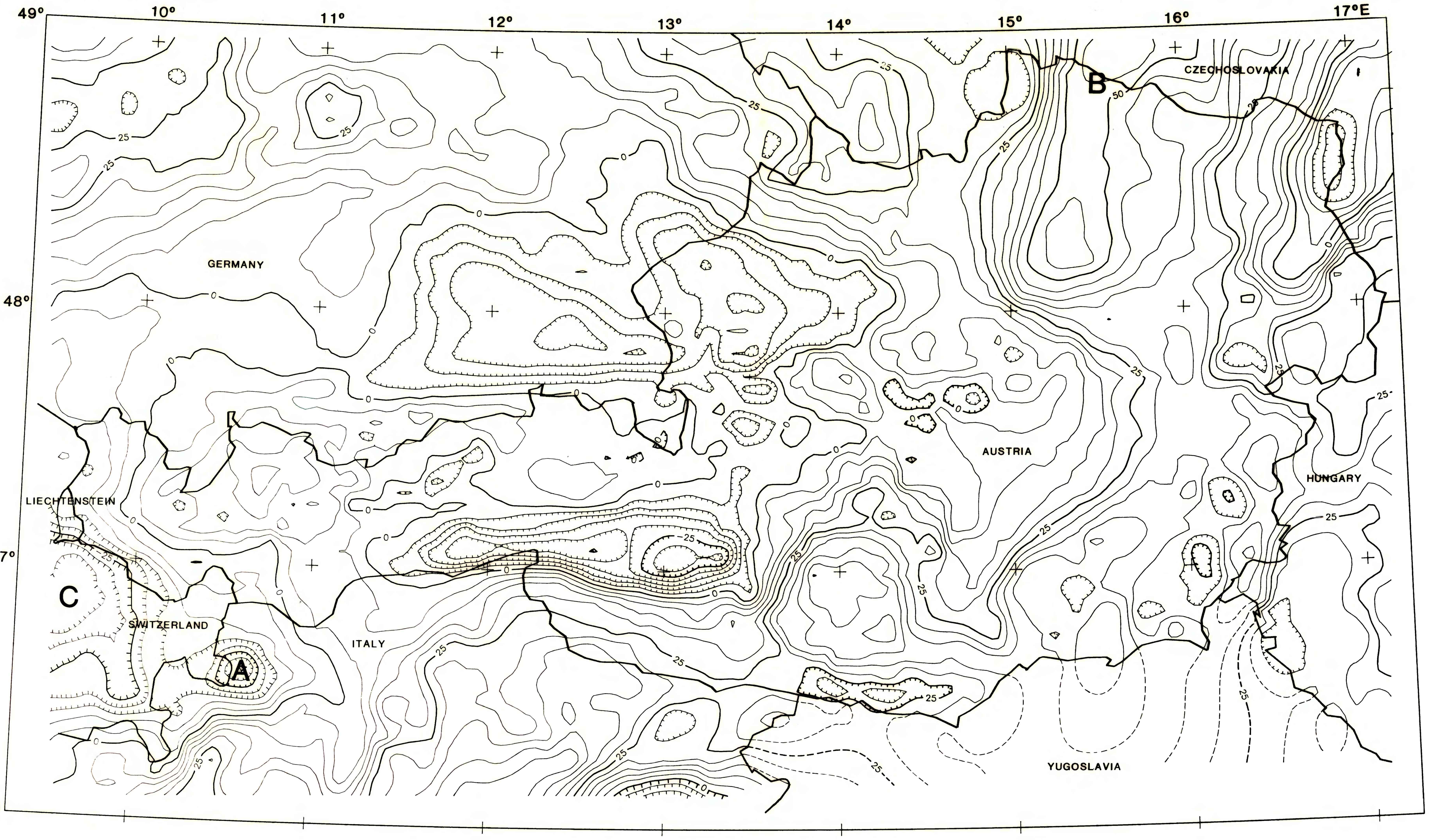
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 87- 402



ISOSTATIC RESIDUAL GRAVITY MAP

OF AUSTRIA

By

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1987

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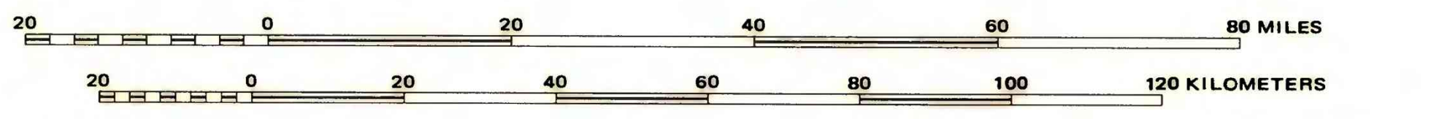
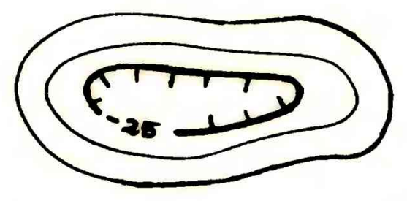


SCALE 1:1,000,000

EXPLANATION



Isostatic gravity contours using Airy-Heiskanen model parameters T = 30 km, ρ = 2,670 kg/m^3, and $\Delta\rho$ = 400 kg/m^3. Contour interval 5 mGal. Hachured contours indicate areas of gravity lows.

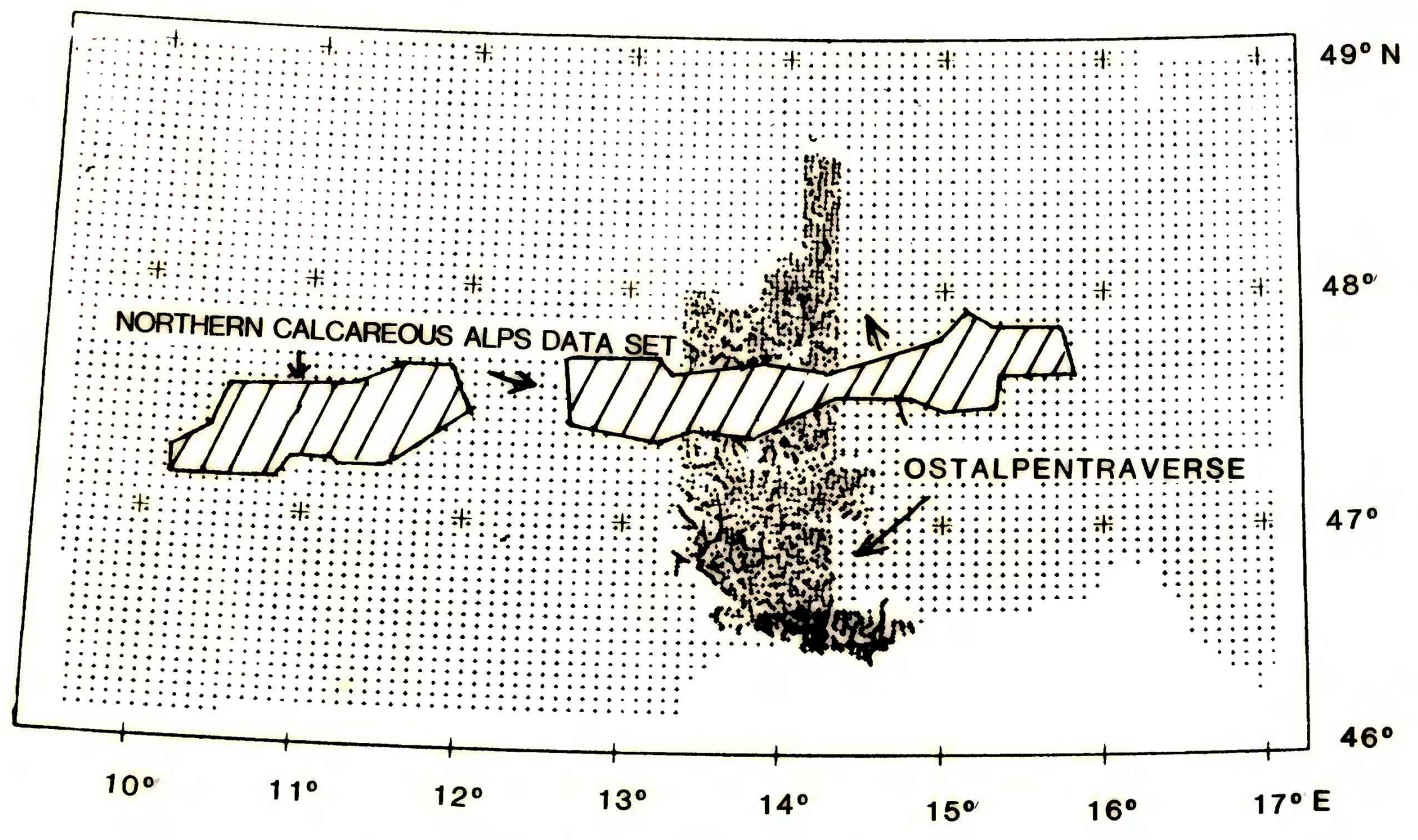
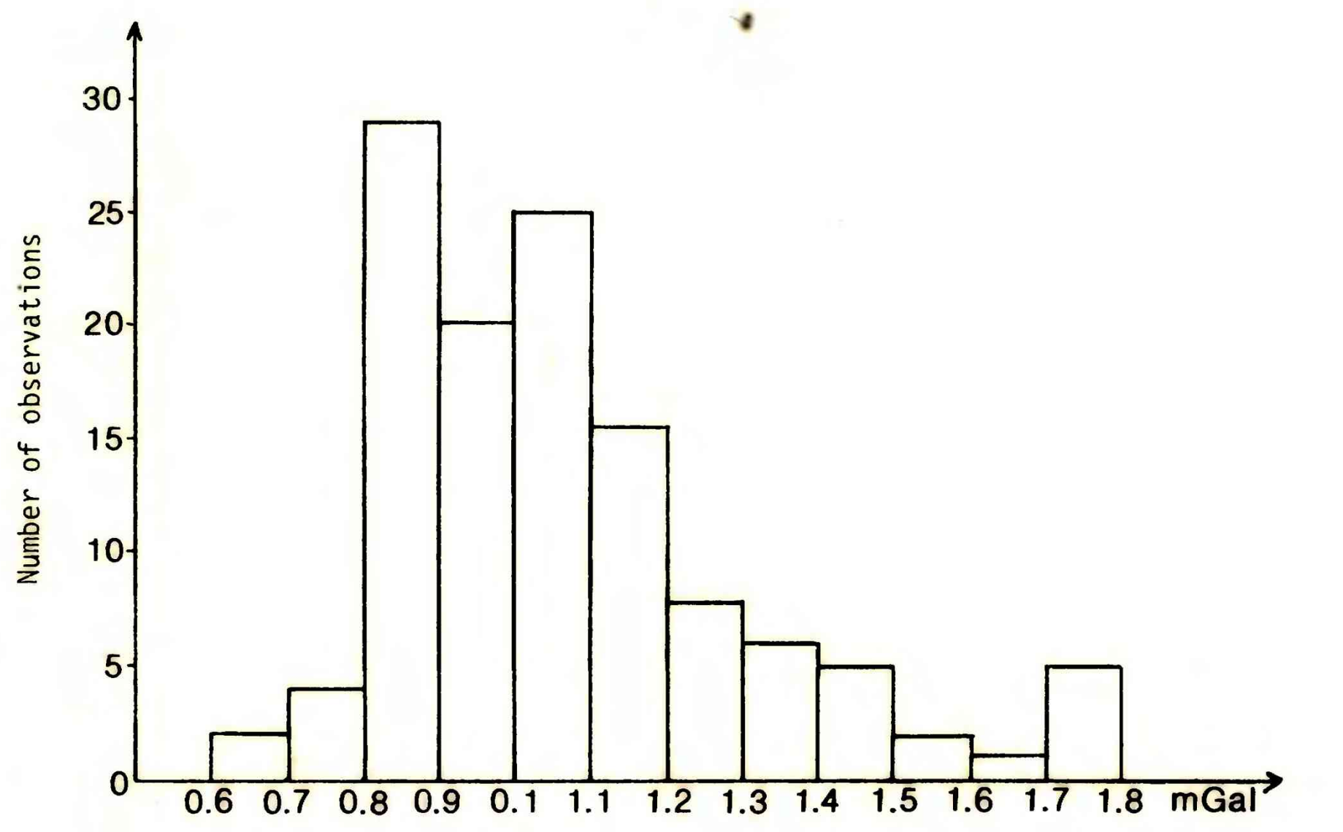


Figure 1. Plot of gravity stations and gridded data used to control the gravity map.



Observed gravity differences between the
Calcareous Alps and Ostalpentraverse data sets

Figure 2. Histogram showing the distribution of observed gravity differences between the Calcareous Alps and the Ostalpentraverse data sets.

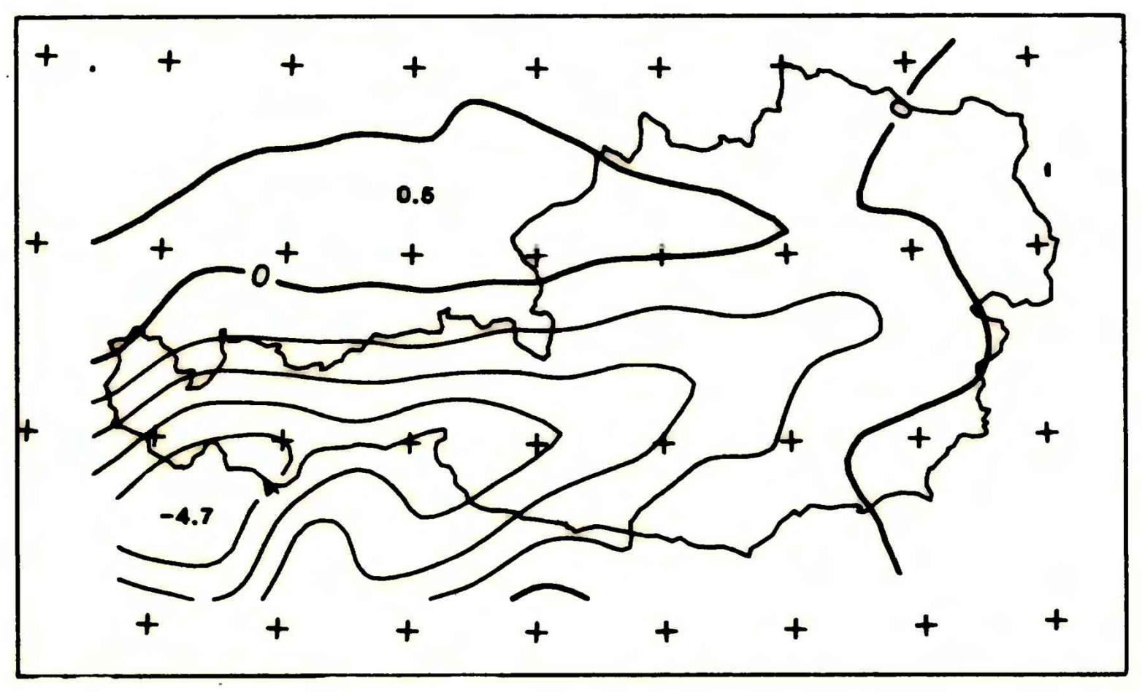


Figure 3. Effect on the residual map of changing the density contrast in the isostatic model from 400 kg/m^3 to 300 kg/m^3. Contour interval = 1.0 mGal.

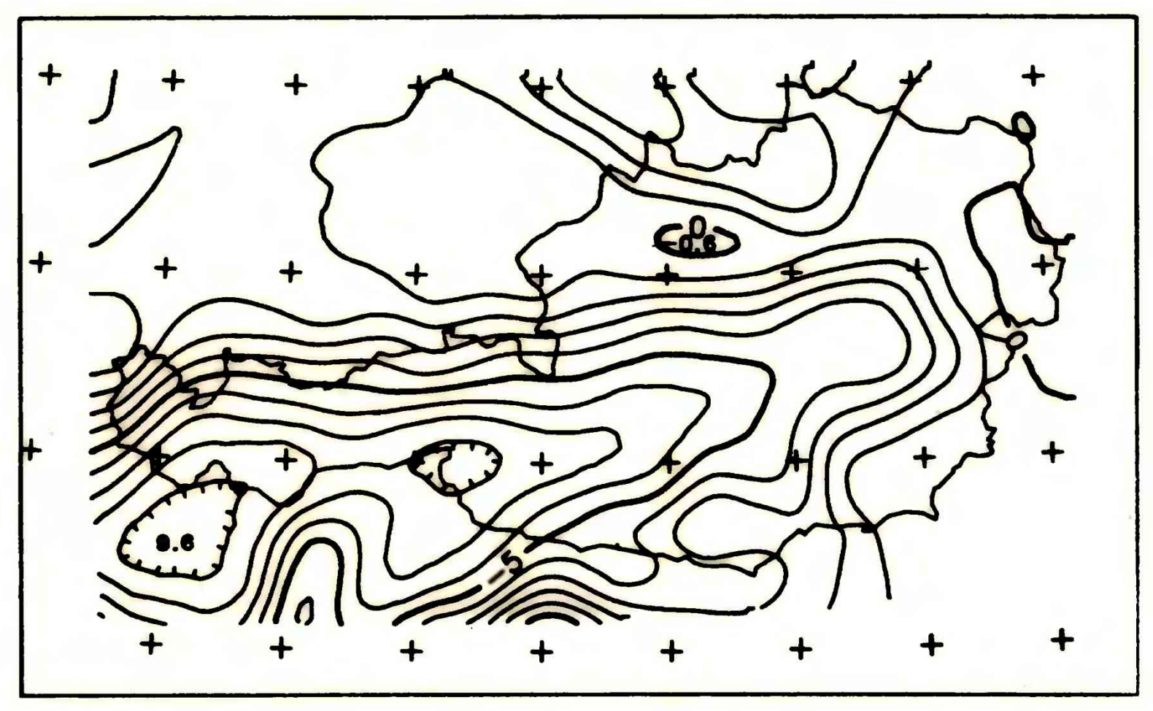


Figure 4. Effect on the residual map of changing the crustal thickness in the isostatic model from 30 km to 25 km. Contour interval = 1.0 mGal.

DISCUSSION

Although first attempts to calculate isostatic residual gravity were performed in Austria almost twenty years ago (Partsch, 1969), the full importance of isostatic corrections was not realized until recently. The success in applying isostatic corrections to Bouguer gravity data for the purpose of resolving major geologic structures in Switzerland (Klingele, 1979) and in California (Jachens and Griscom, 1985) showed the potential usefulness of a similar map for Austria. However, the absence of appropriate computer programs and the difficulties in obtaining digital topography for areas adjacent to Austria further delayed the computation of an isostatic residual gravity map of Austria.

A total of three gravity data sets (Fig. 1) with almost 10,000 Bouguer gravity values was supplied by the University of Vienna, Austria. One data set consists of digitized values of the Bouguer gravity map of Austria (Senftl, 1965a) and the other two are more detailed data sets that consist of gravity stations in the Northern Calcareous Alps and from the Gravimetric Alpine Traverse (Steinhauser and others, 1986), an area that extends from the southern Austrian border to the northern border with Czechoslovakia and between 13°20' and 14°20' east longitude. All gravity values of the three data sets are on the Potsdam datum (Jung, 1961, p. 39) and have been reduced using the 1930 International Gravity formula (Swick, 1942, p. 61).

The gravity datum of the digitized Bouguer gravity map and of the Gravimetric Alpine Traverse data sets (Fig. 1) is the European Calibration Line (ECL) System (Marzahn, 1963) and the Austrian Gravity Standardization Net derived from it. The Northern Calcareous Alps data were obtained with LaCoste and Romberg meters relative to base stations originally established with now-obsolete Askanic gravity meters which had a built-in ball-calibration device. A comparison of complete Bouguer anomaly values of the Northern Calcareous Alps data set at 129 repeat measurements of the Ostalpentraverse data set indicated that there was a scale factor difference of 4 ppt (parts per thousand) for the Northern Calcareous Alps data set, thus causing this set to be, on the average, too high by about one mGal (Fig. 2). The scatter of differences in Figure 2 is primarily caused by the extreme variations of station elevations ranging from about 400 m above sea level to about 2700 m. One mGal has been subtracted from the Northern Calcareous Alps data set to bring these data in line with the other two sets. A total of 9,467 gravity values were used to compute the isostatic residual gravity map.

Mean elevations of Austria have been published by Senftl (1965b) for a geographic grid of 1.5' latitude and 2.5' longitude. The United States Defense Mapping Agency/Aerospace Center provided 5' by 5' mean elevations for the area surrounding Austria (D. Schreibe, written commun., 1985). These two data sets were merged and regridded into a single geographic grid of elevations averaged over cells covering 1.5' of latitude and 2.5' of longitude. This grid of averaged elevations covers the area between 43° and 51° north latitude and 6° to 21° east longitude. These topographic and Bouguer gravity data sets proved to be adequate to calculate an isostatic residual gravity map of Austria.

Isostatic corrections to a radial distance of 166.7 km were computed using a program (Simpson and others, 1984) which assumes local isostatic compensation according to an Airy-Heiskanen model. The model parameters assumed for the Airy-isostatic model are 30 km for the sea-level crustal thickness T, 2,670 kg/m^3 for the the density of the toporaphy above sea-level ρ, and 400 kg/m^3 for the density contrast $\Delta\rho$ between the lower-crustal and the upper-mantle material which has been displaced by the Airy-Heiskanen root (see Heiskanen and Vening Meinesz, 1958, p. 135-140). Published results (Kărki and others, 1961) were used to account for the attraction of surface topography and the corresponding crustal structure assuming perfect isostasy beyond 166.7 km to the antipodes.

The choice of 30 km for the sea-level crustal thickness T and 400 kg/m^3 for the density contrast $\Delta\rho$ between the lower crust and upper mantle is based on seismic measurements (Aric and others, 1979, Makris, 1971, Mueller and others, 1980) and is reasonably consistent with the parameters (T=32 km, $\Delta\rho$ =500 kg/m^3) used for the Isostatic Map of Switzerland (Klingele, 1979) and the parameters (T=30 km, $\Delta\rho$ =300 kg/m^3) used by Kissling (1980) in his study of the Swiss Alps. Changing the density contrast $\Delta\rho$ from 400 kg/m^3 to 300 kg/m^3 results in differences ranging from +0.5 mGal for the basins to -4.7 mGal in the high Alps (Fig.3). These differences were obtained by subtracting the isostatic corrections computed using $\Delta\rho$ =400 kg/cm^3 from those using $\Delta\rho$ =300 kg/cm^3 at a set of grid points and contouring the data. Similarly, changing the crustal thickness from 30 km to 25 km results in differences ranging from -0.6 mGal to +9.6 mGal (Fig. 4).

The range in Bouguer anomalies for the same data set is from -191 mGal in Vintschgau, Italy (A) to +12 mGal in Waldviertel, Austria (B). The mean Bouguer anomaly, based on 9,467 gravity values, is -72 mGal with a standard deviation of 37 mGal. Similarly, the range in isostatic residuals is from -39 mGal in Buendnerland, Switzerland (C) to +59 mGal in Waldviertel (B), and the mean residual is +13 mGal with a standard deviation of 18 mGal. Thus, the Bouguer anomaly range of 203 mGal is reduced to 98 mGal, and the mean Bouguer anomaly value increased by 85 mGal, by removing the computed isostatic regional field. The standard deviation of the mean isostatic residual (18 mGal) is primarily a measure of the heterogenety of rock densities in the upper crust, whereas the standard deviation of the mean Bouguer anomaly (37 mGal) results from a combination of geologic variance, and the variation in crustal thickness associated with topographic loads, as has been pointed out by Oliver and others (1982) in connection with gravity analyses in the southwestern United States.

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