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B. A. ANDREEV

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Abstract

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B. A. ANDREEV

FAYE GRAVITY ANOMALIES AND ISOSTASY

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In recent years, in a number of works by Soviet and foreign scientists, the question of isostatic compensation of the Earth' s crust has been considered. At the same time, conclusions about the degree of isostatic compensation of a region are often drawn without the direct use of isostatic anomalies (the computation of which, as is known, is a difficult matter and not always practically feasible), but from the mean intensity of Faye anomalies, assuming that the mean values of these and other anomalies within regions of considerable area should be close to one another ([1]-[4]).

The question of the correspondence between Faye anomalies and isostatic anomalies has been examined by many investigators. V. Bowie ([5]), and subsequently V. Heiskanen et al. ([6]), noted that the values of isostatic anomalies are almost independent of elevation and differ rather little from Faye anomalies in plains regions and in mountainous regions for stations situated below the surrounding terrain; whereas for stations in mountainous regions situated above the surrounding terrain, Faye anomalies are considerably larger than isostatic anomalies. S. V. Evseev indicated that Faye anomalies are linearly related to the elevation of the observation station and depend, in addition, on the mean elevation of the region. I. D. Zhongolovich ([8]) confirmed the existence of a similar type of relation of Faye anomalies with elevation for continental stations and with the depth of the sea floor for marine stations. S. V. Evseev ([7]) and E. N. Lyustikh ([9]) associated the relation of Faye anomalies with elevation and their discrepancy with isostatic anomalies with the regional character of isostatic compensation.

The author has directly investigated the correlation dependence of $\Delta g_F - \Delta g_I$ on h, where Δg_F is the Faye anomaly, Δg_I is the isostatic anomaly, and h is the elevation of the observation point on the continent or the depth of the bottom beneath the observation point at sea. The initial data were taken from the well-known compilation by V. Heiskanen ([10]). A total of 2210 continental stations were used for the territories of North America, Western Europe, Africa, and India. For the oceans, 596 stations were used—mainly the survey data of F. Vening Meinesz ([11]). The isostatic anomaly was taken as computed, as a rule, according to the Hayford system with a compensation depth of 113.7 km, and only in a few cases, when the corresponding data were absent, according to the Airy-Heiskanen system with a crustal thickness of 30-60 km. The dependence

Fig. 1. Correlation between the difference of the Faye and isostatic gravity anomalies and relief elevation for the continent (a), and sea-floor depth for the ocean (b). The hatched portions are parts of the correlation region determined from a large number of points.

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was investigated by plotting the values of $\Delta g_F - \Delta g_I$ as points on a correlation diagram. In Fig. 1 are shown–separately for the continent and for the ocean –the principal regions of correlation, containing more than 98% of the points of the correlation diagram (depiction of each correlation point is impossible at the given scale of the figure). In addition to the boundaries of the principal region of correlation, the mean lines of this region are also shown there; they approximately correspond to regression lines, since the individual points of the correlation diagram are grouped, as a rule, rather symmetrically with respect to these mean lines.

As we see, the difference $\Delta g_F - \Delta g_I$ has a close correlation with h. For continental stations with $h > 1.3$ km, and also for all oceanic stations, this relation proves to be linear and is characterized by an intensive increase in the difference $\Delta g_F - \Delta g_I$ with increasing elevation for continental stations, and by a less intensive decrease of the same difference with increasing depth of the sea floor for oceanic stations. At elevations $0 < h < 1.3$ km, for continental stations the linear correlation is disrupted, and the mean value of the difference $\Delta g_F - \Delta g_I$ over almost this entire interval has small negative values.

Fig. 1. Correlation between the difference of the Faye and isostatic gravity anomalies and relief elevation for the continent (a), and sea-floor depth for the ocean (b). The hatched portions are parts of the correlation region determined from a large number of points.

At $h = 0$ the mean value of the difference becomes positive, so that in the elevation interval 0–500 m it changes by approximately 65 mgal. The largest positive values of the mean difference $\Delta g_F - \Delta g_I$ are observed at maximum relief elevations (up to 275 mgal at $h = +4$ km), and the minimum negative values at the maximum depth of the ocean floor (down to -130 mgal at $h = -8$ km).

Half the width of the band characterizing the principal region of correlation between $\Delta g_F - \Delta g_I$ and h is 100 mgal for the continent and 70 mgal for the ocean. The scatter of the data is apparently due to relief conditions (see above the conclusions of V. Bowie and V. Heiskanen), and also, undoubtedly, to fluctuations in the density of rocks in the region of the observation station, since the mean values of the difference $\Delta g_F - \Delta g_I$ for the continent are naturally referred to the mean density of lithospheric rocks (2.7 g/cm^3). Within regions of considerable area, values of $\Delta g_F - \Delta g_I$ are observed which, at close values of h, fall both in the upper and in the lower half of the band of the principal correlation region. Therefore, using the diagrams given here, it proves possible, for regions within which relief elevations vary over a comparatively narrow interval, to predict fairly reliably the probable mean value of the difference $\Delta g_F - \Delta g_I$, and, knowing the mean value of Δg_F, to predict the mean value Δg_I.

As an example let us consider the region of the central part of the ice sheet of East Antarctica, crossed in 1956–1958 by the geophysical traverse of the 2nd and 3rd Soviet Antarctic Expeditions (4). Between the Komsomolskaya and Pole of Inaccessibility stations of this traverse (1000–2000 km), the elevation varies only within the limits 3600–4000 m, averaging 3800 m. The mean value of the anomalies Δg_F for this part of the traverse is about +20 mgal. This value may be regarded as underestimated relative to that corresponding to the mean density of bedrock ($\sigma = 2.7$ g/cm^3), since in this region above the bedrock there is a layer of ice ($\sigma = 0.9$ g/cm^3) with an average thickness of about 2 km. The corresponding correction for a plane-parallel layer 2 km thick and with density 1.8 g/cm^3 ($\sigma = 2.7 - 0.9$ g/cm^3) is +150 mgal (rounded). Thus, the corrected value Δg_F will be +170 mgal. The difference $\Delta g_F - \Delta g_I$ at $h = 3.8$ km according to our gra-

···in Africa amounts on average to +250 mgal, i.e., the probable mean value of Δg_I in this region will be $170 - 250 = -80$ mgal. Thus, in the central regions of Antarctica there is probably the presence of intense negative isostatic anomalies. Anomalies of this kind are observed in separate areas of the African and Indian platforms [10].

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Note: Figure translations are in progress. See original paper for figures.