INTERPRETATION OF THE ANOMALIES OF GRAVITY

by

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(Reproduced from an article published in the *Bulletin géodésique* N° 46, Paris, 1935).

(Translated from the French).

If one wishes to interpret the anomalies of gravity it is necessary in the first place to take into account not only the direct effect of the masses i.e. their attraction, but also the indirect effect caused by the deflexions of the geoid due to these masses. Thus it may be shown that in neglecting this last effect one generally finds fewer perturbing masses to explain a certain anomaly than would have been the case had it been taken into account. A field of anomalies can never be explained solely on the basis of the deflexions of the geoid.

In the second place it must be remembered that there are always an infinite number of mass distributions which will satisfy a certain field of anomalies. A solution which is found therefore is never more than a possibility and one cannot assert that it is the true solution.

One of the most convenient means for obtaining some idea of the distribution of the masses and the state of the terrestrial crust is by the application of different methods of isostatic reduction. At present there exist three methods, each of which corresponds to a special hypothesis regarding the crust and the distribution of the compensating masses.

That of Hayford-Bowie assumes a uniform distribution throughout the entire thickness of the crust, a condition which would be produced if the topographic features resulted from a change in density, due either to a variation in temperature, a change in the elastic compression or even to a modification in the state of the crust.

That of Heiskanen-Airy assumes that the compensating masses are localized in a kind of root on the under surface of the crust, which would result if the topographic conditions were brought about by a lateral compression of the crust throughout its entire thickness.

That of the author assumes that the crust may be considered as an elastic slab, floating on the subjacent layer and bending under the weight of the topographic irregularities until a condition of equilibrium is re-established, in such a manner that a kind of root is formed on the interior surface of the crust corresponding to the elastic deformation of the latter. This root, which displaces the denser matter in the sub-jacent layer, represents the compensation. It is less localized than in the preceding hypotheses and the compensation has thus a more or less regional character. This form of compensation results when the topographic conditions have been brought about by erosion, sedimentation or vulcanism.

In order to interpret the anomalies it is necessary to apply all methods and if possible each of them with several different values for the principal elements, i.e. for the thickness of the crust, the density of the crust and of the subjacent layer, the elasticity of the crust, etc. From this one may determine which of the hypotheses best corresponds to the field of anomalies in the given region.

By applying these methods some results have already been obtained by the gravimetric expeditions at sea. It seems probable, for instance, that the island of OAHU (Hawaiian Islands) is simply a volcanic mass resting on the crust without breaking it; apparently the crust has simply warped under the influence of this weight. A similar result has been obtained for the great trough of the Philippines; the crust, according to the gravimetric measurements, does not appear to have broken nor to have been laterally compressed in that region. These two conclusions, however, are based on one single gravimetric profile and it is necessary to await further data before accepting them as conclusive.

In the Indian Archipelago a band of very strong negative anomalies has been found beyond the Sonda Islands and between Celebes and Halmaheira. The calculations here show an important root on the under surface of the crust, and it is necessary therefore to

assume that this has been subjected to a very heavy lateral compression which has caused it to "buckle" towards the inner surface. The geology of the islands which lie in this belt is in agreement with this assumption; it shows plications and nappes which indicate a very considerable compression. The seismological measurements also confirm this; practically all of the earthquake centres are found to lie in this belt or in its vicinity.

The character of the gravimetric profiles to the westward of the Island of Sumatra shows a difference in the belt in this vicinity as compared with the belt to the south of Java and elsewhere. It is no longer symmetrical, as in the other case and, as a study of the anomalies shows, the shape of the root which must be assumed agrees better with the hypothesis that there has been a longitudinal slipping of the crust (with only a very weak component perpendicular to the axis of the belt which corresponds to a slight overlapping of the crust on the bottom of the ocean), than with the hypothesis of a symmetrical "buckling" of the crust towards the interior. From this it follows that it is necessary to admit that the compressive force in the crust does not act in all directions, but in one single direction only, — SSE, — in such a manner that it is practically parallel to the plication zone to the west of Sumatra, intersecting it at a greater angle to the southward of Java and along the remainder of the belt. The fact that several geologists have established that the axis of the island of Java seems to be displaced towards the south with respect to the axis of Sumatra, appears to be in harmony with our supposition; this relative displacement will correspond to a difference in compression of the crust between the belt to the south of Java and that to the west of Sumatra.

Similar conditions are found at the other end of the belt, near the Philippines. Here also the gravimetric profiles which have a symmetrical character near the Talaud Islands, assume an unsymmetrical character to the eastward of the Philippines. This change is explained once more by the change in the direction of the belt with respect to the direction of the force, that is, SSE.

Another belt of weaker anomalies has been determined near the interior arc of the Banda Islands, that is, near Banda, Manoek, Seroea etc.

Although it is a question of a range of volcanoes, it appears that the crust has not only bent under their weight, as in the case of the island of Oahu, but that it has also been laterally compressed in such a manner that a root has been formed. The anomalies according to the method of Heiskanen-Airy do not show deflexions in this belt, so one may conclude that this root corresponds approximately to the external topographical conditions implied by this method.

From the examples cited it is clear that the study of the anomalies of gravity by means of the different methods of isostatić reduction can contribute much to advance our knowledge of the phenomena of the terrestrial crust.