Nature Conservancy) on "The Conservation of British Vegetation and Species". He described the work and organization of the Nature Conservancy, which is specially concerned with the scientific and practical importance of preserving as much as possible of our native flora and fauna. The central immediate object of the Conservancy is to establish a number of National Nature Reserves, of which six are now ready for 'declaration', on making which responsibility for the area is assumed. With the Beinn Eighe reserve in Wester Ross already declared, these make the Conservancy's total holdings to date 21,615 acres, and other reserves are in an advanced stage of negotiation. He outlined the plans for developing the scientific work of the Conservancy, which include the establishment of two research institutes, one in the north and the other in the south of England.

Canon Raven, in his concluding remarks, said that this had been a very memorable conference indeed and that the papers had opened up aspects of field botany which were new. Many suggestions had been made by the various speakers, and he hoped that the Society would develop some of these as projects for collective work involving country-wide studies. The papers which had been read and accounts of the exhibits would be published as a book with the same title as that of the conference.

MOUNTAINS AND GRAVITY*

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THE first laboratory measurements of the gravitational attraction between two bodies were made in 1797 by Cavendish, using the torsion balance. Much later, in a more direct method, an ordinary balance was employed, the scale pans being replaced by small equal spheres and a large mass of lead placed first under one sphere and then under the other. Both methods present experimental difficulties, but the force of attraction between two particles is now known with accuracy.

Even before the Cavendish experiments, attempts had been made to find the gravitational attraction of a large mountain mass. Measurements in the Andes seemed to be only partially successful, but an investigation near Schiehallion in Scotland in 1774 gave a value for the gravitational attraction which is reasonably near the truth. The deflexion of a plumb-line towards the mountain was measured, using as a reference point a star conveniently overhead.

Surveyors' observations made for the determination of latitude involve the same principle, and if the plumb-line is not truly vertical the latitude determination will be in error. Latitude measurements in the plains of India showed big discrepancies, and exactly a hundred years ago, in 1852, the Surveyor General of India wrote to a mathematician, Archdeacon Pratt, of Calcutta, directing his attention to the unsolved problem of reconciling these determinations of latitude. It soon appeared that the errors could be explained only if the plumb-bob was being deflected away from the Himalayas, instead of, as would be expected, towards them.

* Substance of a Friday Evening Discourse at the Royal Institution, delivered on May 9.

The possible explanation of this discovery led to much discussion, and many subsequent measurements of the deflexion of the vertical have been made. The problem can more conveniently be expressed in terms of variations in the earth's gravitational field, gravity being smaller near the mountains than would be expected. Measurements with modern instruments capable of detecting a change in the force of gravity as small as one part in a hundred million are much easier and quicker to make than are measurements of the deflexion of the plumb-bob.

In 1855 the Astronomer Royal, Sir George Airy, suggested that the visible crust of the earth is supported on a denser layer and that the extra mass of the mountains is balanced by light material extending down as roots into the denser layer: this goes far towards explaining the anomalous plumb-bob and gravity readings immediately south of the Himalayan range. In 1859 Pratt developed an alternative hypothesis. He supposed that the upper layer of the earth's crust had originally been of uniform density and thickness, without mountains or valleys or ocean deeps, and imagined that in the course of time the crust underwent vertical expansions and contractions. He considered that the material below the crust would prevent any downward expansion, so that where the crust expanded mountains were formed. It followed that beneath the mountains the crust must necessarily be composed of lighter material than is found beneath surrounding parts where there are no mountains. It is not always realized that Pratt's hypothesis was an attempt to explain mountain formation by simple vertical expansions of the earth's crust.

The Airy hypothesis of mountain roots received little attention; but his underlying notion of the mountains floating in a denser yielding material was taken up by Dutton, who, in giving more precision to the idea, coined the term isostasy. Later, Hayford and Bowie firmly welded the isostatic idea to the Pratt hypothesis; they found from a study of data, mostly referring to America, that if allowance was made for the compensating effect of the supposed lighter material beneath the mountains, computed strictly in accordance with the Pratt hypothesis, many observed values of gravity were brought very nearly into agreement with calculated values, the depth at which compensation is complete being taken at about a hundred kilometres. These and subsequent calculations utilizing numerous gravity determinations from different continents have shown that, when large surfaces of the earth are taken as a unit, there is in many cases a fairly close approach to the distribution of masses required by isostatic theory. It became generally supposed that the Indian gravity evidence, as well as the American evidence examined by Hayford and Bowie, supports the Pratt conception of isostasy: that is, the earth's crust was supposed to be made up of a set of vertical columns, each one uniform throughout, each differing in density from its neighbours, and each having its density exactly related to the present relief of the surface, regardless of what that relief might have been in past ages. Geologists have long known that this does not represent a possible condition of the earth's crust, yet the Pratt–Hayford–Bowie conception of isostatic compensation of hills and mountains remains the accepted basis of routine calculations in the computation of gravity anomalies. Although the Pratt hypothesis can be defended as a mathematical convenience which does not pretend to have any close resemblance to reality, it was not put forward as such, but as a theory of the origin of mountains.

It is only in recent years that the Airy hypothesis has received attention. One reason for the long life of the impossible Pratt–Hayford–Bowie hypothesis seems to be that the actual effects on the surface are not as greatly different with the different hypotheses as might be expected, since the centres of gravity of the supposed compensating masses must lie at a very great depth beneath the surface. But a more important reason is probably the failure of geologists to take an active interest in the development of the idea of isostasy, leaving it to mathematicians, who seem not to have been encouraged to find out whether their postulates were geologically possible.

Although geodetic computations (designed to ascertain how nearly the earth's crust is in isostatic equilibrium) appeared to show that gravity anomalies could largely be accounted for by the postulated compensating masses beneath the mountains, some relatively small and a few fairly large anomalies remained after applying the correction for isostatic compensation. It was, however, widely assumed that these could be accounted for by variations in the surface rocks, as, for example, the contrast between light alluvial sediments and dense lava flows. None of the geodetic calculations had made any allowance for this factor, in spite of the protests of the American geologists G. K. Gilbert and David White. Later, R. T. Chamberlin, E. A. Glennie and others were not satisfied that allowance for local geology would get rid of the gravity anomalies, and the matter was clinched by the extensive gravity surveys of Vening Meinesz and others which revealed very big anomalies clearly defying any such simple explanation.

Until recently, no attempt had been made to evaluate the gravitational effects of surface rocks in a large area where a great thickness of sediments is present, but this has been done in an extensive gravity survey (carried out by the Burmah Oil Co., Ltd., and associated companies) of parts of India and Burma, the results of which have been published by the Geological Society of London[1]. After an investigation into the probable effective densities of the relatively light Tertiary sediments of this region, appropriate corrections were computed by a method suggested by E. A. Glennie, and for the first time a gravity map of a large area was produced in which allowance had been made for local geological effects. Very large anomalies remained, and even when further corrections were made to allow for the hypothetical isostatic compensation, there were still large unexplained residual effects. This work strongly supported the contention of Glennie and others that, contrary to general belief, the gravity evidence from India taken as a whole does *not* support any hypothesis that the region is in isostatic equilibrium. It also demonstrated the possible magnitude of the effects arising from surface geology.

After the removal of these effects due to the known geological structures, the gravity irregularities attributable solely to deep-seated causes were found to have a distribution closely related to the principal lines of earth movement. The hills between Assam and Burma coincide closely with a belt of intensely folded strata, and this is marked by pronounced minimum values of gravity. To the east of this, a gravity maximum corresponds closely with a line along which volcanic activity has taken place in the not very distant past. The work in India and Burma links up closely with the large gravity anomalies found by Vening Meinesz in the Netherlands East Indies.

The Ganges–Brahmaputra, Irrawaddy, Mekong and Red River deltas all show gravity maxima if allowance is made for the effects of the light sediments composing these deltas. The Indus delta has been found also to be an area of relatively high gravity, and so have the Nile and Mississippi deltas.

Although there is no unique solution of a gravity picture, the magnitude of the broad regional gravity anomalies makes it possible to set limits to the nature of the masses responsible for the anomalous gravity values in south-east Asia. Seismic records have shown that an approximate representation of the earth's crust can be obtained by assuming three layers of increasing density, and it is clear that the excess of light material in the areas of relatively low gravity is due to the thickening of the upper layers at the expense of the lower ones.

These various recent investigations of gravity anomalies have shown: first, that the basic assumptions of the Pratt–Hayford–Bowie hypothesis are quite untenable; secondly, that allowance must be made for the effects of surface geology; and thirdly, that there are large areas of the earth's crust, particularly those where there has been recent mountain building, which are not in isostatic equilibrium.

It follows, then, that a device employed as a routine procedure by scientific workers concerned especially with measurements of the earth's crust is founded on a hypothesis which other scientific workers concerned especially with the structure of the earth's crust know to be wrong, and it is desirable to inquire why there should be this contradiction. It seems fair to say that the geologists have been at fault in allowing the mathematicians to develop the idea of isostasy in a manner which has been largely unprofitable—a result of lack of co-operation between groups of scientific workers of admittedly different temperaments. It is to be emphasized that, where a wide field of inquiry includes several separate compartments of science, progress will not be possible unless there is a partnership between men of quite different disciplines, and no fear of incompatibility of temperament between partners should be allowed to stand in the way of co-operation.

[1] Evans, P., and Crompton, W., "Geological Factors in Gravity Interpretation", *Quart. J. Geol. Soc.*, **102**, 211 (1946), which includes references to the authors mentioned above.

OBITUARIES

Mr. R. E. Enthoven, C.I.E.

REGINALD EDWARD ENTHOVEN, who died on May 21, had had a distinguished career in India both as a Civil servant and as an anthropologist. Educated at Wellington College and New College, Oxford, he entered the Indian Civil Service in 1887 when he was barely eighteen. He was posted to the Bombay Presidency, where most of his service was spent, though he acted during 1912–15 as Secretary to the Government of India in the Department of Commerce and Industry.

Quite early in his career, Enthoven published a monograph on the cotton fabrics of Bombay, and his interest in the sociological aspects of Indian life was shown very clearly in his "Report on the Census of Bombay, 1901". His work as census superintendent for that Presidency had been much impeded by