LETTERS TO THE EDITOR

GEOPHYSICS

Earth's Central Density

IN a paper to be published elsewhere, I have derived the formula:

$$\eta = \frac{dk}{dp} - g^{-1}\frac{d\varphi}{dz} \qquad (1)$$

where η is a measure of departure from chemical homogeneity at depth z in the Earth (here treated as spherically symmetrical); k, p and g denote the adiabatic incompressibility, pressure and intensity of gravitational attraction, and φ is a function of the P and S seismic velocities. The index η is equal to unity where the Earth is chemically homogeneous, in accordance with a simpler formula[1] developed in 1949; η exceeds unity where the chemical composition is varying with the depth z. An important property of η is that it is equal to the ratio of the actual value of $d\rho/dz$ (where ρ denotes density) to the value $d\rho/dz$ would take if the composition were unvarying.

Since η depends only on dk/dp, g and $d\varphi/dz$, it is possible to set bounds to η throughout most of the Earth, and so set bounds to the possible density gradients. Physical evidence indicates that dk/dp is of the order of 3–5 units in the Earth's deep interior, g is determined in the Earth within uncertainties which reach a maximum of 30 per cent and are mostly much less, while $d\varphi/dz$ is directly yielded from the seismic velocity distributions. More complete numerical details on the derivation and use of equation (1) are being set down elsewhere.

Equation (1) acquires some immediate special interest through Bolt's revised P velocity distribution[2] in the Earth's core. The P velocity distribution previously obtained by Jeffreys[3] gave $d\varphi/dz$ negative and appreciable in magnitude in the region F. By equation (1), the Jeffreys distribution is found to entail a value of η of order 30 units in F, and thence, in agreement with my Earth model B calculations[4], a large density increase (of about 3 g/cm^3) in this region, resulting in an estimated density of order 18 g/cm^3 at the Earth's centre.

One of the features in Bolt's new distribution is the reduction of $|d\varphi/dz|$ to zero in F. By equation (1), this reduces η from about 30 units to the value of dk/dp, expected to be 4–5 units in this part of the Earth. Thus the value of $d\rho/dz$ in F is reduced to one-sixth or less of the value which corresponds to the Jeffreys distribution.

Much detailed analysis, to be presented in a later paper, is required to work out fine details of the density revision in the core required by Bolt's new seismic velocities, since g itself depends on the density distribution. There are also other aspects of the new velocity distribution to be taken into account. But equation (1) has the value of providing a useful first approximation which shows at a glance that the new velocity distribution can permit a substantially reduced estimate of the Earth's central density. The indicated reduction is of the order of 2 g/cm^3 at least.

This is a result of considerable significance to the physics of the Earth's core. Many investigators have found difficulty in accepting a central density as high as 18 g/cm^3. So long as the Jeffreys velocity distribution is used, equation (1) shows immediately that it is difficult to reduce this figure. But with Bolt's distribution, which, incidentally, is compatible with the travel-time data used by Jeffreys, and in fact includes the latter, a central density of order 16 g/cm^3 (possibly a little less) becomes not only possible but also the preferred figure. Thus the revision is in the direction of reconciling previously discordant views on the properties of the Earth's core.

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[3] Jeffreys, H., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **4**, 498 (1939).

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Cape Town Anomaly and Auroral Emission

IT has been recognized since the time of the *Argus* experiments[1,2] that the anomalously low value of the Earth's total magnetic field in the South Atlantic region must have a profound effect on the particles trapped in the radiation belts. The most convincing illustrations of this are the counting-rates of charged particles observed at relatively low altitudes with the Russian cosmic ships[3,4] and recent American satellites in the *Discoverer* series[5]. The maps prepared by both groups show two regions of high radiation intensity in the area of the South Atlantic Ocean, at heights of 250–500 km, where the counting-rates exceed those at corresponding geomagnetic latitudes elsewhere by factors of the order of 1,000 or more. One of these regions, coinciding well with the centre of the magnetic anomaly off the coast of Brazil, is attributed to the inner radiation belt. The other, referred to as the 'south radiation anomaly', lying between Cape Town and Antarctica, is thought to be due to the outer belt. These assignments are supported by the observation that the *Argus* belts of particles lay in the region between the two natural radiation belts[1], corresponding to the positions of the detonation sites between the two recently discovered anomalous radiation zones.

It is the purpose of this communication to point out that the particle flux into the south radiation anomaly is probably large enough to produce observable auroral effects.

Fig. 1 shows the south radiation anomaly as observed by the Russian second cosmic ship[3] and the traces on the Earth's surface of the mirror points of particles entering the zone, estimated with the aid of the longitudinal integral invariant curves published by Vestine and Sibley[6]. Both the northern and southern traces are shown.

O'Brien *et al.*[7,8] have recently reported data telemetered from the satellite *Injun I*, giving electron energies, fluxes and pitch angles at heights of the order of 1,000 km in the vicinity of Iowa City, which is indicated by the point C in Fig. 1. It is evident that these data may be used as a reasonable sample of the