LETTERS TO THE EDITORS

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A Hypothesis on Compressibility at Pressures of the Order of a Million Atmospheres

I HAVE earlier pointed out[1] that the incompressibility k appears to change surprisingly little across the boundary (at depth of 2,900 km.) between the earth's mantle and the central core. Formal calculations[1,2] based on my results for the earth's density distribution[3,4,5] gave $k = 6\cdot5 \times 10^{12}$, $6\cdot2 \times 10^{12}$ dynes/cm.^{2} for the materials just above and just below the boundary, respectively. The difference between these two values is, moreover, within the uncertainty of the determination. Furthermore, I find that when values of k are plotted against values of the pressure p in the earth's interior, there is no significant difference indicated in the values of dk/dp above and below the core boundary. On the other hand, it is well established that this boundary sharply separates materials that are widely different in rigidity and in density.

The suggestion therefore arises that, at the very high pressures obtaining in the earth's deep interior, that is, at pressures of the order of 10^{12} dynes/cm.^{2}, the compressibility of a substance may be largely independent of its particular chemical constitution. Dr. W. Boas of this University informs me that this suggestion is plausible from the point of view of theories of atomic structure and of laboratory investigations at high pressures; and this view is compatible with statements of Bridgman[6]. I have therefore ventured to put the suggestion forward as a tentative hypothesis that would entail a number of interesting consequences, some of which may possibly admit of being tested in the future. The following are points of interest connected with the hypothesis.

(i) If the compressibility is a fairly smooth function of the pressure throughout the earth's central core, it follows with a high degree of probability that the inner part of the central core (below a depth of order 5,000 km. beneath the earth's outer surface) is solid, that is, possesses significant rigidity (μ); this rigidity would be of the same order as that pertaining in the earth's mantle.

This inference follows from a consideration of the formula $\{(k + 4/3\mu)/\rho\}^{1/2}$ (where ρ denotes density) for the velocity of P seismic waves, in the light of (*a*) the strong probability that the outer part of the central core is in an essentially fluid state; (*b*) the observed marked increase[7] in the P velocity from the outer to the inner part of the central core; (*c*) the improbability of the density decreasing with increase of depth.

It may be noted that even if the main hypothesis set down above should turn out to be not substantiated, there still remains a likelihood of the inner core being solid. This follows since one would *a priori* expect any change in compressibility between the two portions of the central core to be not more pronounced than the change between the outer central core and the mantle. The argument just stated would thus still be relevant.

(ii) As a consequence of (i), a possible explanation of the earth's permanent magnetism would be forthcoming. A discussion by Birch[8] on the alpha-gamma transformation of iron indicates that the Curie temperature of alloys containing γ-iron may conceivably increase with increase of pressure at a sufficient rate to allow of the existence of a ferromagnetic inner solid core in the earth.

(iii) The hypothesis would, if correct, lead to an increased precision in figures for the density variation in the earth, inasmuch as an additional equation of condition would in effect be provided.

(iv) It would follow that the mean density of the inner part of the central core exceeds 14 gm./cm.^{3}.

(v) The sudden changes[9] in values of the P and S velocity gradients setting in at a depth of about 410 km. below the earth's outer surface could be explained as the setting in of a pressure phenomenon independently of chemical composition. This could be an alternative, or perhaps supplementary, explanation to Bernal's hypothesis[10] that the changes at this order of depth in the earth are due to a rearrangement in the crystalline state of the material present.

(vi) The hypothesis would, in relation to the observed diminutions[11] in the P and S velocity gradients in the region extending to about 200 km. immediately above the earth's central core, suggest an increased density gradient in this region over that in the remainder of the lower part of the earth's mantle.

(vii) The hypothesis would lead to a number of quantitative relations which might be of interest to physicists in general, and which would perhaps be capable of being tested, or checked from other theoretical work, in the future. For example, $0\cdot39 \times 10^{12}$ dynes/cm.^{2} would be indicated as the pressure above which the (p, k) relation would, at the temperature prevailing in the earth, become independent of the chemical composition. Further, the form of the (p, k) relation (at the temperature prevailing in the earth) would be available over a range of pressure from $0\cdot39 \times 10^{12}$ to about $3\cdot2 \times 10^{12}$ dynes/cm.^{2}, the latter being the pressure at the boundary of the inner core.

(viii) If the earth's inner core were significantly solid, it would be capable of transmitting significant S seismic waves. This suggests the project of setting up an earth model incorporating the above compressibility hypothesis, and evolving corresponding theoretical travel-time tables for phases such as *PKJKP*, say, where P as usual denotes passage of a wave in the P type through the earth's mantle, K passage in the P type through the outer part of the central core, and J passage in the S type in the inner core. It would, of course, need to be calculated whether sufficient energy would go into a pulse of this type to enable it to be observable at the earth's outer surface; also, allowance would need to be made for some uncertainty in the value of the rigidity of the inner core. But there is the possibility of a seismological test being ultimately made in this way.

The above features appear to be sufficiently interesting to warrant the carrying out of some detailed work on this compressibility hypothesis; and I propose to publish later a more complete quantitative discussion.

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Dec. 6.

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Some Thoughts on Nomenclature

OUR planet the earth is studied in many ways, some of which correspond roughly to the main divisions of universal science, for example, mechanics, physics and chemistry. Such specialized branches of the universal sciences are appropriately indicated by the prefix 'geo', giving the words 'geomechanics', 'geophysics' and 'geochemistry'. These are modelled on the old word 'geometry', which itself has long since lost its special association with the earth, to become the name of the universal science of the measurement and properties of space. Hence the need for another word ('geodesy') relating to the measurement of the 'figure' of the earth, which must be the basis of geography, the mapping of the earth. The meaning of geography has gradually become elaborated to include much more than graphical representation, and besides physical geography, which shades off into geophysics, covers studies that merge into economics, sociology and general biology.

Another venerable word, 'geology', the significance of which has always been more limited than the word might imply, has nevertheless with time gained a deeper and wider content, so that now it covers many subdivisions which likewise shade off near their boundaries into geophysics, economics and biology (past and present).

I have long thought that a comprehensive word is needed to comprise all these branches of the study of the earth, and the recent growing use of the terms 'the earth sciences' and 'geo-science' in America indicates that others have felt the same need. I wish therefore to propose for this purpose the word 'geonomy', analogous to the ancient word 'astronomy', which has many parallel branches—such as astrophysics, astrometry and astrography, not to speak of the now despised astrology.

The analogy can usefully be carried further. The word 'geonomer', like geonomy, flows smoothly from the tongue, and would comprise not only the geologist and geographer but also such awkwardly named vocations as geophysicist (a too sibilant word), geomagnetician and meteorologist.

The corresponding adjective might be either 'geonomic' or 'geonomical'; 'geonomic' seems preferable for its brevity, and has respectable precedents to justify it, such as 'economic'.

The termination 'nomy' also offers a convenient means of creating a new word to replace 'meteorology', which, especially in its English adjectival form, is excessively polysyllabic; and the association of meteorology with the beautiful word 'meteor' is now irrelevant and misleading. I propose that the word be abandoned in all its many official and unofficial uses, in favour of 'aeronomy' (with the associated words 'aeronomer' and 'aeronomic'): 'aerology' is of course an alternative, but already has a specialized meaning for a part of meteorology.

Possibly the same model might be followed to provide a name for the study of the ionosphere. 'Ionomy', 'ionomer', 'ionomic' might thus replace 'radio-physics' and the associated words, which are certainly less easy to pronounce, and in view of the possible confusion with the physics of radioactivity, somewhat ambiguous: it is to be admitted, however, that ionomy might seem applicable to the study of ions in the laboratory as well as in the ionosphere.

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Control of Electrical Twinning in Quartz

IN the Dauphine twins of quartz, the polarity of the electric axes is reversed on either side of a twin boundary. Structurally the change is slight. It has been known for some time that electrical twinning could be induced either by heating[1] or by pressure[2]; but up to the present its elimination has not, so far as we are aware, been reported.

We have investigated the influence of stress upon quartz plates, bars and cylinders when heated and have found that by suitable combinations of stress and temperature upon particular cuts, the twinned parts of the crystal may be untwinned, so that the material hitherto rejected in the manufacture of quartz oscillators may be utilized.

The most useful method consists in applying a steady torque to a plate of suitable orientation, heated to a temperature which may be considerably below the α–β inversion point. This results, in a single treatment, in eliminating all the twin boundaries except for a small band running down the narrow edges, as shown in Fig. 1. Reversing the sense of the torque did not bring about a change in the polarity of the crystal developed, which depended only upon the orientation and shape of the plate relative to the crystal axes.

An investigation was made of a series of plates, the length in each case being perpendicular to the optic axis. In order to get substantially

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