

LETTERS TO THE EDITORS

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Temperature of the Interior of the Earth

BULLEN^{1,2} has derived both the density and the compressibility of the earth as functions of depth, and has found that the bulk modulus k , which is the reciprocal of the compressibility κ , is a linear function of the pressure p :

$$k = k_0 + ap. \quad (1)$$

Ramsey³ has re-examined this relation from the point of view of the theory of solids, and his conclusions agree with those of Bullen, namely, that the linear relation (1) is valid both in the core and in the mantle below 1,000 km. Ramsey, however, found that the constant k_0 had different values in the core and mantle, although the derivative $dk/dp = a$ was sensibly the same.

In view of equation (1), it seems reasonable to suppose that a similar relationship exists between the volume coefficient of thermal expansion α and pressure p , namely, that the reciprocal of α is a linear function of p :

$$\frac{1}{\alpha} = \frac{1}{\alpha_0} + bp. \quad (2)$$

In a recent investigation on the thermal properties of the earth (based on the theory of solids), Uffen⁴ has obtained values of α within the mantle, and it is found that they are in excellent agreement with hypothesis (2). It is assumed that the relation (2), like the relation (1), is valid both in the core and the mantle. The values of the constants $1/\alpha_0$ and b are found to be:

$$1/\alpha_0 = 2.4 \times 10^4 \text{ }^\circ\text{K.}, b = 6.2 \times 10^{-8} \text{ }^\circ\text{K. cm.}^2/\text{dyne.} \quad (3)$$

A theoretical investigation for the justification of (2) is in hand.

It is now possible to make an estimate of the adiabatic temperature gradient throughout the earth. The adiabatic gradient may be written

$$\frac{dT}{dp} = \frac{\alpha T}{\rho c_p}, \quad (4)$$

where ρ is the density and c_p the specific heat at constant pressure. From (2) and (4),

$$\frac{dT}{T} = \frac{dp}{\rho c_p \left(\frac{1}{\alpha_0} + bp \right)}. \quad (5)$$

Both Uffen⁴ and Verhoogen⁵ obtained values of the ratio α/c_p in the mantle using seismic data. Uffen found that the values of c_p were approximately constant (in agreement with Bridgman's observations at relatively low pressures), and that the variations in α/c_p were almost entirely due to variations in α . A constant value for c_p is assumed, so that from (5),

$$\ln T = \frac{1}{c_p} \int \frac{dp}{\rho \left(\frac{1}{\alpha_0} + bp \right)}. \quad (6)$$

It is estimated that variations in c_p will not affect the validity of (6) by more than 5 per cent. Since ρ is known as a function of depth (and hence of pressure), equation (6) can be integrated numerically.

Hypothesis (2) is assumed to hold at all depths below 1,000 km., although preliminary investigations show that it is not likely to be much in error up to depths of 500 km. Taking T at 1,000 km. to be $3,600^\circ\text{K.}$ (Uffen⁴), values of T can be estimated at all greater depths. It is found that the temperature at the boundary of the core and mantle is $4,350^\circ\text{K.}$ and at the centre of the earth a little greater than $4,800^\circ\text{K.}$ The increase throughout the core is thus only 500° . The results should be of considerable interest to Bullard's⁶ theory of the transfer of heat from the core. Further implications of equations (1) and (2) are being investigated, and it is hoped to publish a fuller account elsewhere.

J. A. JACOBS

University of Toronto,
Toronto 5, Ontario.
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¹ Bullen, K. E., *Bull. Seis. Soc. Amer.*, **30**, 235 (1940); **32**, 19 (1942).

² Bullen, K. E., *Mon. Not. Roy. Astro Soc., Geophys. Supp.*, **5**, 355 (1949); **6**, 50 (1950).

³ Ramsey, W. H., *Mon. Not. Roy. Astro Soc., Geophys. Supp.*, **6**, 42 (1950).

⁴ Uffen, R. J., Ph.D. thesis, Univ. of West. Ont., Canada.

⁵ Verhoogen, J., *Trans. Amer. Geophys. Union*, 32-1 (1951).

⁶ Bullard, E. C., *Mon. Not. Roy. Astro Soc., Geophys. Supp.*, **6**, 36 (1950).

Effect of Water Vapour on Explosions of Carbon Monoxide

It is well known that the low-pressure explosion of carbon monoxide - oxygen mixtures is characterized by an upper and a lower pressure limit of explosion at a particular temperature. We find that it is also characterized by an upper and a lower pressure limit for a glow, accompanied by slow oxidation, to occur.

Garner and Gomm¹, Cosslett and Garner² and Hadman, Thompson and Hinshelwood³ found water vapour to have no effect on the lower explosion limit. In accordance with this, we find that water vapour has no effect on the lower glow limit. Hadman *et al.*³ also concluded that water vapour had no effect on the upper explosion limit. We cannot confirm this conclusion. Water vapour raises both the upper glow limit and the upper explosion limit. As a consequence it reduces the temperature of the tip of the explosion peninsula.

Hadman *et al.*³ made their statement because, using a dry mixture and a static method, they obtained the following values for the upper explosion limit:

650° C.	67 per cent O ₂ .	P = 240 mm.
680° C.	67 " " O ₂ .	P = c. 360 "

and compared these values with the following, obtained by Kopp, Kowalsky, Sagulin and Semenoff⁴, using a wet mixture and a flow system:

650° C.	{ 90 per cent O ₂ .	P = 260 mm.
	{ 33 " " O ₂ .	P = 190 "
680° C.	{ 33 " " O ₂ .	P = c. 400 "

The comparison, made in 1932, is scarcely very satisfactory. The agreement is neither extensive nor exact. The comparison ignores any possible difference in results for flow and static systems. Examples are known where ignition temperatures determined in flow systems have been high relative to determinations in static systems. Nevertheless, the statement that water vapour has no effect on the upper ex-