to the compressibility of Mg_2SiO_4 spinel. This gives the difference in free energy of the two forms due to compression. When this reaches 68,000 joules, spinel becomes the stable form.

Calculation indicates that this value will be reached at a pressure corresponding to a depth of 520 ± 180 km. within the Earth. This is in good agreement with the depth of the 20° discontinuity found by seismology and is considered to provide strong evidence supporting the Jeffreys–Bernal hypothesis.

An olivine–spinel transition in the mantle is capable of explaining the variation with depth of density, elasticity and electrical conductivity. It is consistent also with the inference by Bullen[5] and by Birch[6] that the transition takes place over a wide range of depths. A substantial pressure interval would accompany the transition, because of the presence of other components in solid solution, particularly Fe_2SiO_4, $MgSiO_3$, Ca^2, Al^3, Cr^3. (Spinels are widely tolerant towards ionic substitutions and are often able to dissolve compounds with ABO_3 type formulæ.) The presence of a finite temperature gradient and the possibility of hysteresis and non-attainment of equilibrium also contribute towards a range of transition.

Occurrence of the transition raises difficulties for the convection theory of orogenesis, because of the liberation of latent heat during the transition and difficulties in maintaining equilibrium. However, the contraction theory is considerably strengthened. As cooling causes inversion of olivine to spinel, the volume contraction for the same heat loss is about twenty times greater than the normal thermal contraction.

This communication is essentially an abstract of a more comprehensive investigation[7] the full results of which will be published in due course.

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[1] Jeffreys, H., "The Earth", 3rd edit. (Camb. Univ. Press, 1952).
[2] Bullen, K. E., *Mon. Not. Roy. Astro. Soc.*, *Geophys. Supp.*, **3**, 395 (1936).
[3] Bernal, J. D., *Observatory*, **59**, 268 (1936).
[4] Tempkin, M., *Acta Physicochim. U.R.S.S.*, **20**, 411 (1945).
[5] Bullen, K. E., "Introduction to the Theory of Seismology", Chapter 13 (Camb. Univ. Press, 1947).
[6] Birch, F., *J. Geophys. Res.*, **57**, 227 (1952).
[7] Ringwood, A. E., Ph.D. thesis, University of Melbourne (1956).

With great interest I have read the preceding important communication by Dr. A. E. Ringwood, which seems to confirm a hypothesis about a phase-transition of the olivine between the depths of 200 km. and 900 km. in the Earth, which I proposed (*Proc. Roy. Netherlands Acad. Sci.*, B, **59**, 1; 1956), starting from a different basis, namely, the over-whelming evidence in favour of convection-currents in the mantle. This demands the same chemical constitution throughout the whole mantle, and so we have to assume a phase-difference between the upper layer, above 200 km. depth, and the lower layer, below 900 km. depth, with a transition-layer between, in order to explain the density results, derived by Jeffreys, Birch and others on seismological grounds.

In this paper I tried to show that all the facts agree to this supposition, if at least the transition energy K per gram is smaller than an upper limit given by

$$\left(\frac{K}{cA}\right)_m \leqq {}_l\theta_e - {}_u\theta_e$$

where the left-hand side is the mean value over the whole transition layer of the ratio of K to the product of the specific heat c and the heat equivalent A, while ${}_u\theta_e$ and ${}_l\theta_e$, respectively, are the values of the equilibrium temperature θ_e of the two phases, at the upper and lower boundaries, respectively, of the transition layer. For a value of c of 0·20 (see "Handbook of Physical Constants" by Birch, Schairer and Spicer) the value of K derived from Ringwood's result, namely, $F = 68{,}000 \pm 10{,}000$ joules/mole, would give:

$${}_l\theta_e - {}_u\theta_e \geqq 580° \pm 90°$$

As this value for the difference in temperature at 200 km. and 900 km. depth is acceptable, I cannot agree with Ringwood's conclusion regarding the incompatibility of the convection theory of orogenesis with the phase-transition hypothesis here presented.

In the paper mentioned above, I had occasion to make the following points. In the first place, the cooling of the Earth must bring about a broad transition-layer between the two phases, which slowly travels upwards; it now has reached the position between 200 km. and 900 km. depth. Secondly, the presence of convection currents which in this period of mountain formation we must surmise to rise below the continents, where the radioactivity of the sial must cause a higher temperature than below the oceans, and to subside below the oceans, must bring about a change of the denser phase into the lighter one below the continents, and the reverse below the oceans. This can explain the regressions of the continents during the first period of an orogenic cycle and the subsidence afterwards in the way indicated by the geological evidence. In the third place, this state of affairs can explain why in general the temperature gradient found below the ocean floors is about the same as that found below the continents, notwithstanding the difference of radioactive heat production in the two areas which might be expected to give a difference in gradient; the phase changes indicated must have a contrary effect on the gradient at the surface.

I may refer to the paper mentioned for some further evidence in favour of the hypothesis here presented. Dr. Ringwood's paper is a most important contribution to it, by giving a solid base for the phase-transition hypothesis.

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Surface Adhesion and Elastic Properties of Mica

Consideration of the crystal structure of mica[1] suggests that the strong adhesive forces observed between mica cleavage surfaces may be the same as the forces which hold the alumino-silicate layers together in a block of the material. Cleavage occurs between two such layers along a plane of potassium ions, and the surfaces so formed may be flat and molecularly smooth over appreciable areas[2]. Apparently, both filled and empty potassium ion sites are present on the cleavage plane, but there is little