54. *The Plastic State of the Earth under Gravitational Forces.*

By Katsutada SEZAWA,

Earthquake Research Institute.

(Read July 6, 1937.—Received Sept. 20, 1937.)

1. *The probable plastic condition of the rocky shell.*

In the previous paper[1] I examined the possible plastic condition of the earth's core on the assumption that the rocky shell is almost incompressible, the conclusion pointing to the contingency that were the rocky shell fairly compressible, the material in the same shell would also be plastic. It is well known that the earth's core is in a fluid state, whereas the shell next to it is solid, the reason of which is probably that, although the actual temperature in the core is higher than the melting point of the metals in that core, the same temperature is still lower than the melting point of the rock under hydrostatic pressure corresponding to that of the core. My previous conclusion with respect to the difference in the plastic properties between the earth's core and the shell consequently involves certain ambiguities. From my new calculation it appears that, while the material in the rocky shell may be so compressible that their condition is almost plastic, those in the central part of the earth's core would even be elastic, provided the plastic constants there were the same as that of the shell. But, since the material in the central part, because of the high temperature, will asume extremely low plastic constants, the elastic condition just cited virtually does not exist.

In the present paper we shall assume that the rocky shell next to the core is composed of two layers; namely, the outermost layer 480 km thick that was found by Jeffreys[2] and the next one 2420 km (=2900 km −480 km) thick, every one of the respective layers and the core being of uniform density.

Let a, b, c be the radii of the respective outer boundaries of the outermost layer, the intermediate shell, and the core, their values being

1) K. SEZAWA, "On the Plastic Properties of the Earth's Core," *Bull. Earthq. Res. Inst.*, **15** (1937), 582~589.

2) H. JEFFREYS, "On the Materials and Density of Earth's Crust," M.N.R.A.S. *Geophys. Suppl.* 4 (1937), *No.* 1, 50~61.

6370 km, 5890 km, and 3470 km respectively. Let also ρ_1, ρ_2, ρ_3 be the densities of the three parts under consideration. Then, from the formula

$$V=\frac{4\pi}{r}\gamma\int_0^r \rho r'^2 dr+4\pi\gamma\int_r^\infty \rho r' dr', \tag{1}$$

the gravitational potentials of the three parts assume the forms

$$\left.\begin{aligned}
V_1&=\frac{4\pi\gamma}{3r}\left\{c^3(\rho_3-\rho_2)+b^3(\rho_2-\rho_1)\right\}+2\pi\gamma\rho_1\left(a^2-\frac{r^2}{3}\right),\\
V_3&=\frac{4\pi\gamma}{3r}c^3(\rho_3-\rho_2)+2\pi\gamma b^2(\rho_2-\rho_1)-\frac{2}{3}\pi\gamma r^2\rho_2+2\pi\gamma a^2\rho_1,\\
V_3&=2\pi\gamma c^2(\rho_3-\rho_2)-\frac{2\pi\gamma}{3}r^2\rho_3+2\pi\gamma b^2(\rho_2-\rho_1)+2\pi\gamma a^2\rho_1,
\end{aligned}\right\} \tag{2}$$

γ, r being the gravitational constant and the radius respectively of any point in the Earth. The rates of pressure change with radius are then

$$\left.\begin{aligned}
\frac{\partial p_1}{\partial r}&=\rho_1\frac{\partial V_1}{\partial r}=\frac{-4\pi\gamma}{3r^2}\left\{c^3\rho_1(\rho_3-\rho_2)+b^3\rho_1(\rho_2-\rho_1)\right\}-\frac{4\pi\gamma\rho_1^2 r}{3}\\
&=-\frac{\xi_1}{r^2}-\eta_1 r,\\
\frac{\partial p_2}{\partial r}&=\rho_2\frac{\partial V_2}{\partial r}=-\frac{4\pi\gamma}{3r^2}c^3\rho_2(\rho_3-\rho_2)-\frac{4\pi\gamma\rho_2^2 r}{3}=-\frac{\xi_2}{r^2}-\eta_2 r,\\
\frac{\partial p_3}{\partial r}&=\rho_3\frac{\partial V_3}{\partial r}=-\frac{4\pi\gamma\rho_3^2 r}{3}=-\eta_3 r.
\end{aligned}\right\} \tag{3}$$

If every medium were in elastic condition, the equations of equilibrium would be of the forms

$$\left.\begin{aligned}
\frac{-\xi_1}{r^2}-\eta_1 r+(\lambda_1+2\mu_1)\left(\frac{\partial^2 u_1}{\partial r^2}+\frac{2}{r}\frac{\partial u_1}{\partial r}-\frac{2u_1}{r^2}\right)&=0,\\
\frac{-\xi_2}{r^2}-\eta_2 r+(\lambda_2+2\mu_2)\left(\frac{\partial^2 u_2}{\partial r^2}+\frac{2}{r}\frac{\partial u_2}{\partial r}-\frac{2u_2}{r^2}\right)&=0,\\
-\eta_3 r+(\lambda_3+2\mu_3)\left(\frac{\partial^2 u_3}{\partial r^2}+\frac{2}{r}\frac{\partial u_3}{\partial r}-\frac{2u_3}{r^2}\right)&=0,
\end{aligned}\right\} \tag{4}$$

where the suffixes 1, 2, 3 refer to the three media under consideration. The solutions of these equations are

$$\left.\begin{aligned} u_1&=\frac{-\xi_1}{2(\lambda_1+2\mu_1)}+\frac{\eta_1 r^3}{10(\lambda_1+2\mu_1)}+B_1 r+\frac{C_1}{r^2},\\ u_2&=\frac{-\xi_2}{2(\lambda_2+2\mu_2)}+\frac{\eta_2 r^3}{10(\lambda_2+2\mu_2)}+B_2 r+\frac{C_2}{r^2},\\ u_3&=\frac{-\eta_3 r^3}{10(\lambda_3+2\mu_3)}+B_3 r. \end{aligned}\right\} \tag{5}$$

The corresponding stresses are such that

$$\widehat{rr}_1=\frac{-\xi_1\lambda_1}{(\lambda_1+2\mu_1)}\frac{1}{r}+\frac{\eta_1(10\lambda_1+12\mu_1)}{20(\lambda_1+2\mu_1)}r_2+(3\lambda_1+2\mu_1)B_1-\frac{4\mu_1 C_1}{r^3},$$

$$\widehat{\theta\theta}_1=\widehat{\phi\phi}_1=\frac{-\xi_1(\lambda_1+\mu_1)}{(\lambda_1+2\mu_1)}\frac{1}{r}+\frac{\eta_1(10\lambda_1+4\mu_1)}{20(\lambda_1+2\mu_1)}r^2+(3\lambda_1+2\mu_1)B_1+\frac{2\mu_1 C_1}{r^3},$$

$$\widehat{rr}_2=\frac{-\xi_2\lambda_2}{(\lambda_2+2\mu_2)}\frac{1}{r}+\frac{\eta_2(10\lambda_2+12\mu_2)}{20(\lambda_2+2\mu_2)}r^2+(3\lambda_2+2\mu_2)B_2-\frac{4\mu_2 C_2}{r^3},$$

$$\widehat{\theta\theta}_2=\widehat{\phi\phi}_2=\frac{-\xi_2(\lambda_2+\mu_2)}{(\lambda_2+2\mu_2)}\frac{1}{r}+\frac{\eta_2(10\lambda_2+4\mu_2)}{20(\lambda_2+2\mu_2)}r^2+(3\lambda_2+2\mu_2)B_2+\frac{2\mu_2 C_2}{r^3},$$

$$\widehat{rr}_3=\frac{\eta_3(10\lambda_3+12\mu_3)}{20(\lambda_3+2\mu_3)}r^2+(3\lambda_3+2\mu_3)B_3,$$

$$\widehat{\theta\theta}_3=\widehat{\phi\phi}_3=\frac{\eta_3(10\lambda_3+4\mu_3)}{20(\lambda_3+2\mu_3)}r_3+(3\lambda_3+2\mu_3)B_3. \tag{6}$$

From the boundary conditions that

$$\left.\begin{aligned} &r=a; && \widehat{rr}_1=0,\\ &r=b; && \widehat{rr}_1=\widehat{rr}_2, && u_1=u_2,\\ &r=c; && \widehat{rr}_2=\widehat{rr}_3, && u_2=u_3, \end{aligned}\right\} \tag{7}$$

it is possible to determine B_1, C_1. B_2, C_2, B_3, which, however, is somewhat complex. If, however, the differences $\rho_3-\rho_2$, $\rho_2-\rho_1$, $\lambda_1-\lambda_2$, $\lambda_2-\lambda_3$, $\mu_1-\mu_2$, $\mu_2-\mu_3$ are fairly small, we can put $C_1=0$, $C_2=0$, from which we have

$$\left.\begin{aligned} \widehat{rr}_1-\widehat{\theta\theta}_1&=\frac{8\mu_1\pi\gamma\rho_1^2}{15(\lambda_1+2\mu_1)}r^2,\\ \widehat{rr}_2-\widehat{\theta\theta}_2&=\frac{8\mu_2\pi\gamma\rho_2^2}{15(\lambda_2+2\mu_2)}r^2, \end{aligned}\right\} \tag{8}$$

$$\widehat{rr}_3-\widehat{\theta\theta}_3=\frac{8\mu_3\pi\gamma\rho_3^2}{15(\lambda_3+2\mu_3)}r^2.$$

These expressions show that the lateral (horizontal) compression $\widehat{\theta\theta}$ (or $\widehat{\phi\phi}$) is always larger than the radial (vertical) compression $\widehat{rr}$; for example, at $r=a$, $\widehat{rr}_1=0$, $\widehat{\theta\theta}_1=8\mu_1\pi\gamma\rho_1^2r^2/15(\lambda_1+2\mu_1)$. It will be seen that the differences under consideration tend to increase with increase in r. Put $\gamma=648\cdot10^{-10}$, $\rho_1=3\cdot5$, $\rho_2=4\cdot5$, $\rho_3=11$, $\lambda_1=\mu_1$, $\lambda_2=\mu_2$. Then $\widehat{rr}_1-\widehat{\theta\theta}_1$ for different radii assumes the values shown in Table I.

TABLE I.

r (km)	6370	5890	5890	5500	5000	4500	4000	3470	3470	0
$10^{-11}(\widehat{rr}-\widehat{\theta\theta})$ in C. G. S.	1·79	1·53	2·54	2·21	1·92	1·48	1·16	0·88	0	0

Jeffreys conjectured the distribution of tenacity of the earth's crust to be that as shown in Table II. d in Table II denotes the depth be-

TABLE II.

d (km)	0	30	300	1000
Tenacity. 10^{-9}	1·5	0·61	0·092	0·009

neath the ultrabasic layer. Since tenacity may be taken as $2k$ (k being the plastic constant) at any rate in the order of its value, it is possible to assume that the materials are in a plastic state at almost any depth in the earth, with the exception of the central part of the earth's core.

2. *The plastic equilibrium of the earth.*

With the condition that all the layers of the rocky shell, besides the core, are almost in a plastic state, it is now possible to deal with the earth as a plastic body. The equations of equilibrium assume the forms

$$\left.\begin{aligned}&\frac{-\xi_1}{r^2}-\gamma_1 r+\frac{\partial\widehat{rr}_1}{\partial r}+\frac{2}{r}(\widehat{rr}_1-\widehat{\theta\theta}_1)=0,\\&\frac{-\xi_2}{r^2}-\gamma_2 r+\frac{\partial\widehat{rr}_2}{\partial r}+\frac{2}{r}(\widehat{rr}_2-\widehat{\theta\theta}_2)=0,\end{aligned}\right\}\qquad(9)$$

3) H. JEFFREYS, "On the Relation between Fusion and Strength," *Phil. Mag.*, 19 (1935), 840~846.

$$-\eta_3 r+\frac{\partial\widehat{rr}_3}{\partial r}+\frac{2}{r}(\widehat{rr}_3-\widehat{\theta\theta}_3)=0,$$

provided, owing to the conditions of symmetry, the relations $\widehat{\theta\theta}_1=\widehat{\phi\phi}_1$, $\widehat{\theta\theta}_2=\widehat{\phi\phi}_2$, $\widehat{\theta\theta}_3=\widehat{\phi\phi}_3$ exist.

Let k_1, k_2, k_3 be the plastic constants of the successive three layers. Then

$$\widehat{rr}_1-\widehat{\theta\theta}_1=2k_1,\qquad \widehat{rr}_2-\widehat{\theta\theta}_2=2k_2,\qquad \widehat{rr}_3-\widehat{\theta\theta}_3=2k_3. \tag{10}$$

Substituting (10) in (9) and solving the resulting equations, we have

$$\left.\begin{aligned}&\widehat{rr}_1+4k_1\log r+\frac{\xi_1}{r}-\frac{\eta_1 r^2}{2}+I_1=0,\\&\widehat{rr}_2+4k_2\log r+\frac{\xi_2}{r}-\frac{\eta_2 r^2}{2}+I_2=0,\\&\widehat{rr}_3+4k_3\log r+\frac{\xi_3}{r}-\frac{\eta_3 r^2}{2}+I_3=0,\end{aligned}\right\} \tag{11}$$

where I_1, I_2, I_3 are integration constants. The boundary conditions are

$$\left.\begin{aligned}&r=a; &&\widehat{rr}_1=0,\\&r=b; &&\widehat{rr}_1=\widehat{rr}_2,\\&r=c; &&\widehat{rr}_2=\widehat{rr}_3.\end{aligned}\right\} \tag{12}$$

Substituting (11) in (12) and determining I_1, I_2, I_3, we obtain

$$\left.\begin{aligned}\widehat{rr}_1=&\,\xi_1\Big(\frac{1}{a}-\frac{1}{r}\Big)-\frac{\eta_1}{2}(a^2-r^2)+4k_1\log\frac{a}{r},\\ \widehat{rr}_2=&\left\{\xi_1\Big(\frac{1}{a}-\frac{1}{b}\Big)+\xi_2\Big(\frac{1}{b}-\frac{1}{r}\Big)\right\}-\left\{\frac{\eta_1}{2}(a^2-b^2)+\frac{\eta_2}{2}(b^2-r^2)\right\}\\&+4k_1\log\frac{a}{b}+4k_2\log\frac{b}{r},\\ \widehat{rr}_3=&\left\{\xi_1\Big(\frac{1}{a}-\frac{1}{b}\Big)+\xi_2\Big(\frac{1}{b}-\frac{1}{c}\Big)\right\}-\left\{\frac{\eta_1}{2}(a^2-b^2)+\frac{\eta_2}{2}(b^2-c^2)\right.\\&\left.+\frac{\eta_3}{2}(c^2-r^2)\right\}+4k_1\log\frac{a}{b}+4k_2\log\frac{b}{c}+4k_3\log\frac{c}{r},\end{aligned}\right\} \tag{13}$$

$$\left.\begin{aligned}\widehat{\theta\theta}_1=\widehat{\phi\phi}_1=\widehat{rr}_1-2k_1,\\ \widehat{\theta\theta}_2=\widehat{\phi\phi}_2=\widehat{rr}_2-2k_2,\\ \widehat{\theta\theta}_3=\widehat{\phi\phi}_3=\widehat{rr}_3-2k_3,\end{aligned}\right\} \tag{14}$$

where

$$\left.\begin{aligned}&\xi_1=\frac{4\pi\gamma}{3}\left\{c^3\rho_1(\rho_3-\rho_2)+b^3\rho_1(\rho_2-\rho_1)\right\}, && \eta_1=\frac{4\pi\gamma\rho_1^2}{3},\\ &\xi_2=\frac{4\pi\gamma}{3}c^3\rho_2(\rho_3-\rho_2), \qquad \eta_2=\frac{4\pi\gamma\rho_2^2}{3}, && \eta_3=\frac{4\pi\gamma\rho_3^2}{3}.\end{aligned}\right\} \tag{15}$$

On the free surface $r=a$, we have

$$\widehat{rr}_1=0, \qquad \widehat{\theta\theta}_1=\widehat{\phi\phi}_1=-2k_1, \tag{16}$$

which prove that there is lateral (horizontal) compression even on the free surface of the earth.

In the special case $\rho_1=\rho_2=\rho_3(=\rho)$, $k_1=k_2=k_3(=k)$, we get

$$\left.\begin{aligned}\widehat{rr}_1=\widehat{rr}_2=\widehat{rr}_3=-\frac{\eta}{2}(a^2-r^2)+4k\log\frac{a}{r},\\ \widehat{\theta\theta}_1=\widehat{\theta\theta}_2=\widehat{\theta\theta}_3=-\frac{\eta}{2}(a^2-r^2)+4k\log\frac{a}{r}-2k.\end{aligned}\right\} \tag{17}$$

The angle β, which the slip surface makes with any radius, is obtained in the same way as that shown previously, namely

$$\tan 2\beta=\frac{\widehat{rr}-\widehat{\theta\theta}}{2\widehat{r\theta}}=\frac{\widehat{rr}-\widehat{\phi\phi}}{2\widehat{r\phi}}, \tag{18}$$

where $\widehat{r\theta}=0$, $\widehat{r\phi}=0$. From the equation of the slip surfaces

$$\frac{rd\theta}{dr}\left(=\frac{rd\phi}{dr}\right)=\tan\beta, \tag{19}$$

we get

$$\theta_n=A_n\log r, \qquad \phi_n=B_n\log r \tag{20}$$

for every layer.

3. *The possible existence of an elastic continent.*

The earth's crust near its surface, as a whole, is subjected to high lateral pressure. If, on the other hand, a continental layer were, owing to its boundary edges or fault surfaces in it, in such a state as to be free from lateral pressure, the condition in some cases would possibly be elastic.

In this case the three strain components

$$\frac{\partial u}{\partial r}, \qquad \frac{u}{r}+\frac{1}{r}\frac{\partial v}{\partial \theta}, \qquad \frac{u}{r}+\frac{v}{r}\cot\theta+\frac{1}{r\sin\theta}\frac{\partial w}{\partial \phi} \tag{21}$$

reduce to

$$\frac{\partial u}{\partial r}, \qquad \frac{u}{r}+\frac{c}{r}, \qquad \frac{u}{r}+\frac{c}{r}, \tag{22}$$

c being a constant, so that

$$\Delta=\frac{\partial(u+c)}{\partial r}+\frac{2(u+c)}{r}. \tag{23}$$

Were u replaced by $u+c$, all the conditions of the problem would be the same as in Section 1. Thus we find that

$$\left.\begin{aligned} \widehat{rr}_1&=\frac{-\xi_1\lambda_1}{\lambda_1+2\mu_1}\frac{1}{r}+\frac{\eta_1(10\lambda_1+12\mu_1)}{20(\lambda_1+2\mu_1)}+(3\lambda_1+2\mu_1)B_1-\frac{4\mu_1C_1}{r^3}, \\ \widehat{\theta\theta}_1&=\frac{-\xi_1(\lambda_1+\mu_1)}{(\lambda_1+2\mu_1)}\frac{1}{r}+\frac{\eta_1(10\lambda_1+4\mu_1)}{20(\lambda_1+2\mu_1)}+(3\lambda_1+2\mu_1)B_1+\frac{2\mu_1C_1}{r^3}. \end{aligned}\right\} \tag{25}$$

The boundary conditions are

$$\left.\begin{aligned} r&=a'; \qquad \widehat{rr}_1=0, \qquad \widehat{\theta\theta}_1=0, \\ r&=(a'-t); \qquad \widehat{rr}_1-\widehat{\theta\theta}_1=-2k_1, \end{aligned}\right\} \tag{26}$$

where a' is the radius of the continental surface with respect to the earth's centre and t_1 the depth from the free surface at which the crustal state varies from elastic to plastic. The negative sign $-2k_1$ in (25) was taken because of the condition that, in the present case, the value of the vertical compression exceeds that of the horizontal. Substituting (24) in (25) and eliminating terms higher than the second order in t_1, we get

$$t_1=\frac{\lambda_1+2\mu_1}{\mu_1}\frac{k_1}{(\eta_1a'+\xi_1/a'^2)}. \tag{26}$$

Using the numerical values shown in Section 1 and putting $2k_1=5.10^9$, $\lambda_1=\mu_1$, we get

$$t_1 = 8{\cdot}6\ km.$$

This results from the condition that $\widehat{\theta\theta}_1$ and $\widehat{\phi\phi}_1$ are approximately zero not only at the surface $r=a'$, but almost at any depth near the same surface.

4. *The difference between shallow- and deep-focus earthquakes.*

The actual condition of the crust is such that stresses in the same crust arise from two kinds of statical disturbances, namely, continental loading and the spherical symmetrical central attraction, both being gravitational. Even should the two distubances under consideration be of the same origin, owing to the difference between the respective conditions of their application it would be rather in order to consider the additive effects of the two disturbances thus separated.

The stresses due to continental loading may now be represented by

$$\left.\begin{array}{ll} r=a'; & \widehat{rr}_1=0, \\ r<a'; & \widehat{rr}_1-\widehat{\theta\theta}_1=-f(r), \end{array}\right\} \tag{27}$$

where $f(r)$ varies increasingly to a certain depth, but diminishes with further increase in depth in consequence of the isostatic support of the continent. $f(r)$ may thus assume the empirical form

$$f(r)=c_1te^{-c_1t}, \tag{28}$$

where t is the depth and c_1, c_2 are constants.

The spherically symmetrical central force gives rise to

$$\widehat{rr}_1-\widehat{\theta\theta}_1=\frac{8\mu_1\pi\gamma\rho_1^2}{15(\lambda_1+2\mu_1)}r^2 \quad (\equiv\varphi(r)), \qquad (r<a) \tag{29}$$

r being nearly equal to a in this case.

It may be assumed that, although not strictly so, the sum of $-f(r)$ and $\varphi(r)$ is the resultant stress condition of the actual crust, the sign of $-f(r)$ being always opposite to that of $\varphi(r)$. Thus, we get

$$\left.\begin{array}{ll} \sum(\widehat{rr}_1-\widehat{\theta\theta}_1)=-c_1te^{-c_2t}, & \left[t<(a'-a)\right] \\ \sum(\widehat{rr}_1-\widehat{\theta\theta}_1)=\dfrac{8\mu_1\pi\gamma\rho_1^2}{15(\lambda_1+2\mu_1)}a^2-c_1te^{-c_2t}, & \left[t>(a'-a)\right] \end{array}\right\} \tag{30}$$

from which it is possible to get the conditions

$$\left.\begin{array}{ll}\sum(\widehat{rr}_1-\widehat{\theta\theta}_1)<2k_1, & (t<t_1)\\ 2k_1<\sum(\widehat{rr}_1-\widehat{\theta\theta}_1), & (t_1<t<t_2)\\ -2k_1<\sum(\widehat{rr}_1-\widehat{\theta\theta}_1)<2k_1, & (t_2<t<t_3)\\ \sum(\widehat{rr}_1-\widehat{\theta\theta}_1)<-2k_1, & (t_3<t)\end{array}\right\} \quad (31)$$

in which, in the majority of cases, $t_1<(a'-a)$, $t_2>(a'-a)$, and $t_3>t_2$.

It appears that $t_1<t<t_2$ gives the depth corresponding to the case of a shallow seismic focus and $t_3<t$ that corresponding to the case of a deep-seated earthquake. In the range $t_1<t<t_2$, the value of the vertical compression exceeds that of the horizontal, whereas in the range $t_3<t$, the horizontal compression is invariably larger than the vertical, the two ranges under consideration being plastic. The intermediate range $t_2<t<t_3$, on the other hand, is elastic in consequence of the condition that the value $|\sum(\widehat{rr}_1-\widehat{\theta\theta}_1)|$ in such a range never exceeds $2k_1$. The reason why an earthquake of intermediate depth, say 100 km, scarcely ever occurs will now be apparent.

The above result suggests that, generally speaking, earthquakes are prone to occur at such depths wherein the condition of the earth's crust varies from elastic to plastic under gravitational forces. Since from the nature of things, the value of $|2(\widehat{rr}_1-\widehat{\theta\theta}_1)|$ in the range of depth $t_1<t<t_2$ does not greatly exceed $2k_1$, $t_1<t<t_2$ may be assumed to be an almost continuous range within which exist shallow-focus earthquakes. On the other hand, deep-focus earthqnakes generally originate within a certain range of depth, say, from 200 km to 400 km. In this range the condition of the crust varies from elastic to plastic. No earthquake occurs at still greater depths because of the perfect plastic condition of the crust at such depths. It should, however, be borne in mind that, for simplicity, we have dealt with the plastic problem of the crust of the outermost layer under the assumption that k_1 is always constant. In the condition of varying k_1 as is actually the case, the problem should be modified to a certain extent.

Added Oct. 20, 1937.—It is possible to know that the folding as well as the reverse fault can be formed by the horizontal compression in excess of the vertical one as a mere result of the central gravitational force, whereas the normal fault arises from the additional action of the continental or mountain loading.

54. 重力を受ける地球のプラスチック釣合

地震研究所 妹 澤 克 惟

この前の論文に於て地球の核だけがプラスチック性であるとすると岩石層までも非壓縮性でなければならぬといふ結論に達した．しかしそれは多少無理であるから更に地球全體を公平に取扱つて見ると殆ど地球全體がプラスチック性となるのである．地球の核は單に金屬性であり高壓に於けるその融解點が内部の温度よりも低いことに過ぎぬやうである．

地球の表面近くでは横壓が鉛直壓よりも大きくその結果としてプラスチック性をなすものである．地球の極く中心ではすべての方向の壓力が均一に近づき，從て若しそのプラスチックの常數が表面と同じであれば，その附近のみが彈性體といふことになるが，温度等の關係から常數が非常に低くその結果やはりプラスチック性をなすものである．

大陸はその自由な周圍の爲に球形體の重力をその儘では受け難く，大陸の極く表面ではある深さまで鉛直壓が横壓よりも大きくなる．卽ち極く表面は別としてそれ以下の深さではプラスチック體をなすのである．更に少しく深くなると普通の球形體の中心力の作用が大きくなり，その影響である過大横壓と互に打消してプラスチック體でなくなる傾向がある．一層深くなると横壓の方が超過して再びプラスチック體となるのである．しかし大陸の表面近くの場合とは過大壓力の方向が違つてをる譯である．

若し地震の源が地殼の彈性體の部分に隣りする部分のプラスチック體の所に存在するものであるとすると，上記の二つのプラスチック層は淺發地震と深發地震の震源層を與へることになる．又二つの層の中間の層は彈性體の性質がある故に震源になり得ないといふ結果にも到達するのである．又，下層のプラスチック體の更に深い所は彈性と隣りしないプラスチック體であり，地震に關係がないことになるのである．

地質學者はしばしば地表附近に横壓力を假定する．若し自由な周圍の大陸は考へずに單純な地球のみを取つて見ると，重力に起因して横壓力が當然存在することがわかるのである．卽ち褶曲や Reverse fault の說明がつく．之に反して大陸や山の存在を考へるときに Normal fault の機構がわかる譯である．