in well-nourished animals, such as our dogs, and in the debilitated. Even though the *P* value may indicate *no difference* resulting from starvation, this finding of no difference is of importance and against current opinion. The notation of Chang and Scheaffer of the length of time for the transportation of spermatozoa—beyond the period of starvation—poses another problem, that of the mechanism of the effect of starvation. Chang and Schaeffer emphasize the need for knowledge and the lack of clarity in this unsettled problem.

W. HORSLEY GANTT
HARRY A. TEITELBAUM
Pavlovian Laboratory, Phipps Psychiatric Clinic, John Hopkins University, Baltimore, Maryland

7 November 1956

Rigidity of the Earth's Core

The rigidity of the earth's core is significantly less than that of the mantle. This is confirmed by the apparent absence on earthquake seismograms of shear waves that have traversed the core. Additional evidence cited by Honda et al. (*1*) is based on the amplitude of earthquake-generated shear waves reflected from the core (*ScS*) relative to the amplitude of direct-arriving shear waves (*S*). Since some assumptions concerning the radiation pattern of shear waves from an earthquake focus must be made, the latter method is useful for order of magnitude determinations only.

A quantitative estimate of the rigidity of the core may be obtained by a difficult computation involving the known rigidity of the mantle and the data for bodily tides and pole movements. Takeuchi (*2*) found a maximum value of core rigidity of 10^9 to 10^{10} dyne/cm^2 by this method. More recently, Molodenskiy (*3*) gives $\frac{1}{2} \times 10^{12}$ dyne/cm^2.

In this paper (*4*) the rigidity of the core is determined from the amplitude ratio of twice reflected shear waves, ScS_{II} to once reflected waves ScS_I under conditions of near vertical incidence. This procedure minimizes the number of

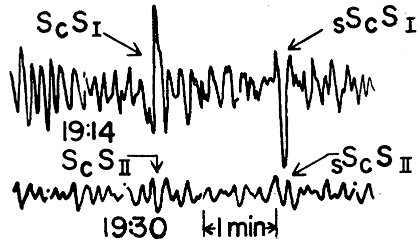

Fig. 1. Core phases from the earthquake of 22 December 1940.

assumptions required to interpret the data. Five occurrences of $ScS_{I,\ II}$ pairs suitable for amplitude-ratio determinations were found on Huancayo seismograms of near earthquakes with intermediate focal depths (see Table 1). The identification of these phases is made certain by the presence of their surface images $sScS_{I,\ II}$ (see Fig. 1).

To interpret the amplitude-ratio data, we use the approximate relationship

$$ScS_{II}/ScS_I = [Rc \exp(-2\sigma d)]/2 \quad (1)$$

where σ is the average absorption coefficient for shear waves in the mantle, d is the depth of the core, and Rc is the reflection coefficient for shear waves vertically incident on the mantle-core interface. The dimensionless dissipation parameter $1/Q$ is related to σ by $1/Q = \beta T \sigma / \pi$, where β and T are the velocity and period of shear waves, respectively. Rc is given by

$$Rc = [(\mu_m \rho_m)^{1/2} - (\mu_c \rho_c)^{1/2}] [(\mu_m \rho_m)^{1/2} + (\mu_c \rho_c)^{1/2}]^{-1} \quad (2)$$

where μ and ρ are rigidity and density respectively, and the subscripts m and c refer to mantle and core in the neighborhood of the boundary. Implicit in the use of Eq. 1 are the assumptions that spherical divergence and the plane-wave, steady-state reflection coefficient are applicable. Since the wavelengths and focal depths are small compared with the radii of curvature of the boundaries, these assumptions are reasonable. They are partially validated by the identical amplitudes of *ScS* and its surface image *sScS* as shown in Fig. 1. The mean ratio of ScS_{II}/ScS_I for five earthquakes was 0.3.

Table 1. Huancayo observations of amplitude ratio ScS_{II}/ScS_I. The average amplitude ratio is 0.29.

Earthquake date	Origin time (hr:min:sec)	Distance (deg)	Focal depth (km)	Magnitude	Amplitude ratio
6 May 1936	03:38:55	4	160	6	0.25
16 Feb. 1943	07:28:35	4	190	7	0.42
26 Feb. 1952	11:31:00	5	260	7	0.25
19 Sept. 1935	09:55:47	7	250	6½	0.29
22 Dec. 1940	18:59:46	8	230	7	0.25

As indicated by Eq. 1, this decrease in amplitude may be ascribed both to absorption of the shear waves in traversing the mantle and to loss on reflection from the core boundary. On the assumption of a perfectly elastic mantle in which $\sigma = 0$, Eqs. 1 and 2 yield a maximum value of core rigidity: $\mu_c < \mu_m \rho_m / 16 \rho_c$. Using $\rho_m/\rho_c \sim 4/7$ and $\mu_m = 3 \times 10^{12}$ dyne/cm^2 (*5*), we find $\mu_c < \mu_m/30 \sim 10^{11}$ dyne/cm^2. Assuming a vanishing rigidity in the core, and taking $T = 11$ sec. and $\beta = 6.2$ km/sec, we find that the maximum value for the average dissipation constant in the mantle is $1/Q \sim 200 \times 10^{-5}$. This is sufficiently close to values of $1/Q$ found by other methods (*6*) to indicate a rigidity in the core between zero and at least an order of magnitude smaller than 10^{11} dyne/cm^2. Since the incompressibility in the core is of the order of 10^{13} dyne/cm^2, the ratio of rigidity to incompressibility is smaller than 10^{-3}, indicating a state unlike that of a normal solid.

FRANK PRESS
Seismological Laboratory, California Institute of Technology, Pasadena

References and Notes

1. H. Honda, H. Sima, K. Nakamura, *Science Repts. Research Insts. Tôhoku Univ.* 7, 169 (1956).
2. H. Takeuchi, *Trans. Am. Geophys. Union* 31, 651 (1950).
3. M. Molodenskiy, *Geofiz. Inst. Trudy* No. 19 (146), 3 (1953).
4. Contribution 802, Division of Geological Sciences, California Institute of Technology.
5. K. E. Bullen, *Phys. Chem. Earth* 1, 68 (1956).
6. F. Birch *et al., Geol. Soc. Amer. Spec. Paper No. 36* (1942).
7. M. Ewing and F. Press, *Bull. Seismol. Soc. Amer.* 44, 471 (1954).

24 September 1956

Effect of a Severe Storm on Electric Properties of a Tree and the Earth

For more than a decade, virtually continuous measurements have been made of the relatively steady-state standing potential of a tree. The potential difference is determined between two reversible, nonpolarizable silver-silver chloride electrodes imbedded in the cambium in the long axis of the tree, and separated by about 3 feet. These potentials show diurnal, monthly, and seasonal variations of considerable interest and, over the years, a suggestion of a correlation with sunspot activity.

It seemed worthwhile, therefore, to begin the study of the electric environment of the tree as measured by earth and atmospheric potentials recorded simultaneously with the potentials of the tree in order to determine the possibility of an interrelationship.