

shows also the adiabat of silicon iron obtained by Kormer and Funtikov^[148], and the adiabats of iron and nickel^[36,39,42] and titanium^[43].

The abscissas of the diagram are the pressures and the corresponding distances from the earth's surface, while the ordinates are the densities. As shown by the diagram, the shock adiabats of forsterite, enstatite, and most other magnesium silicates lie parallel to the compression curve of the lower mantle, at a distance of 0.3 g/cm^3 in the direction of the ordinate axis. This discrepancy increases somewhat after corrections are introduced for the difference between the temperatures of the earth's mantle and shock compression. The agreement between the experimental compression curves and the Bullen curve for the lower mantle should occur in the case of iron-magnesium silicates containing $\sim 15\text{--}20\%$ iron by weight.

The hypothesis with the largest number of adherents is that the earth has an iron-nickel core. Contradicting it are the views of Lodochnikov^[149] and Ramsey^[150], who believe that the earth has a uniform chemical composition and that the core is made of metallized silicates. This hypothesis is based on the notion of the phase transformation of the densest crystalline forms of iron-magnesium silicates of the lower mantle into even denser metallic states of the liquid core.

In spite of the fact that from the crystal-chemistry point of view the attainment of such silicate-based metallic states has very low probability^[143], these views still find adherents to this day, and not only among astronomers^[151] but also among geochemists^[144]. Dynamic experiments did not confirm the hypothesis of Lodochnikov and Ramsey. The experimental points obtained at pressures $2\text{--}2.5 \text{ Mbar}$ on the shock adiabats of quartz, forsterite, and enstatite lie at densities which are almost half the density of the earth's core (see Fig. 59).

It is difficult to judge at present the extent to which this result can be undisputedly related to terrestrial conditions, since the geological time scale differs from the time scale of explosion experiments by more than 22 orders of magnitude. Comparison of the adiabats of iron and nickel with the $P - \rho$ diagram of the earth's core shows that the core cannot consist of iron alone or of its alloy with nickel. According to the experimental data of Kormer and Funtikov^[148], agreement with the Bullen model can be attained by introducing into the composition of the iron core some $15\text{--}20\%$ of silicon by weight. The same result can be obtained also by adding oxides or sulfides^[147] of iron.

The question of a core consisting of iron alone was considered by Zharkov^[152]. This point of view leads, however, to unrealistically high temperatures in the earth's center, $\sim 11 \times 10^3 \text{ K}$.

Some of the deductions given here were drawn

earlier in^[147], and with respect to the composition of the core also in the paper by Knopoff and MacDonald^[153]. The latter based their conclusions on experimental data obtained in the Soviet Union on shock compression of iron and other metals.^[36,38]

11. DYNAMIC STRENGTH OF MATERIALS

The most universal example of realignment of the crystal lattice under the influence of shock waves is the transition of a substance from the elastic state into the plastic one. This transition has all the characteristic features of phase transformations in shock waves. Its study yields the dynamic ultimate strengths of metals at extremely large deformation velocities.

Macroscopically, the deformation of the medium behind the shock-wave front remains uniform. Within the limits of elasticity, a similar character of unilateral compression is exhibited also by the deformation of the atomic space lattice, shown in a highly exaggerated form^[154] in Fig. 60a.

At large degrees of compression, the thermodynamically most convenient is symmetrical deformation of the unit cells under the action of hydrostatically stressed states. The transition to such a state is connected with a realignment of the crystal lattice and forced migration of the atoms from layer to layer.

A possible structure of the transition zone^[154], comprising the front of the waves, is shown schematically in Fig. 60b. Its real width is not known at present. Nor have the crystallographic aspects of this unique process of cold recrystallization—the dimensions of the newly formed crystal blocks and their orientation relative to the "parent" crystals—been investigated.

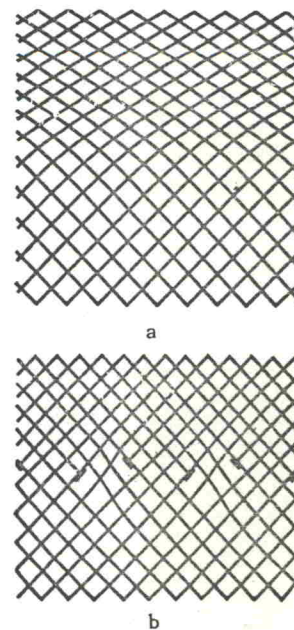


FIG. 60. Boundary of shock wave for elastic (a) and quasi-hydrostatic (b) compression of the three-dimensional lattice, after^[154].