

## Physics of Stressed Solids

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The internal energy of a system is subdivided into a work or potential function and a thermal or kinetic function, the former expressed in terms of the current electrostatic theory of intercrystalline bonding, and these functions then examined for variations of temperature, hydrostatic pressure, unidirectional stress and combined hydrostatic and unidirectional pressure. From these considerations a theory is evolved which not only seems satisfactorily to explain and correlate phenomena of deformation, creep or plastic flow, cold working, elastic afterworking, rupture, shear and certain other phenomena hitherto described as "anomalous" effects but has been corroborated experimentally in some of its predictions, in particular for the effect of hydrostatic pressure on deformation and compressive strength. The mechanism evolved consists of two processes—one an elastic deformation which is a function of the strain or potential energy of the system. Failure occurs here by "brittle" rupture wherein

the maximum extension or maximum internal tension is the criterion. The other is a deformation by means of a two-phase transfer mechanism and is a function of the thermodynamic potential relations of the system. This latter type is also a function of time and therefore a function of the rate of application of load. When both processes of this mechanism are operative failure occurs by shear; the criterion for this type of failure is given by a function of time, the strain or potential energy and the thermodynamic potential relations of the system. Expressions are derived for creep or plastic flow of polycrystalline substances from the thermodynamic potential relations which not only satisfy the well-known phenomena of creep in metals but also express recent empirical creep data of some substances immersed in liquids in which they are somewhat soluble. An expression is also derived for the "brittle" potential type of rupture under combined thrust and hydrostatic pressure.

THE thesis presented in this paper is that the phenomena of deformation, flow or creep, and rupture may be interpreted and correlated from a study of the internal energy stored up in the lattice as a result of deformation.

The energy of deformation may be subdivided into energy of work and energy of heat, that is, into an energy of position and an energy of motion. If this energy of deformation exceeds a certain critical limit, determined by the physical characteristics of the material and the amount of externally applied compensation, a release of the strain energy takes place in such a manner that the system does the least work. If the energy relations are such that release is effected through the potential component, i.e., work function, the system exhibits potential or brittle rupture and the system relieves itself of its strain energy by doing work in the direction of greatest extension which is the direction of least external constraint. If the stress and energy relations are such that release may be effected through the kinetic component, i.e., the work done on the substance is largely dissipated by heat transfer, the specimen deforms by means of a "two-phase" flow mechanism. This is the dominant

effect in phenomena of creep and plastic deformation.

In general, deformation and failure are effected by a combination of these two mechanisms and observed as shear and as "gliding along shear planes."

Many of the ideas incorporated in this discussion have been tentatively put forth by other writers but the picture as a whole with its correlations and the theory of rupture presented appears to be new and is therefore presented with the hope that it will prove of interest. This subject needs stimulus for further work on deformation phenomena under hydrostatic confining pressure because it is believed by the writer, perhaps also by others, that further advances in our knowledge of crystal lattice forces will come from such studies.

## EMPIRICAL HISTORY

Volume compressibility, like density or heat capacity, is insensitive to variations in structure. By that we mean the volume compressibility of a single crystal is the same as that of a polycrystalline aggregate of the same material. Shear strain, creep, and other related phenomena on the other hand, will vary with crystallographic