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ROCK CLEAVAGE

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CHAPTER VI.

RELATIONS OF THE ELONGATION AND SHORTENING OF ROCK MASSES, AND HENCE OF FLOW CLEAVAGE, TO STRESS.

Thus far in the discussion there has been a basis of observed geological fact. It has been possible to observe the causal relation between parallel arrangement of mineral particles and flow cleavage, and between the parallel arrangement of the mineral particles and the direction of elongation and shortening of rock masses. It is not possible to observe directly the relations of cleavage to the stresses which have deformed the rock, but as the relations of cleavage to the elongation and shortening of rock masses are known and as the relations of elongation and shortening of solid bodies to deforming stresses may be worked out in their simpler aspects, both experimentally and mathematically, and are accepted as proved in physical and engineering treatises, the general relations of cleavage to the stresses producing it may be stated with some confidence. The first step in the discussion, then, is a summary of the simpler and most obvious relations of deformation of solid bodies to stress.[a]

STRAIN.

Strain means any change in the relative position of the particles of a body. The change may be either of form or volume, or both. When the form changes the strain is called distortion. When the volume changes, the strain is called dilatation.

Any small sphere in an unstrained mass becomes an ellipsoid after strain—i. e., a strain ellipsoid, the greatest, mean, and least axes of which are called the principal axes of strain. In a special case (simple dilatation) all diameters of this sphere are changed equally and the resulting ellipsoid is a sphere. If these axes remain constant in direction during strain, the strain is called "irrotational" strain; if not, it is called "rotational" strain.

[a] Hoskins, L. M., taken mainly from "Flow and rupture of rocks": Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 845-872.
Van Hise, C. R., Principles of North American pre-Cambrian geology: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 636.
Thompson and Tait, Natural philosophy.
Becker, G. F., Finite homogeneous strain, flow, and rupture of rocks: Bull. Geol. Soc. America, vol. 4, 1893, p. 22; Jour. Geol. vol. 4, 1896, p. 430.
Young, Thomas, A Course of Lectures on Natural Philosophy and the Mechanical Arts, London, 2 vols., vol. 1, 1807, p. 135.
Peirce, C. S., Manuscript report to the Director of the U. S. Geol. Survey, 1897.

Any irrotational strain in which all three principal axes are changed in length in such a ratio that the volume remains constant, has been called "pure shortening" by Van Hise,[a] and this term will be used below. In a special case of irrotational strain without change of volume, one of the axes may remain unchanged in length; then the strain is known as a "simple shear" (Thompson and Tait[b]), or a "pure shear" (Becker[c]), or a "simple detrusion" (Young[d] and Peirce[e]). An irrotational strain is illustrated in two dimensions in figs. 28 and 29. Every particle of the body takes part in the deformation.

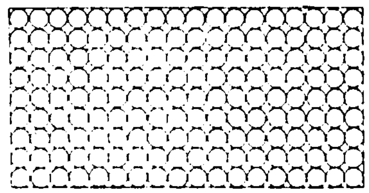

Fig. 28.

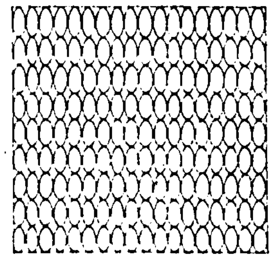

Fig. 29.

Figs. 28 and 29.—Diagrams showing irrotational strain (pure shortening).

A rotational strain occurring without change of volume is illustrated by the deformation of a rectangle A-B-C-D (fig. 30) into a parallelogram A-B-C′-D′ whose base and altitude are equivalent to those of the rectangle. All lines parallel to A-B move parallel to it through distances proportional to their distances from A-B. It is a strain analogous to that assumed by a deck of cards in which each card has been slipped a small amount over the card next below. While there is differential movement between the planes, there is no distortion in the planes themselves. The strain is equivalent to an elongation and a shortening at directions at right angles to each other combined with a rotation. This strain has been called "simple shear" (Hoskins, Van Hise) and "scission" (Becker). Peirce, in the report referred to, prefers the term scission, and in the following discussion the term scission will be used. The plane of scission referred to on subsequent pages corresponds to the plane of slipping between the cards in the above illustration.

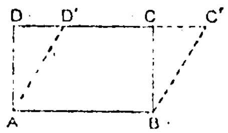

Fig. 30.—Diagram showing scission.

It has been proved that scission is equivalent to a pure shortening combined with a rotation of the body as a whole. In fig. 32 the flat-

[a] Van Hise, C. R., Principles of North American pre-Cambrian geology: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 636.
[b] Thomson and Tait, A Treatise on Natural Philosophy, 2d ed.
[c] Becker, G. F., Jour. Geol., vol. 4, 1896, p. 430.
[d] Young, Thomas, A Course of Lectures on Natural Philosophy and the Mechanical Arts, London, 2 vols., vol. 1, 1807, p. 135.
[e] Peirce, C. S., Manuscript report to the Director of the U. S. Geol. Survey, 1897.