EARTH STRUCTURE.¹

IN a copiously illustrated volume Mr. T. Mellard Reade, the well-known author of the "Origin of Mountain Ranges," expounds his views on certain geomorphological changes of profound interest to geologists. By tumefaction, wrinkling and denudation, the features of the face of our world are ever changing.

Evidences of the former activity by which regions of vast extent have been elevated or depressed almost vertically are, for example, found in raised sea beaches and submerged valleys. Fossiliferous rocks high up in mountain ranges, as in the Alps and Himalayas, attained their present positions by wrinkling during the process of mountain building.

Sedimentation results in the filling up of depressions, but its weight, no matter how mobile the undercrust may be, is not, according to the author, sufficient to raise neighbouring areas. Also it must not be overlooked that the phenomena presented to us represent pulsatory movements by which large tracts have been alternately raised and lowered. Secular contraction, inasmuch as it acts in one direction, does not seem adequate to explain these regional breathings. If by this and other well-known hypotheses we fail to explain vertical elevations and depressions, Mr. Reade invites us to consider the following.

We live on a rocky crust some thirty miles in thickness which rests upon a shell of igneous magma. By the expansion or contraction of portions of this magma due to changes in its temperature, tracts of the superincumbent crust are raised or lowered. The first question we are inclined to put relates to the manner in which these assumed variations in temperature are brought about. Blanketing by deposition of sediments the author regards as insufficient, but that there are such local subterranean alterations in temperature is evidenced by the shifting of volcanic centres and the intermittent activities of the same.

Variations in the character of lavas which have issued from the same vents, but at different times, indicate chemical and mechanical changes in a subjacent magma, and with such changes heat may be evolved or absorbed, and a magma may increase or decrease in its volume. Attention is also directed to the remarkable chemical and mineralogical alterations and the accompanying volumetric changes which have taken place in rock masses. With the phenomena of recalcence and magnetisation, alterations in bulk take place. In short, "the earth is not an inert mass cooling in space," but it is a planet within which there is flux and reflux, action and reaction, mechanical, chemical, and other activities in operation which result in the evolution of heat and alterations in volume, and in the latter we are to look for the cause of vertical elevations and depressions. References to the effect of these displacements in altering the level of oceanic water are made. The swelling or contraction of a

magma beneath an ocean bed must result in a general rise or fall of water on the land.

The second form of geomorphic change considered is that which is due to a tangential creep and ridging of sediments due to fluctuating increases in temperature, and consequent expansion brought about by sedimentation. The wrinkles or mountain ranges on the face of the world are the results of such changes. With a falling temperature contraction sets in, strata shorten, and tensions result in faulting. By the faulting, wedge-shaped blocks fall inwards to act like keystones for the material on their flanks. The old theory that the features of the world are largely due to a shell accommodating itself to a retreating nucleus also accounts for the formation of the wrinkles by compression, but, unlike the theory advocated by Mr. Reade, it does not provide an explanation for normal faults which partition the roof of the world into block-

FIG. 1.—Showing cumulative effects of changes produced by hot and cold water upon a lead plate forming the lining of a pantry sink. A section along *a, b*, is shown in Fig. 2. (From "The Evolution of Earth Structure.")

like masses. That continental outlines are due to subsidences of the neighbouring oceanic basins, and are therefore sketched out by fault lines, is, according to the author, very doubtful; at all events, evidences of such dislocations, we are told, remain to be discovered. His own view is that for the most part such outlines are defined by mountain ranges, which represent thick accumulations of detritus derived from the denudation of land areas, lifted up by expansion on the platforms where they were deposited.

A large section of the work refers to observations and experiments which throw light upon the foregoing hypotheses. The effects of end pressures as applied to layers of sheet lead, bars of soap, damp sand, and other materials are already fairly well known. An anticlinal rises near to the source of pressure, but the foldings are not altogether in accordance with those observed in nature. The effects of thrust are not con-

¹ "The Evolution of Earth Structure, with a Theory of Geomorphic Changes." By T. Mellard Reade. Pp. xv+342. (London: Longmans and Co., 1903.) Price 21s. net.

veyed to a sufficient distance, and Mr. Reade points out that, with similarly applied forces, something similar should occur in the earth's crust.

Results more in accordance with structures noted by the geologists are, however, seen in the effects of pressure originating in the general expansion of stratified material.

An observation bearing upon this form of action, which extended over many years, refers to the cumulative effects of changes produced by hot and cold water upon a lead plate forming the lining of a pantry sink. First it ridged up to form an overfold and eventually cracked. The fold was cut out, bent down, and soldered. In eight years' time the fold had again grown, little by little, by material imperceptibly flowing to the site of the fold, until it resembled the model of a mountain range.

The crescentic form of this ridge is seen in Fig. 1,

the centre of the discs, but one on the right and the other on the left of a diameter. By placing cores upon the bed plate, or by deforming the bottom disc of clay upon which the other discs are placed, centripetal pressure results in anticlinals, spiral folding, various forms of shearing, and other structures, each being dependent upon the bias given by the form of the core, and it is for multilateral pressures akin to those employed in his experiments that the author ascribes many of the forms met with in mountain ranges.

Other interesting chapters relate to the effects of expansion due to atmospheric changes in temperature as exhibited by asphalt, cement, rails, and other substances, the production of slaty cleavage, and the supposed permanence of oceanic basins and continental domes.

The effects of denudation as a factor playing an important part in shaping the features of the world are

FIG. 2.—Photograph of section along saw-cut line *a, b*, Fig. 1, showing structure of the fold and overfold. (From "The Evolution of Earth Structure.")

whilst a section of the same through *a, b* (Fig. 2) shows that it had become an overfold. It is a form that could not be produced by external pressures, and as it so closely accords with the theory it is intended to illustrate, it well deserves the space, which is that of a whole chapter, devoted to its history.

Torsional structures, as, for example, those noted in the dolomites, and the curved axes of mountain ranges met with in nature, may be explained by multilateral or circumferential pressure, particularly when it is assumed that an initial bias is given by the form of the floor on which the strata have been deposited.

Experimental demonstrations of the effects of this form of pressure were made by compressing discs of clay confined by a circular metal loop, the diameter of which could be altered, much in the same manner that the diameter of a loop in a piece of string may be altered by pulling on the two ends. The ordinary effect of converging pressure is to produce doming, not in

hardly mentioned, the reason being that they have already received so much attention from other writers. Mr. Reade deals almost entirely with activities which are hypogenic, and these, although some of them may be old acquaintances, he presents to geologists in a manner so novel that they acquire an importance which most certainly they did not previously possess. The ancient contraction theory is to be largely supplanted by one of expansion and contraction.

The amount of vertical movement asked for may be taken at 10,000 feet, or $1/2000$ of the earth's radius—to human beings a quantity that is stupendous, but when regarded as a deviation in the smoothness of our globe it becomes a quantity that is insignificantly small. The author will no doubt find many followers; some may hesitate, but even those who have crystallised an ancient faith will pause to think and give to originality the consideration it deserves.

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