direction, and he may be perfectly assured that it will not follow him. . . . A man may pass within a yard of a rattle-snake with safety, provided he goes quietly, but should he irritate a rattlesnake, or tread incautiously upon it, he would infallibly receive a wound from its fangs."

THE STRUCTURE OF THE APPALACHIAN ZONE.

PART FOURTH.

IN this brief survey, we have seen that the mountains composing the Appalachian Zone are made up of strata similar to those now forming. From analogy as well as from internal evidence we know that these were once horizontal, whereas now we find them bent, folded, turned up on edge, and in some cases even fractured. We have seen also that the curves tend to become broader and less steep as we follow them north-westerly; the whole resembling the ripples caused by casting a stone into a body of water, abrupt near the point of concussion, but becoming broader and gentler as they recede. Can we, from these facts, write the history of these mountains and determine the nature of the mighty force which exerted so tremendous an influence?

Often has this question been answered affirmatively, but the interpretation of the facts differ. It would be out of place here to enter into an elaborate discussion of theories respecting the origin of mountains. Only two hypotheses will be given, both of which have attracted much attention, and both are based on the structure of the Appalachians.

In 1842 the Brothers Rogers, after years of investigation amid these mountains, presented their celebrated theory. They hold that the wave-like flexures of the Appalachian strata are the result of an actual onward billowy movement, proceeding from beneath; a combined vertical and tangential movement. They argue forcibly that no merely vertical, no merely horizontal movement, alone, could produce the phenomena. The wave-like undulations of the ground during earthquakes, so well attested by many observers, seemed to afford the key. It was assumed, therefore, that the earth's crust in these disturbed regions, rested on a widely extended surface of fluid lava, and that the accumulation of a vast body of elastic gases and vapors subjected this portion of the crust to an excessive tension, causing it to give way at successive times in a series of long parallel rents. The removal of pressure upon the lava by the explosive escape of the gases, would cause it to rise along the fissure like an enormous billow and to lift with it the overlying flexible crust. Gravity would produce a violent undulation of the lava surface. wave succeeding wave, flattening and expanding as they proceed and imparting a billowy motion to the overlying strata. Simultaneously with each epoch of oscillation, the undulating tract was pushed bodily forward, and secured in its new position by the permanent intrusion, into the rent and dislocated region behind, of the liquid matter, injected by the same forces which gave origin to the waves. This thrust would steepen the advanced side of each wave, and if repeated, as it would be near the region of greatest disturbance, would produce the folded or inverted structure.

Prof. James Hall announced his theory in the Palaeontology of New York, Vol. III. He rejects altogether an interior force and regards the flexures as resulting from depression of the crust. He believes that the line of the Appalachian barrier is due to the original deposition of material, not to any subsequent operation dislocating its strata, and that the declination of elevation westward is due to the thinning out of the formations. He holds that when large masses of sediment are spread along the sea-bottom the effect will be a yielding of the crust beneath and a general subsidence. The greatest depression, accordingly, would be along the line of greatest accumulation, and the settling would be less in the direction of the thinning margin. By this process the lower side became stretched, rents and fractures would occur on that side, while the compressed upper surface would be wrinkled and folded. This can be easily shown by bending a young twig. The outer surface is stretched and finally gives way, while on the inner side the bark is thrown into folds. This folding has not contributed to the height of mountains. On the contrary, the sharper the fold, the more likely it is to be split or weakened at the arching, and so to be more liable to the effects of denuding agencies. In this way is explained the existence of so many mountains with trough-shaped strata; these mountains being merely the troughs of waves whose crests have been washed away.

Here then are two interpretations of the same record, yet diametrically opposed. Rogers' theory accounts for most of the facts, but leaves us a task, as difficult as the other, to account for the theory. The means employed, according to these authors, are too terrific, without analogue anywhere. It is inconceivable, too, how the fluid matter cou'd be sustained in the rents and hollow so as to render the elevations permanent. To Prof. Hall's theory the main objection is, that the material accumulating, as it certainly did, in shallow water, is incompetent to affect the earth's crust, which is not less than fifty miles thick. Indeed, there is reason to doubt whether the earth has merely a crust. Ten years hence we may all believe our globe solid. At the same time there is much in favor of this theory. It is competent to account for the succession of phenomena and is easily illustrated by experiment. A long continued subsidence certainly did occur in the Appalachian region, for there we find shallow water deposits, many thousands of feet thick, each showing by the ripple markings that it was near the surface when deposited. The character of many strata shows that the rate of subsidence at times must have been exceedingly small, only a fraction of an inch per annum. It is more than probable that such a sinking over an extended area would cause a corresponding elevation at some point. Where would we look for such an elevation but in the trough itself? As shown in the experiment of the bent twig, the folds are sharpest where the compression is greatest. By this theory faults and other phenomena are susceptible of easy and reasonable explanation.

The determination of the time during which the Appalachian Revolution occurred depends upon some principles respecting which all geologists are fully agreed. The facts on which these are based need to be summarily recorded.

After a careful study of life as shown in the successive strata of the earth's crust, geologists have divided the world's history into seven great ages, each marked by the dominance of some form of life. Earliest among the stratified rocks we find an enormous accumulation, many thousands of feet in thickness, everywhere controled and everywhere altered in their constitution, as though they had been subjected to a high temperature. In this process of alteration all traces of life, both animal and vegetable, would be obliterated, or at least rendered difficult of detection. Under such circumstances these rocks were classed together as belonging to the Azoic or lifeless age. Latterly, however, there have been discovered traces of life, low in order indeed, but still, life, and so we know this immense series as the Eozoic, or the age of dawning life

Resting on this contorted mass we find a succession of rocks, just such a succession as might be expected to rest on a continually subsiding sea-bottom, first a sandstone, then a mixed mass of sand and limestone, and finally a heavy limestone; a similar succession follows, the two series together making up the Silurian age, the age of mollusks or shell-fish. In this age no land plants existed, no mammals peopled the land, no fishes peopled the sea. Yet the rocks tell us that life in its lower forms was abundant, for some of the limestone are simply masses of shells tightly packed together. Stone lilies of wondrous beauty and complexity, waved to and fro on the bottom; uncoiled nautili, twelve feet in length, scoured the sea, myriads of little shells were everywhere, while tangled masses of strange seaweeds grew in all the shallow waters.

Upon the Silurian, we find the strata of the Devonian age. In its earliest epoch we find a new form of life introduced, fishes, the first of vertebrates, appear in vast numbers; while corals, mollusks and articulated animals, so well represented in the previous age, still abound in the waters. We now find evidence of a main land, covered with soil and bearing vegetation, for even midway in its course we discover a few sea-drift logs of