

but to the hypothesis of alteration by ascending heat, Naumann has objected that the inferior strata in some cases escape change, and that in descending, a certain plane limits the metamorphism, separating the altered strata above, from the unaltered ones beneath; there being no apparent transition between the two. This, taken in connexion with the well-known fact that in many cases the intrusion of igneous rocks causes no apparent change in the adjacent unaltered sediments, shows that heat and moisture are not the only conditions of metamorphism. In 1857, I showed by experiments, that in addition to these conditions, certain chemical reagents might be necessary; and that water impregnated with alkaline carbonates and silicates, would, at a temperature not above that of 212° F., produce chemical reactions among the elements of many sedimentary rocks, dissolving silica, and generating various silicates (1). Some months subsequently, Daubrée found that in the presence of solutions of alkaline solutions, at temperatures above 700° F., various silicious minerals, such as quartz, feldspar, and pyroxene, could be made to assume a crystalline form; and that alkaline silicates in solution at this temperature would combine with clay to form feldspar and mica (2). These observations were the complement of my own, and both together showed the agency of heated alkaline waters to be sufficient to effect the metamorphism of sediments by the two modes already mentioned,—namely, by molecular changes, and by chemical reactions. Following upon this, Daubrée observed that the thermal alkaline spring of Plombières, with a temperature of 160° F., had in the course of centuries, given rise to the formation of zeolites, and other crystalline silicated minerals, among the bricks and cement of the old Roman baths. From this he was led to suppose that the metamorphism of great regions might have been effected by hot springs; which, rising along certain lines of dislocation, and thence spreading laterally, might produce alteration in strata near to the surface, while those beneath would in some cases escape change (3). This ingenious hypothesis may serve in

1. Proc. Royal Soc. of London, May 7, 1857; and Philos. Mag. (4) xv., 68; also Amer. Jour. Science (2), xxii., and xxv., 435.

2. Comptes Rendus de l'Acad., Nov. 16, 1857; also Bull. Soc. Geol. de France (2), xv., 103.

3. It should be remembered that normal or regional metamorphism is in no way dependent upon the proximity of unstratified or igneous rocks, which are rarely present in metamorphic districts. The ophiolites,