

afford, at the ordinary pressure, nearly 45 cubic feet of steam to the cubic foot of rock. There is no doubt, therefore, about enough moisture.

The distribution of heat through the rocks without the aid of moisture is impossible; for heat travels but a short way into dry rock. A thickness of two or three feet is sufficient to confine nearly all the heat of the hottest furnace, and will make it safe to walk over liquid lavas. But let the walls of the furnace be wet, and the heat will go through with a rush, for the water becomes steam.

4. *Pressure.* — Pressure, as already stated, is the chief source of the movements by which a large part of the heat for metamorphism was produced. It has caused (1) a foliated structure in slates and other rocks, and (2) minor changes in the texture of rocks. The first of these subjects is treated under mountain-making; the second, on page 321.

In the following remarks, *local* metamorphism is first considered, and then *regional*.

LOCAL METAMORPHISM.

Local metamorphism, as above explained, makes changes in rocks in the vicinity of the source of heat, as those of the walls of dikes. The results are often called *contact-phenomena*, and any minerals formed, *contact-minerals*.

The results of change along the walls of trap dikes in the Triassic areas of eastern North America comprise minerals in the inclosing rock, in the dike, or partly in both. They include crystallizations of epidote, tourmaline, garnet, chlorite, quartz, hematite, and magnetite, besides various zeolites. Garnets occur in the sandstone within a few yards of the trap, and also in rifts in the trap near its walls, and sometimes the latter are yellow topazolites of great beauty. Many square yards of the surface of a joint in the trap of East Rock, at New Haven, Conn., are thickly covered with garnets and crystals of magnetite. At Rocky Hill, N. J., according to H. D. Rogers (1840), the "baking" effects of a trap dike are distinct for a fourth of a mile from the dike; and, fifty feet off, a thin bed contains "kernels of pure epidote," and cavities that are "studded with crystals of tourmaline;" and at one place the latter crystals are half an inch in diameter. The sandstone, when containing these minerals, has generally lost its usual red color and become grayish-white to greenish, the green color coming sometimes from the chlorite or epidote generated by the heat.

The production of the metamorphic results, and the extent of the region affected, has depended chiefly on the presence of moisture for conveying and utilizing the heat. The sandstone walls of a dike may crumble into small chips, because of the want of moisture there at the time of the eruption, while in other places the rock becomes firmly consolidated. The presence of steam is sometimes indicated by remains of the tubular channels through which it rushed, their walls being bleached and penetrated with chlorite; and chlorite may occur, in some places near by, spangled with minute but perfect crystals of hematite.