observed that the small differences among the varieties of these rocks, depending on impurities, or on the composition of the grains, have great influence over the results; and so also has the amount of moisture present in the rocks or in cavities among them. Beds of iron ore, or of coal, or of salt, may be in a sandstone series.

If the fragmental rock consists of quartz grains only, metamorphism can make nothing but a harder sandstone, or quartzyte; while, if it consists of grains of quartz and feldspar, it may be converted by metamorphism into a gneiss, or even a granite; or if there is disseminated clayey material, which contains no alkali, it cannot make a micaceous quartzyte, but may make a kind containing the mineral ottrelite, or andalusite.

These examples illustrate the dependence of the metamorphic products on the chemical composition of the ingredients present, and show that speculations on the origin of the minerals, made without a knowledge of the ordinary impurities, are valueless.

The following are some of the results of metamorphism, arranged under the different heads mentioned: —

1. Incipient Metamorphism.

These changes generally involve the loss of some volatile or combustible ingredient.

1. A *carbonaceous* shale or sandstone, when heated, usually loses some mineral gas or oil, the volatile part of the carbonaceous material; and then "the fixed carbon" that is left may be oxidized and so escape as gas (being burnt out), leaving the rock white (if a limestone, a white marble) unless some other source of color is present. If the carbonaceous material is a bed of coal, the volatile part may escape, and the "fixed carbon" remain as a bed of anthracite. As a consequence of the last process, the coal-bed has become thinner, owing to the loss, and is less pure in proportion to its thickness.

2. The *water* in the rocks is easily volatilized. But under rock-pressure much may be retained at temperatures above 212° F. That of clays, 14 per cent of which is chemically combined in pure clay, may, under pressure, be retained and help to make, in low-grade metamorphism, hydrous minerals, as chlorite, serpentine, etc. The water of limonite (the yellow-brown iron oxide, $2\,Fe_2O_3 + 3\,H_2O$) is driven off at 212°, reducing it to hematite (the red oxide, Fe_2O_3); and in this way common sandstones of yellowish, grayish, greenish, brownish, and other colors (generally due to disseminated limonite) become red. Most colored sandstones redden on heating, and in this way many sandstones have been made red. But at a higher temperature under low rock pressure, the red oxide coloring a red sandstone may be converted into steel-lustered crystals; or become reduced to magnetite (Fe_3O_4); or combine with silica to make silicates (epidote, chlorite, etc.) and by such means the red color may be discharged.