A few illustrative examples of regional metamorphism, culled from different quarters of the globe, and various geological formations, may here be given. The subject is further discussed in Book VI. Part I.

Early Stages of Metamorphism.—In 1871 Zirkel showed that some of the clay-slates of the disturbed Silurian and Devonian tracts of central Europe contain minute microscopic needle-shaped microlites. Considerable diversity of opinion has arisen as to the nature of these rudimentary crystallizations. They have been regarded as microlites of hornblende, rutile, epidote, etc. More recently they have been carefully isolated, extracted, and analyzed by E. Kalkowsky, who regards them as staurolite, constituting from two to five per cent of the rock.[58] The whet-slate of Belgium has been found by Renard to be characterized by the presence of abundant garnets. Microscopic tourmaline and rutile likewise occur among clay-slates. No one would class as metamorphic the rocks in which these microlites occur, and yet the presence in them of microscopic microlites and crystals shows that they have undergone some of the initiatory stages of metamorphism, by the development of new minerals. All that is known of the probable origin of these minerals, negatives the supposition that they could have been formed in the original sediment of the sea-bottom on which the organisms entombed in the deposits lived and died. For their production, a temperature and a chemical composition of the water would seem to have been required such as must have been inimical to the co-existence in the same water of such highly organized forms of life as brachiopods and trilobites.

One of the most marked of the early stages of regional metamorphism is characterized by the appearance of fine scales of some micaceous mineral (muscovite, biotite, etc.). As these micaceous constituents increase in number and size, they impart a silky lustrous aspect to the surfaces on which they lie parallel. In many cases, these surfaces are probably those of original deposit, but where rocks have

[58] Neues Jahrb. 1879, p. 382. These bodies are to be distinguished from the minute crystals of such durable minerals as zircon, rutile, etc., so often recognizable as clastic grains in sediments, and which may often have played a part in the sedimentation of more than one geological period.