3. The *carbonic acid* of limestones is driven off at a low temperature, as in limekilns. But under heavy rock-pressure the loss does not take place; for limestone may be melted in a strong iron flask without decomposition, as shown by Sir James Hall (1790). Again, when iron carbonate ($FeO.\ CO_2$) is present in a sandstone, heat may expel the carbonic acid (CO_2) and leave the iron to oxidize and become the red oxide (Fe_2O_3). This is a second source of the red color of red sandstones and shales. But under pressure the ore may be crystallized without loss.

4. *Consolidation of rocks* also goes forward in the feebler stages of metamorphism. Subjection to heavy superincumbent pressure forces the particles into closer contact, and this favors consolidation in clays (W. Spring). The consolidation in the case of ordinary shales, even Silurian, as the Utica shale, is feeble, unless some metamorphic heat has given aid.

2. Crystallinic Metamorphism.

Calcyte ($CaO.\ CO_2$), or dolomyte, magnesian limestone, if pure, becomes under metamorphic action a white *crystalline* rock, like architectural or statuary marble, in which state, as the naked eye may detect, each grain has the cleavage of crystallized calcite or dolomite. The process is simply that of crystallization. It is a change without fusion. It is a molecular change solely, like the change which takes place in tempering steel from fine to coarse, or the reverse.

Again, under slow metamorphic action, a granitic sandstone, consisting of quartz, feldspar, and mica (the constituents of granite), loses the worn surfaces of the grains and becomes a granite. The sandstone being a massive rock, it is massive still — a true granite, and not gneiss. A sandstone, consisting of feldspar and quartz, without the mica, becomes the granite-like rock called granulyte. Such sandstones make up the Triassic of the Connecticut Valley, and some portions, well consolidated, look exceedingly like granite, although they have not been subjected to the heat and pressure of the true metamorphic process. The following analysis, by F. W. Taylor, of the Connecticut rock, from Portland, — the common building stone, — shows its granite-like composition (see 10th Census, Vol. 10, Rep. on Building Stones, page 127): silica 69·94, alumina 13·55, Fe_2O_3 2·48, Mn_2O_3 0·70, lime 3·09, soda 5·43, potash 3·30, moisture 1·01 = 99·50. If the granitic sandstone were thin-bedded it might become gneiss; and a shale might make a mica schist of like composition. Moreover, in the intenser stage of metamorphism a bedded granitic sandstone, instead of being changed to gneiss might become plastic or fused, and so lose all bedding and become granite. Such

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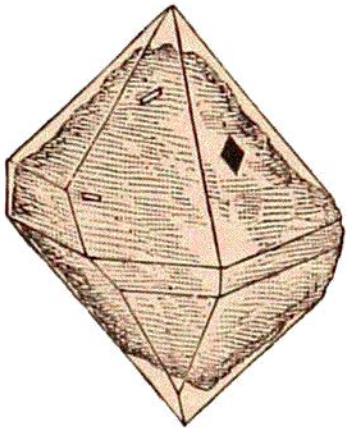

Grain of quartz of Potsdam sandstone, Wisconsin, enlarged into a crystal. A. A. Young, '82.