persthene also occurs altered to hornblende; cyanite to andalusite; labradorite and anorthite to saussurite. Quartz changes to tridymite, or to biaxial silica, when it is heated to or above 2200° F., which accounts for the occurrence of tridymite in volcanic rocks; and tridymite, or biaxial silica, becomes uniaxial optically at 260° F.; but further than this it does not change on heating.

Pyroxene, a common volcanic mineral, has long been known as a furnace product, and since 1823 as the result of the fusion of its constituents; but Deville, in 1858, obtained crystals by simply heating to a bright red heat a piece of ferruginous Fontainebleau sandstone with chloride of magnesium; the crystals of pyroxene cemented the quartz grains of the sandstone. Hornblende has never been produced experimentally from fusion; but in 1890 the Russian chemist, Krustchoff, heated together its constituents for three months, at a temperature of only 900° to 1000° F., and obtained hornblende in crystals; and along with them were crystals of quartz and of a light-colored pyroxene (diopside). The facts show that the change of pyroxene to hornblende requires only a heating of the rock containing it to 1000° F. It indicates also that if a pyroxene-bearing rock, on cooling from fusion, rests long at this temperature, it would probably become throughout a hornblende rock, and appear as if so primarily.

Paramorphic metamorphism should be of common occurrence; for paramorphs are essentially identical except in crystallizations (pages 62, 67, 69).

4. Metachemic Metamorphism.

Through the *chemical* work of metamorphism have been made nearly all the common siliceous minerals among rock constituents, even many kinds that are also of igneous origin: as the feldspars, micas, quartz, minerals of the hornblende and pyroxene group, the chlorites, epidote and the related species, scapolites, garnets, tourmaline, chrysolite, and many others. The older metamorphic and igneous rocks have been the chief sources of the materials. Even in formations not older than the Cretaceous, as described in Becker's account of the rocks of California, the results of metamorphism include orthoclase, albite, oligoclase, labradorite, muscovite, biotite, hornblende, pyroxene, glaucophane, epidote, zoisite, garnet, chlorite, serpentine, talc, and other species.

In these metachemic changes, without aid from outside ingredients, feldspar may be altered to *hydromica*, or *mica* (muscovite), under metamorphic action (Van Hise). Each of these minerals contains silica, alumina, and potash, but the mica, a third less of silica; hence a feldspathic or granitic sandstone may be made micaceous, and a feldspathic shale may be converted into a hydromica or mica schist. Hydromica schist is a common rock in the regions of crystalline rocks of eastern North America, and in other such regions over the globe; and feldspathic sediments, derived from the abundant feldspar of these rocks, are their only source. For mica scales float easily in transporting waters and become scattered among other materials instead of being gathered together into beds. A felsyte may change to pinite, as near Boston (Crosby), which mineral is essentially a massive mica.

But if the shale is an argillaceous rock without potash (no undecomposed feldspar being present) it is very likely to contain more or less iron, magnesia, and lime; and then it has the elements required for making a