

The determination of the depth of an igneous source is possible, if at all, only by geological investigation. Petrology can prove a rock to be igneous and eruptive; but it cannot, except in some obvious volcanic cases, prove that it is not, at the same time, metamorphic.

The statement that "massive crystalline rocks are igneous" expresses nothing as to their metamorphism, and especially when it relates to the older crystalline rocks of the globe; and the occurrence of a deposit of hematite or magnetite in gabbro, syenite, or any related rock, is nothing against the origin of the magnetite as a metamorphic sediment. The igneous granite of metamorphic origin often contains masses and strips of schists, from a few inches to many rods in length, which are pieces broken from the associated schistose formations, in the course of the upturning and metamorphism. Such "inclusions" do not occur in igneous rocks of other modes of origin; the ejections along fractures or vents break off pieces, sometimes 1000 cubic feet in size; but long strips of schist show that the schistose beds were part of the formation that became generally plastic or fused.

The production of metamorphic change by mechanical force *without heat* has been proved by the experiments of M. Carey Lea on salts of silver (*Am. Jour. Sc.*, 1893, A. Harker, *Geol. Mag.*, June, 1894). Shearing force, or trituration, produces, without the development of heat, a change which heat will not produce, and more effectively than simple pressure.

V. MINERAL VEINS, LODES, LOCAL ORE DEPOSITS.

Veins occur in rocks of all ages and of all kinds. They are the fillings of fissures or of open spaces made in any way—exclusive of those called *dikes*, which are due to intrusions of melted rock. The materials are usually crystalline; and among the kinds are included a large part of the stony minerals and gems of the world as well as most of its ores, those of iron excepted.

FISSURES, FORMS OF VEINS.

1. A Brief Review of the Way of Making Fissures.

Fissures for vein-making have been produced:—

(1) *By contraction on drying*: examples of which are mud-cracks (for the fillings of mud-cracks are vein-like in formation); the cracks in many limestone concretions (page 97); the cracks in an argillaceous stratum or in its more argillaceous layers, which are limited to the layer.

(2) *By contraction on cooling*: either cooling from fusion, as in igneous rocks, or cooling from the heat attending metamorphism.

(3) *By subterranean movements*: to some extent the lighter movements following undermining and ordinary earthquakes, but preëminently the movements, light and heavy, that have attended mountain-making; movements that flexed strata 10,000 to 30,000 feet or more thick, over regions often hundreds of thousands of miles in area, sometimes raising the rocks to verticality, or shoving up the strata along fractures for miles, besides making fissures and opened spaces in all parts of the disturbed formations.