

part of the limestone stratum where limited above and below by cherty layers; that the rock adjoining was largely converted into dolomite by magnesian solutions, and that this "dolomitization" was an early step in the process, and aided in making the cavities; that the ores often occur mixed up with chert or sand that were set loose by the decomposition of the limestone.

There are two theories of origin, one deriving the ore *from above*, the other *from below*. The former is favored and the latter opposed by the absence of proof that the bodies of ore extend downward through the limestone vein-like, and that igneous action was concerned. The theory of filling from above encounters the objections that the ores of lead are not soluble, and could not have been carried into the cavities in solution by sea water, and that the gathering of galena from Archæan veins, once in the regions, by abrading and transporting waters, is improbable, and does not account for the presence of the eroding agents which made the cavities.

The other theory, which was suggested by Percival, and is advocated by Jenney (1893), makes the deposits similar in origin to the silver-lead deposits of Leadville and other Rocky Mountain localities. But the objections to it mentioned above exist; and so they do in the case of some Colorado ore deposits, where igneous action below is nevertheless believed to be probable. The making of the ore deposits is generally referred to the close of Paleozoic time, when the Appalachians were made; but Jenney supposes it to have been at the close of the Cretaceous period, simultaneous with that of most Colorado deposits.

In Derbyshire, England, the Subcarboniferous limestones contain similar lead deposits, and along with the ores are Permian fossils, proving that they originated not earlier than the Permian.

The different modes of origin of ore-bearing deposits, above described, are the following. In the deeper veins the earth's interior heat has been accessory to special sources of heat.

A. HEAT FROM CRUSTAL MOVEMENTS, AND NOT FROM IGNEOUS EJECTIONS OR HOT SPRINGS.

- (1) *Regular veins*. — Mostly in metamorphic rocks.
- (2) *Grouped interlaminar veins*. — Generally short, as the smaller auriferous quartz veins of gold regions, and some tin, copper and other veins.

B. HEAT FROM IGNEOUS EJECTIONS, VAPORS, AND HOT SPRINGS.

- (3) Ore impregnating non-calcareous rocks.
- (4) Veins or groups of veins intersecting non-calcareous rocks.
- (5) The ores in veins intersecting calcareous rocks, and occupying cavities in them made by their corrosion. Often combined in the same region with 3.

Besides these there are, of uncertain origin : —

- (6) Cavities supposed to be in part previously made limestone caverns, as those of the Mississippi Valley.