the bottom. We may thence infer that so long as the circulating liquid fills the whole cavity the attraction of the walls for the precipitated particles is controlling, but that when gas enters gravity becomes predominant and draws these particles to the bottom.

In opal and chalcedony geodes we can often see both forms of precipitate: the crust uniformly covering the walls, and the horizontal deposit. Fig. 4 represents a geode of iron-opal, from Dreiwasser, in Hungary, in which, besides the crustification and horizontal deposit, stalactitic and stalagmitic forms also appear. A thin crust of translucent hyalite covers all parts of the wall, including the floor. The cylindrical stalactites are also of hyalite. Some of them extend to the bottom, and are perhaps joined to stalagmites rising from the crust there. The remaining space is half filled with a milk-white, opaque, opaline substance, in which occurs a thin layer of translucent hyalite. On the same specimen several other less regular cavities are visible. All of them were lined with the hyalite crust, and some have also the opaline layers. These layers are parallel in all the cavities; and it cannot be doubted that they were horizontally deposited. The stalagmites stand at right angles to them, and were unquestionably vertical when formed. The geode certainly occupied, therefore, at the place of formation, the position shown in Fig. 4.

We must resist the temptation to describe the manifold forms of deposit in limestone caves. Fig. 5, an ideal diagram, showing a wall-accretion and stalactites and stalagmites, separate and grown together, is given, not to illustrate the variety of the phenomena, but to indicate their analogy with those of the little geode in the iron-opal of Fig. 4. It is easy to conceive that under some circumstances, particularly in old cavities lying above the water-level and not subject to further enlargement, the formation of stalactites, &c., might ultimately fill the whole space.

The floor of caves often shows deposits coloured with ferric oxide, the explanation of which is obvious. Sometimes we find in the upper caves traces of sediments also; and in one instance in an outlet cave pebbles of very hard rocks came under my observation which certainly came from the surface. The chemical reaction of the formation and filling of these caves is so simple as to need no discussion here.

Much more various observations, however, can be made in the *artificial caves* formed by mine-workings. Here we have conditions analagous to those of the natural caves, but much greater variety, since the most widely different substances come into play. The mine-workings are situated at an artificially depressed water-level, and will show, in general, processes analagous to those observed in limestone caves, particularly the formation of stalactites. From calcareous rocks, from mineral deposits, and from the mine-masonry, crusts, stalactites, and sinter are formed, analagous to those which occur in cavities at the natural water-level. Processes of oxidation will here also play the leading part, although reduction may also be effected through the more abundant organic matter in the mine-waters. Thus stalactites of pyrites, evidently reduced from ferrous sulphate by organic matter, are often found in metal-mines. A respectably large number of observations already illustrate the processes which are going on under our eyes in mines, and from which we can draw conclusions as to the destruction and creation of many minerals by circulating underground solutions. But we must not forget that these proofs apply only to the conditions of the shallow or vadose circulation, and that, for the explanation of the formation of the more ancient deposits, we must look to the rock-regions below the water-level.

To give at least one American example: Dr. R. W. Raymond found in an old Spanish mine, in the Cerillos Range of New Mexico, an iron pick-axe, the eye of which was filled with beautifully crystallized galena, evidently a reduction of lead-sulphate by the decaying wood of the handle of the pick.

It may be said, in general, that the results of the processes of oxidation, chlorination, and reduction observed in those regions of ore-deposit which lie above water-level have come to pass under conditions analogous to those just described; so that we are able to adduce extended series of proofs, not only as to formations now going on, but also as to similar formations long since finished.

(*B.*) *The Deep Underground Circulation.*

Thus far, we have considered only such processes as take place in the region above water-level, and are still, in some cases, open to our observation. As we descend to a deeper region there is less hope of encountering formative processes still active. When we penetrate by mining into the depths we artifically depress the water-level, and create conditions unlike those which attended the formation of the deposits.

But, if we compare the deposits formed below water-level, under proportionally greater pressure and at higher temperature, with those of the upper region, it appears beyond doubt that the former also must have been produced by deposition from fluid solutions.

When we compare the low solubility of certain ingredients of the deposits with the spaces in which they occur, often in large quantity, it is impossible to assume that they could have been precipitated from solutions existing in these spaces only. We must concede that immense volumes of solutions must have flowed through the spaces—in other words, that the deposits were precipitated from liquids circulating in these channels.

The formation of these cavities has been already discussed, and referred to mechanical and chemical causes. It remains to consider the manner of their filling. We have seen that the uppermost layer of the ground-water has an apparently lateral, but really descending movement; and it is very natural to imagine that this top layer slides, as it were, upon a lower mass, which is apparently stagnant. According to this conception, the deep region would be comparable to a vessel filled with various permeable and soluble materials, over which water is continually passed, so that, from the moment when all the interstices have been once filled, only the uppermost water-layer has any movement.

But, with increase of depth, the pressure of the water-column increases, as does the temperature. The warm water certainly tends to rise, if not prevented by interstitial friction, as is, no