

1,246ft. above sea-level, while the spring in the Einigkeit shaft at Joachimsthal was struck at 675ft. above sea-level—that is, 571ft. lower than Carlsbad. The irruption of the thermal waters of Teplitz, in Bohemia, into the lignite-mine of Dux, four miles away, which took place first in 1879, and has occurred recently since, shows plainly that subterranean communications may thus be established for long distances by mining.

Additional data for the study of these relations are furnished by the miners on the Comstock Lode, where, with the advancing depth of operations, ascending thermal waters were unexpectedly encountered, the abundance and high temperature of which presented extraordinary obstacles to mining. The great richness of the deposit was the reason that the hope of going deeper was not abandoned, as in Joachimsthal, where the only effort was to dam out the waters from existing workings; but that, on the contrary, the struggle was accepted against the waters themselves and the enormous heat which they caused in the mines.

As is well known, the upper workings on the Comstock, before any ascending waters had been encountered, were not specially hot, though warmer (70° to 75° F.) than other mine-workings in similar positions. Dr. F. Baron v. Richthofen noticed no abnormal mine-temperature, although he ascribed the Comstock to earlier solfataric action.

At a later period, upon the cutting-through of clay-partings in the rock, the hot water repeatedly broke into the workings with great force, as, for instance, in the North Ophir Mine, when, according to Clarence King, the workmen had scarcely time to escape. The water is said to have had a temperature of 104° F., and filled the workings immediately to a height of 100ft. In another case the water broke into the 2,200ft. level of the Savage Mine, and filled the large spaces both of that mine and of the Hale and Norcross up to the 1,750ft. level, or to a height of 450ft. Gas was continually but not violently evolved, and, although Professor J. A. Church reports it to have been under a pressure of 200lb. per square inch, he believes that this was not a gaseous but a hydrostatic pressure.

The water which in 1880 flooded the Gold Hill mines came from a bore-hole in the Yellow Jacket shaft, at a depth of 3,080ft., had, according to George F. Becker, a temperature of 170° F., and was heavily charged with hydrogen sulphide. In the upper levels of the mine, Becker says there is evidence of the presence of carbonic acid, and on the 2,700ft. level, where the temperature was 150° F., a deposit of sinter was found, consisting mainly of carbonates. Church remarks that it was at first believed that the repeated irruptions of water came from chains of cavities existing in the rock, but that at the time of his visit the conviction was that they came through shattered and decomposed seams, parallel with the lode, and sometimes of great thickness.

Systematic and long-continued temperature-observations in several Comstock mines enabled Becker to represent comprehensively for different lines the increase of temperature with depth; and it thus appeared that this increase was greatest in the vicinity of the lode, diminishing with the distance from the lode: that the vehicle of heat was the water; and hence that it was through the lode itself that communication with the hot depths took place, and the phenomenon denominated "solfataric action" by Richthofen was caused.

The chemical constitution of these intruding waters will be considered further on, after certain phenomena occurring nearer to the surface have received attention.

Related Phenomena near the Surface.—A sort of transition to the corresponding phenomena on the surface itself is illustrated by the mines at Sulphur Bank, California, which have furnished some of the most important data contributed by America to the study of the genesis of ore-deposits.

This is a once rich, but now, apparently, practically exhausted, quicksilver-mine, in the working of which not only thermal waters but gaseous emanations were encountered as obstacles. At the time of my visit, in 1876, an open-cut exploitation was in progress, the terraces of which had extended in some places about 16ft. below the natural surface. Sulphur, as well as quicksilver, was won; but it subsequently appeared that the sulphur-deposit was confined to the uppermost zone, while the quicksilver (or cinnabar) extended in considerable proportions to deeper regions.

At that time sulphur and cinnabar was found in a decomposed basalt, partly as the filling of irregular fissures, traversing the rock in all directions, partly as impregnations in the rock itself, which had often been reduced to a porous mass. The process of decomposition proceeded unquestionably from the fissures, which, moreover, gave forth hot mineral waters and gases. The odour alone was sufficient proof that the gases contained H_2S , to the oxidation of which into $\text{S}_2\text{H}_2\text{O}_2$ the acid reaction of the rock and its moisture was to be ascribed. The miners (mostly Chinese) chiefly followed in extraction the fissures (partly because it was the easiest way to make rapid progress, partly because the richest ores were there concentrated), and, as a result, large round blocks, often several metres in diameter, were left standing. These had a distinct shaly structure, but were so loosely held together that a kick would reduce them to ruins. In the interior of the larger, light-gray blocks was often found a nucleus of solid, dark, undecomposed rock.

The cracks were filled chiefly with an opaline mass, in which a white, opaque ingredient was variously kneaded, as it were, with a gray to black one, translucent at the edges. The specimens taken fell into irregular pieces, bounded by fissures, evidently the result of loss of volume or loss of moisture by the opaline mass.

The cinnabar formed either distinct mineral crusts in the crevices or impregnations of the porous neighbouring rock. This was true of the sulphur also; only the latter appeared, as a rule, in crystalline aggregates upon the cinnabar crusts—an indication of its later origin. Occasionally the cinnabar was deposited in beautiful crystals on the fissure-walls, but these were generally so loosely attached that it was difficult to secure a specimen.

The pyrites, mostly disseminated in the rock, tended so strongly to decomposition, evidently by reason of its saturation with sulphuric acid, that specimens containing it soon fell to pieces.

These observations suffice to show that in this case hot mineral waters ascend through fissures containing ore-crusts and opaline deposits; and when it is considered that the deposit of amorphous hydrated silica is unquestionably the work of the mineral water which decomposed the rock, and also that the cinnabar occurs in the interior of the opaline mass, the two phenomena cannot well be