Art. IV.—*Notes on the Distribution of Ores in Horizontal Zones in Vertical Depth.*

By Professor James Park, M.A.Inst.M.E., M.Inst.M. and M., F.G.S., Director Otago University School of Mines.

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It has been clearly demonstrated by mining operations in the United States, England, and elsewhere that while in many veins the metallic sulphides are intimately mixed without any definite arrangement, in other veins, particularly those of lead, zinc, and iron, there is a more or less orderly distribution in horizontal zones in a vertical direction: that is, there are certain horizontal zones each of which is characterized by a dominant sulphide.

This arrangement of the metallic contents of a vein in more or less horizontal zones was noticed in Cornwall many years ago; and no better example could be found than that presented by the celebrated Dalcoath Mine, which commenced as a tin-mine, at a lower depth yielded nothing but copper, and again below that, tin.

In the great lead- and zinc-mining region of Ozark, in the lower Mississippi Valley, the vertical distribution of the ores, according to Bain,* is as follows:—

(1.) Oxidized zinc and lead ores, with galena.
(2.) Blende, with a little galena.
(3.) Iron-sulphide predominates, and increases with depth.

Spurr,† in his report on Monte Cristo mining district, in Washington, states that the quartz, pyrite, chalcopyrite, pyrrhotite, blende, galena, realgar, stibnite, and calcite show a marked tendency to aggregate themselves in horizontal zones in the order named above.

Rickard mentions the orderly distribution of ores in Colorado.‡ Weed states that in the Castle Mountain district, in Montana, the order appears to be galena on top, passing into highly zinciferous ores below, and these into low-grade pyrite.§

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* H. F. Bain, U.S. Geol. Survey, Twenty-second Annual Report, Part II, p. 161.

† J. H. Spurr, *loc. cit.*, p. 841.

‡ J. A. Rickard, Trans. Inst. Min. and Met. London, Vol. vi, 1899, p. 196.

§ Weed and Pirsson, Bull. 139, U.S. Geol. Survey, 1896.

At the Broken Hill mines in New South Wales the general distribution of ores in vertical depth has been as follows :—

(*a.*) Oxidized ores of lead and silver.
(*b.*) Galena with blende.
(*c.*) Blende with galena.

Weed, in his paper on "Ore-deposition and Vein-enrichment by Ascending Hot Waters,"* appears to support the hypothesis which assumes that the distribution of ores in horizontal zones is the result of primary concentration by ascending hot solutions.

The eruption of igneous magmas is often succeeded by intense solfataric action, of which notable examples are found in the Yellowstone Park in the United States, and in the volcanic region of the North Island of New Zealand. The ascending waters slowly circulating in contact with the heated rocks below become superheated, and in their upward course dissolve various substances, which they carry with them along the line of least resistance—that is, towards the hot-spring pipe or vent. Many substances insoluble in normal conditions are rendered easily soluble in the presence of heat and pressure. The underground water will therefore possess its greatest solvent power where the greatest heat and pressure are attained, which will naturally be at the greatest depth. With loss of heat and pressure the less soluble substances held in solution will be precipitated—that is, those substances whose dissolution was effected under extreme heat and pressure. As the waters ascend they will continue to lose heat and be relieved of pressure, with the result that the dissolved minerals will be precipitated in the inverse order of their solubility. When the hot waters reach the surface the only substances in solution, in most cases, will be the extremely soluble alkaline sulphates, carbonates, and silicates. An obvious result of this process of vein-filling will be an impoverishment of the veins at great depths, due to the migration of the valuable minerals from below to the zones of precipitation above. It is a notorious fact that hot springs seldom deposit metallic sulphides at the surface. The great mushroom-capped veins of the Hauraki region and Great Barrier Island, in New Zealand, are composed of siliceous sinters, chalcedonic and crystalline quartz, manifestly the result of long-continued solfataric activity. The overhanging mushrooms of quartz are almost devoid of gold and metallic sulphides; but the necks in all cases contain gold, and sulphides of silver and iron.

* W. H. Weed, Amer. Inst. Mining Eng., Vol. xxxiii, 1903.

Had denudation removed the mushroom caps, the sulphide-bearing necks would now be exposed at the surface.

The well-known Martha Lode, at Waihi, consists of chalcedonic and crystalline quartz, apparently the result of hydrothermal activity, which at one time probably manifested itself at the surface. There is no overhanging cap.

At the outcrop the quartz is almost pure silica, containing no sulphides excepting a trace of argentite associated with free gold containing about one-third its weight of silver. Above water-level the ore is clean, and free from oxidized products.

In many places both above and below water-level the joints in the veinstone are discoloured with films of manganese and iron oxides, which appear to owe their origin to the infiltration of meteoric water from the wall-rock, and not to the oxidation of contained sulphides.

Between the adit level and No. 1 level there began to appear small limonite-crusted cavities in the thin veins of crystalline quartz which traverse the main lode. At No. 1 level there are detached branches of iron-pyrites in the quartz, and at No. 2 level the sulphide ore forms a rib two or three feet thick.

The lode is being worked to a depth of 750 ft. below adit level; and although there has been an increase in the proportion of iron-pyrites, there has been no decrease in the gold and silver values.

A greater measure of denudation than the lode has already suffered would have exposed the sulphide ore at the surface.

In the study of vein-filling it is always well to bear in mind that veins which outcrop at the surface may have been truncated to a greater or less degree by denudation.

After their formation, some veins, through movement of the walls, have been brecciated and recemented by circulating mineralised waters. Such waters, ascending through the crushed vein-matter, would deposit their metallic contents as sulphides through the reaction of primary sulphides contained in the ore.

In this way a secondary concentration of sulphide ore may be effected by ascending waters. The common belief, however, is that secondary enrichment is in the majority of cases the result of the transference of material from the oxidized portions of a vein to a lower level through the agency of descending waters, from which the metallic contents are precipitated by the reducing action of organic matter or primary sulphides.