Modern Practice in Gold Mining.*

By JOHN HAYS HAMMOND.

Problems in mining may be classified as those relating to —(1) mining geology; (2) mining engineering; (3) metallurgy; (4) mechanical engineering.

1. Mining geology deals with the determination of the geological character, with especial reference to their genesis and magnitude, of ore deposits and co-relatively their commercial values. This is the most important province of the mining engineer, but, unfortunately, one in which but few are proficient.

2 Mining Engineering.—In this class are the problems relating to the methods of the exploitation of the mine.

3. Metallurgy.—Under this catagory are included the methods of reduction of ores. This branch of mining engineering is rapidly becoming specialised. The importance of the problems presented to the metallurgists is obvious, as they relate to the adoption of appropriate processes upon which depend the highest percentage of extraction of the metals from their ores with the least possible reduction charges.

4. Mechanical Engineering.—In this class are the problems pertaining to the installation of mining machinery.

The problem of deep mining likewise belongs to this class, and the author would point out the salient factors of this problem. The great importance of deep mining—i.e. of obtaining maximum depths—may be gauged by taking the special case of deep-level mining upon the Witwatersrand. As is well known, this formation is unique as regards its reliability, both in respect of the continuity of the ore-bearing formation and of the payable grade of the ore. There are many miles of reef along the Witwatersrand banked formation, but estimate here is confined to the central, which has been more thoroughly explored than the other sections of the Rand. The author has estimated the value of the gold contents per lineal mile, along the direction of the outcrop of the reef, worked down to a vertical depth of 1,000 feet, to be £9,000,000 sterling The central section embraces upwards of ten miles, to which the above estimates apply. These figures are obviousiy sufficient to stimulate the ingenuity of the engineer to increase the limits of deep mining. The factors determining the limit to which deep mining may be carried are—(1) Depths *per se—i.e.*, costs of deep shafts and of haulage; (2) ventilation; (3) drainage.

1. Depths *per se*—From an engnieering point of view mining could be carried on at depths which considerations of an economic nature would preclude. With the existing types of hauling engines, wire cables, etc., there is no difficulty in hauling through vertical shafts from depths of 6,000 feet. An improvement in types of engines and appurtenant machinery, which is undoubtedly within the power of the engineer, would enable this depth to be considerably increased. From the bottom of the vertical shaft an incline shaft, or a second vertical shaft, could be sunk to a vertical depth of, say 4,000 feet, thus giving a total depth of 10,000 feet. Such depths increase greatly the first cost of operations, in that they involve a corresponding increase in the size of the plant required for short sinking, for hauling, mining material, miners and ore, in addition to the cost of the shaft itself. The actual extra cost per ton of ore, etc, hauled would not be excessive, and would not greatly militate against profitable mining, unless the margin between profit and loss had already been a narrow one in the shallow levels

2 Ventilation.—One of the great obstacles to deep mining is the difficulty of securing the requisite efficiency of ventilation. This is due to the increase of heat in the workings as depth is attained. The heat encountered in mine workings may be due to one or a combination of two or more of the following causes:—(1) The increasing secular heat as the interior of the earth is approached; (2) proximity of the mine workings to regions of heated volcanic rocks, solfataras hot springs, etc., (3) chemical decomposition of certain constituents of the ores, or of the enclosing wall rocks, confined to deposits of comparatively rare occurrence; (4) animal heat and heat due to use illuminants and explosives, all of subordinate importance. Geologists estimate as the result of deep boreholes and other tests, that the average increment of temperature due to internal heat of the earth is 1 degree Fahr. for about 60 feet vertical depth. The rate of increase in different localities is by no means uniform, sometimes being as low as 1 degree Fahr. in upwards of 250 feet vertical depth. Indeed, in the same mine, the increment of temperature is not invariable, though generally it is fairly constant in some mines —indeed, remarkably so. The isogeotherms are chiefly affected by the proximity of regions of solfataric action or other volcanic phenomena, and by the conductivity of the rocks in which they lie. If 1 degree in 60 feet be accepted as the average increment of temperature, there will be an increase of 16 degrees per 1,000 feet vertical, equivalent to 80 degrees at a depth of a mile. Assuming the normal surface temperature to be 60 degrees Fahr., this would give a temperature of 140 degrees Fahr., one by no means insuperable, but at the same time not economical. To counteract the effects of this undue temperature, artificial ventilation is requisite. Under very favorable conditions the cost of the necessary artificial ventilation in metal mines, especially where inflammable and noxious gases are of rare occurrence, would not preclude mining to depths of 10,000 feet. Nevertheless, high temperatures, even when not intolerable, entail extra expense, due to the fact that the miners are thereby more or less incapacitated. Under these conditions short shifts are adopted, and not only artificial ventilation, but also the frequent use of iced drinks, cold baths, etc., are necessary.

(3) Drainage.—The is one of the least determinable factors. The water pumped from mines is sometimes almost exclusively limited, even in workings of considerable depths, to the upper levels of the mines. On the contrary, however, there is sometimes a progressive increase in the water as depth is attained. The increase is by no means constant, and generally varies considerably from level to level, depending upon the character of the ground drained by underground developments. Where there is an abnormal influx in depth, the expense of pumping becomes a menace to profitable mining operations, though under normal conditions this increased cost may not prove an insuperable factor.

The extra cost of deep mining as has been indicated, is chiefly due to longer haulage, etc., to increased cost of drainage and of ventilation. In the working costs of shallow mines, or of those of moderate depths, these items are small compared with the total cost, in which are included general expenses, cost of development, stoping, metallurgical treatment, etc. Therefore the additional cost of mining in depth entailed by these factors could be considerably increased before reaching a sum which would make deeper mining unprofitable. The factors, then, which determine the limit of deep mining, and by deep mining depths of 4,000 feet and upwards are referred to are—(1) The discontinuance, or, what is tantamount, the impoverishment of the ore deposit. This, irrespective of other considerations, is the cause of cessation of deep mining operations in the majority of cases; (2) the excessive costs of first plant, of ventilation and drainage under unfavorable conditions. This applies especially to the exploitations of ore deposits, where the margin between profit and loss is close: (3) difficulties of a purely engineering nature.

From the foregoing considerations it will be seen that the difficulties included in this category will not be insuperable until long after the question of deep mining has become one of academic interest alone.

*A paper read before the Engineering Conference.