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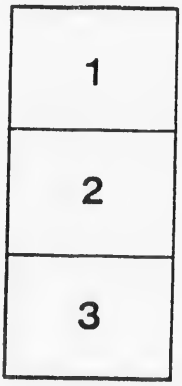

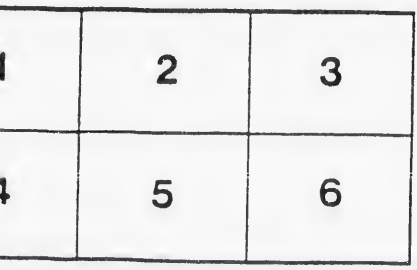

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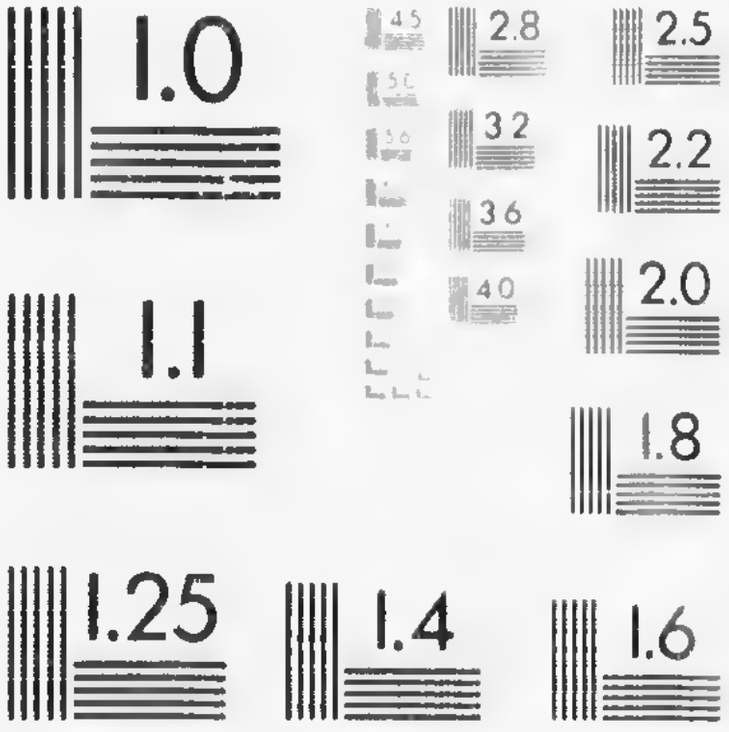

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The Occurrence and Reduction of Gold.

By ALFRED WOODHOUSE, F. G. S., Mem. Inst. Mining and Metallurgy.

In this paper I propose to deal with points of interest that have struck me in the Gold fields of India, Africa and Nova Scotia, and as my acquaintance with the latter is very short, I put forward my views with considerable diffidence, trusting that other members with far greater experience of this Province, will not hesitate to criticise and explain the errors I fall into, for in my opinion, it is the discussion and not the paper that educates.

The subject Gold has a fascination for every one and if termed the "root of all evil," is decidedly a blessing to civilization when properly employed. Gold is, I believe, the only mineral for which a market is always ready, and is the standard by which all products are valued.

Although Gold occurs usually in very small quantities compared with other metals, it is probably one of the widest distributed, as traces of Gold are found almost everywhere, but not generally in payable quantities.

My experience in different countries has shown that the profitable working of Gold *does not necessarily follow* the existence of the metal in payable quantities, and I therefore propose to point out in this paper some of the causes of failure.
This King of metals occurs in three forms as follows:—

1. In veins of quartz or other hard substance embedded in the matrix.

2. Associated with sulphurets of Iron, Copper, Lead, Etc. either chemically combined or otherwise.

3. In alluvial, that is in the detritus formed by the erosion of auriferous rocks from action of weather, sun and atmosphere, by which the particles of gold have been liberated, and owing to specific gravity, the lighter grains of ground or powdered rock are carried away, leaving the heavier mineral near the original source. I do not purpose entertaining the disputed question of Nuggets, as their origin is practically theoretical.

These three occurrences of gold are far too extensive to be dealt with in one paper, and I will therefore confine myself to the first, or occurrence in Quartz and other hard silicious matrix.

Although one continually hears that gold occurs in some particular distr ', in quite a different way from any other country, my experience tends to prov : that, *practically the same Laws of Nature* govern all districts in different parts of the v orld, and I have found practical knowledge in any one country proves invaluable in new fields.

The miner however, must expect to find *local characteristics* and probably no two districts have the same, but if parallel veins of quartz occuring in identically the same formation and lying only a few feet apart, differ so entirely not only in yield of gold, but actually in the nature of matrix, we may reasonably expect very great differences in two districts thousands of miles apart, and to sum up I wish to convey the probability that gold occurs in veins of quartz in all countries, following certain laws of Nature, affected by certain local Characteristics and that the difference in yield of two parallel veins in similiar formation tends to prove that our knowledge of the origin of gold is even to-day very limited.

A visitor to Nova Scotia hears a great deal about the Anticlinal (or Anticline) Angulars etc., but does the Anticline affect the richness of the ore or do the veins nearest this point prove richer than those farther away? I think we must look further for the cause of rich streaks or deposits.

"Angulars" is a good local name for the numerous veins, strings or droppers of quartz that fall into and in some cases cross the true or formation veins or leads. These small angulars are not confined to Nova Scotia but are generally found in all Countries under the name of Feeders, which have leeched the country rock of mineral matter and fed them to the Mother or Formation veins.

All Angulars however do not bring in a deposit of gold and therefore certain Angulars must have special advantages, if these are *really* the only source for introduction of gold, which theory I can not agree with. Owing to the entire absence of a system of cross cutting in settled ground below, little is known of parallel veins except from surface indications which are usually most deceptive, but I think it probable that it will be found many of these angulars are merely strings of quartz connecting two parallel veins. Angulars do not always terminate on contact with Formation veins but pass clear through and continue on the opposite side or they may continue parallel with the vein for several feet and then cross over, in these cases they should, I think, be called "Cross Courses," and these cross courses *do* in my opinion play a very considerate part in the occurrence of gold, and I have found by experience the nearer the cross course approaches to a parallel with the true vein the richer the deposit of mineral matter.

In the Montagu district the gold "Chutes or Streaks" usually occur from 200 to 250 feet apart and dip to the west at an angle of 43° to 45° and the irregularity indicates that the "Chutes" owe their origin to something more than Angulars or Cross courses.

If it is acknowledged that the precipitation of gold and metals is caused by certain laws of nature, and not by chance, then we have reason to expect that the same laws have placed the gold in Nova Scotia mines that occasioned the deposit in other countries.

The following will illustrate one theory how gold may have been deposited in "Chutes" or "Streaks":

All will admit that originally the formation of Slate and Quartzite was in a horizontal position as it was deposited under water probably containing mineral matter in solution, now it follows that this mineral matter would be precipitated provided certain foreign elements were introduced, say for instance, some vegetable matter.

No doubt everyone has seen the peculiar streaks or lines of seaweed on the ocean carried in comparitively parallel lines by currents, the water between these lines of seaweed being entirely clear of foreign substance. Precipitation of mineral matter will be far greater on the line of seaweed or foreign substance than in the clear water. This illustration merely shows the possible theory of Gold Deposits in streaks by vegetable or other matter carried in parallel lines by currents over the newly deposited muds since converted into slates and quartzites.

Interesting as the theory of formation may be, I propose confining myself to the practical and profitable side of gold mining, that is following and extracting to the greatest advantage this valuable metal.

In commencing mining operations the Engineer's first work is to very thoroughly inspect his ground, locating as much as possible his different leads and learning where gold has been found by former owners, making careful notes of past results (though in all probability no two accounts will entirely agree) but, from his notes he will be able to make a rough plan and form some fair idea where gold may be expected below. With this knowledge he locates the position of his first attack, by Adit if possible, if not by Main Shaft, selecting a position as convenient as possible to the Mill Site, which should be chosen well above the flat ground, so that no trouble will occur in the future from Tailings. As the main workings and mill site form the centre of all future operations, too much care cannot be given to the selection of a place which offers the greatest facilities for permanent works, as the past proves. Managers often forget to look ahead to the future, when the mine requirements may assume very great proportions and instead of adding to the original works, a *fresh start* has to be made on a more suitable site.

The works should be laid out *originally* with a view to future contingencies and the plan of operations carried out by degrees systematically as funds will permit. Above all things the reckless cutting up of the surface by what are termed trial shafts should be avoided, as these become reservoirs to catch water and flood the future workings necessitating costly pumping machinery, and once the mischievous work is done, it can never be repaired.

Having located the Main Shaft, the manager should decide to sink a certain depth say 120 feet as a first level and steadily continue to this depth, no matter what rich rock is met, the gold will not run away, and can be far more cheaply raised by overhand stoping from below, than from the system of burrowing or underhand stoping so common in the Province.

I very strongly advise following the value of the rock passed through by saving "the drillings," the miners being supplied with marked tins for this purpose and it should be the Foreman's business to see these are delivered regularly to the Manager who should pan them off and enter result in a book kept for that purpose. Many rich deposits have been found by this method when the gold occurred too finely distributed to be visible and would possibly otherwise have been overlooked.

As a rule the gold or rather the payable portion of the lead, will be found to occur principally in Chutes or Streaks, the Quartz rock between two Streaks proving unpayable, and yet too often this unprofitable rock is taken out and crushed not only with a loss on the work, but also to the wear and tear of the machinery.

It is true every mine cannot maintain an assay department but the Manager can always follow his ore with the pan and I am surprised to see the pan so seldom used in Nova Scotia knowing from experience its great value as a guide.

The question of vertical or inclined shafts is one that is attracting practical attention, the inclined shaft for prospecting work, has the advantage that the lead is tested as sunk upon but any fault, slide, or change in dip of the vein at once causes trouble and with the numerous quartz leads found in most districts of Nova Scotia which must be cross cut afterwards. I consider vertical shafts are most desirable for permanent works, *as it is only the one vein and that at one point* which can be tested by the incline following the lead. When the vertical shaft has been sunk to a level it is easy to rise up or sink a winze on the vein which must be carried out before stoping can be commenced.

Working Capital is provided to carry out the dead work which opens a mine, that is, sinking a shaft and drifting on the various leads as met in the cross cutting and further when the mine is proved, for the purchase and erection of the necessary machinery. When this has been accomplished, the cost of developing fresh ground to replace that extracted, should be added to cost of breaking and crushing a ton of ore.

With the shaft down to first level the pan should prove the value of rock passed through and the result carefully noted on the large working plan of the mine so that the position of the gold streaks on the next level may be fairly located. And my experience has shown, that once the occurrence of the gold is determined, that nature is wonderfully true to herself and unless from some fault or intrusion of trap, the gold will be found where looked for. If more careful attention was given to this matter, much useless work would not be attempted to the greater profit of the owner.

In some mines of the Province notably Montagu "Nuggets" so called are found within the line of the Streak or Chute, and often contain from two hundred to three hundred ounces of gold in a few hundred weights of quartz. These nuggets apparently occur with some regularity 10 or 12 feet apart, and very naturally greatly increase the yield, but as it has been the custom in the past, to crush all ore throughout the mine the average value of the rich Chute is much reduced by the addition of the unprofitable rock between the Streaks worth possibly only two or three dwts. per ton and as there would be fully ten times as much of this poor rock crushed compared to the true streak ore, it proves the rich ore has to pay the loss on treating unprofitable rock for an increased tonnage which must return a lower yield per ton throughout.

When the developments of Montagu enable the manager to attack only the Streaks, leaving the poorer rock 'in situ' the returns should greatly exceed those of the past, especially as by that time more of the occurrence of the gold will have been learnt by experience under systematic workings.

The mines I have seen in the Province appear unusually free of water, except such as is derived from surface where the numerous pits and cuttings form attractive reservoirs and I have reason to think that if the shafts were puddled with clay well tamped behind the lagging, very little water would be found below.

Considering the minute proportion of gold to the bulk of rock, too much care cannot be given to avoiding unnecessary handling of the ore, from which there must be loss in gold and expense. The rock as broken should fall into passes connecting with the level, when a truck after being filled carries it to the shaft, and is hoisted to surface on the cage and delivered by tramway to the Millhouse. When tipped, the ore is shot through a grizzle into the ore bins which supply the self feeders and the large lumps which fail to pass through are put into the stonebreaker. By this method, handling of quartz is reduced to a minimum.

Too often the first object of a manager is to make a good show on surface, and starts erecting substantial works before he has learnt the value of the mine, this is surely putting the cart before the horse, for surface works do not pay the dividends and it is far wiser to expend working capital *first* in development and proving what the mine contains, merely erecting such plant as is absolutely necessary to compete with the requirements of the developments, *before* launching out into handsome buildings and expensive machinery, a system which has brought many a good mine into liquidation.

Ample working capital is most essential, and I do not consider Nova Scotian mines as a rule have had a fair chance. What could have been accomplished in other countries if they had had only the few hundred pounds available, that has been the history of this Province? They would have anticipated failure and I consider very great credit is due to the mining men here to have done so much with the small means at their command.

Again, owing to the fact that many of the mines have been opened by men with small Capital, the profits have been distributed without building up a reserve fund for developing new ground when the rich ore they worked yielded smaller returns, and in consequence many mines that have yielded handsome profits in the past, are now closed down from want of funds, to open out rich ore lying below. With ample working capital the mines can be worked not only on a larger scale but drawing ore from a dozen different points, the temporary falling off in yield at one or two places does not materially affect the return.

With the experience of Indian Mines, having a working capital of at least $100.000, and those of the Transvaal where half a million dollars is far from an uncommon working capital for machinery and mine development, the small system of working in this Province, cannot be considered a fair comparison and yet I am convinced, from my own personal experience, that Nova Scotian mines will amply repay the outlay of large capital provided it is judiciously expended, I mean in bona fide development and not for show on surface.

The quartz occurs principally as bedded veins in a country formation of Talcose or Argillaceous Slate and dense quartzite tilted almost on edge, and the leads are likely to continue gold bearing to great depth, in fact, as deep as the slates. It is however, probable that the sulphurets will increase as greater depth is reached. And as considerable gold is associated with these sulphurets of iron, copper, arsenic, lead

and zinc, more attention should be given to their concentration and treatment, a subject that has received little thought in the past and generally they will be found a welcome asset.

The ore having been delivered at the Mill the next process is, to extract the gold as effectually as possible, and I would impress upon mining men that Amalgamation is a Science, and that it does not mean feeding so much rock under stampers with the addition of water to splash out the crushed particles, which are then conducted over some amalgamated copper plates. Any school boy or ignorant man can do that and catch a certain percentage of the gold.

The Science of Amalgamation is arresting and separating the last particle of gold that can profitably be extracted from the quartz rock, and I mean by this, that there is a point of gold saving, beyond which it costs more to extract the extra percentage than the value of the gold recovered.

The two first objects are to get the particles of crushed rock out of the mortar box, when reduced sufficiently to pass the screens without unnecessary pounding, and secondly to retain the gold in or as near the box as possible, and with this idea an amalgamated plate is generally placed inside the mortar box with quick silver being introduced at intervals on the crushed ore or pulp leaving the box, the great object is to check the forward flow of pulp as much as possible without causing it to silt, the tendency of a check being to precipitate any particles of gold either floating on the water, or held in suspension onto the amalgamated copper plate.

The advantages and disadvantages of introducing quicksilver into the mortar boxes, are much disputed, but I have found that with most ores it answers well, provided a copper plate is securely fixed at the back in a recess cast for the purpose but in case of introduction, it should be used cautiously, otherwise it will be flowured and splashed out onto the plates and probably a good deal will pass away into the tailings, as it is found flowured quicksilver will not readily remain on the copper plate.

In case of grease and oil getting into the box with the quartz, it is advisable to introduce common caustic soda every few hours, as this dissolves the grease and keeps the inside sweet.

For ordinary quartz, I find a drop of 8 9 inches 80 to 85 times a minute most effective, and with course gold a steel wire screen with 1000 holes per square inch, in some ores however, the gold is so finely disseminated, that 2000 holes is not too fine but the capacity of the mill is naturally reduced with the smaller mesh.

The pulp as splashed through the screens falls on a plate 10 inches wide inclined towards the battery, with a pitch of 1 in. 10 or 12 and is thus directed over a series of two ripples of quicksilver with a third one below empty, so as to catch any quicksilver washed over, and thus protect the plate which should be 4 feet long with two ripples below, the upper one only being filled with quicksilver, from here the pulp passes over a second plate 4 feet long and then is conducted to the concentrator.

Although there are numerous patents for concentrating they are mostly very expensive, and often decidedly complicated, and I find the old fashioned straight

throw Australian percussion table answers very well and has the great advantage of cheap construction by the mine carpenter.

This concentrator consists of a solidly built wooden table some 8 feet long with two divisions. The first with a copper plate set at a low angle say 45 degrees 18 inches long from which with a rise of 1 ½ inches in 2" 6" is built the floor up which the ore must ascend. The lower half of the table is similar. This table is hung by four strong iron arms and is held firmly against a bumping block by a powerful spring, with a treble cam the table is pushed forward about one inch to be pressed back by the spring when free of cam, from 180 to 240 times a minute.

The jar naturally settles the heavy pyrites the lighter sand passing off with the water. Any straying particles of gold or amalgam are caught on the copper plate, while floured quick silver is again united by the continuous action. The machine is capable of taking 5 to 7 tons every 24 hours. The concentrates are removed with a small shovel by the amalgamator when necessary.

A frequent loss of gold occurs from using too much water over the tables, there should only be just enough to make the black sand and pyrites drag along without actually silting.

Plates should be dressed every four hours, and at that time the battery and water should be stopped, as a piece of amalgam once moved is liable to be swept away with a rush of water. In dressing the plates, a very weak solution of cyanide of potassium may be used to remove any oxide of copper, but on no account should a plate be touched by the naked hand, a piece of chamois leather should always be used.

The quicksilver in the ripples should be retorted once a month as retorted quicksilver has a greater affinity for the fine particles of gold than that which is charged and the gold produced from retorting well repays the cost and trouble.

The use of Sodium Amalgam and Cyanide is not to be encouraged, as both are very dangerous to the plates, and quicksilver, unless thoroughly understood, but a very small piece of Sodium Amalgam say the size of a pea, may be placed in each ripple once or twice a week to liven up the quicksilver.

Samples of tailings should be drawn every hour, water and all, and allowed to settle, and fire assays should determine the daily loss of gold per ton.

All details of Millwork, such as stopages, length and cause, time quicksilver introduced to mortars, speed of stamps, delivery of ore, etc., should be regularly entered in the Mill-book, which should be signed at end of shift by amalgamator. If these details are necessary, in an ordinary office, surely they should be attended to when a valuable mineral like gold is concerned.

It is not possible to enter into the question of the various chemical processes for treatment of concentrates in this paper, but I have found very effective results from simply grinding them to a fine slime, more especially if they have been spread out on floors, and exposed to the action of the sun and weather for several months. If a little salt is added, the material kept constantly moist and turned over once a

week, decomposition is rapidly affected and a very considerable proportion of the gold is liberated on treatment and is rapidly absorbed by quicksilver.

In grinding, I have found it advisable to add very little water for some time, so that the quicksilver may permeate the very thick mud in minute globules which however are not in the form of floured mercury and to assist the process, I usually add a little salt, caustic soda and cyanide, and after grinding for three or four hours a stream of water is turned on and carries off the slime to a percussion table, when pyrites not sufficiently ground is retained. The quicksilver remains in the grinding pan, which after the water is syphoned off, is ready for a fresh charge of concentrates say 5 or 10 cwt.

My object in dwelling on the concentrator and grinding process for treatment, lies in the fact that both can be carried out on most of the mines in the Province at low cost and are fairly effective, but should practical bulk treatment prove the sulphurets to have that value, I believe they have, it will then be time for the manager to look about for a more effective and modern process.

I am indebted to my partner Mr Lucias J Boyd for the plans accompanying this paper and which illustrate some of the questions dealt with.