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“Notes on Gold Dredging.”

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THE method of dredging for gold in “alluvial wash,” at present adopted in New Zealand, is the result of some 30 to 40 years’ experience. As now carried on, it may be said to be entirely “bucket-dredging,” for although suction-pumps have been tried their use has been discarded.

The essential parts of a working dredger are: the pontoons, which form the barge on which all the machinery is placed in position; the ladder-frame, including the buckets by means of which the wash to be treated is raised; the revolving cylindrical screen and tables, or as an alternative, an ordinary sluice-box, in which the wash is treated; the elevator, not always necessary, for returning the treated wash into the river, behind the dredger, in such a position as not to inconvenience dredging operations; and the winches, for altering the position of the dredger by means of ropes fastened to the shore.

The Pontoons.—The pontoons are built of wood or iron. They are always double, with a well about 5 feet in width between them, extending fully half their length, through which the ladder can be lowered.

The Ladder-Frame.—The ladder-frame, built strongly of iron or steel, is so arranged that a chain of buckets can travel continuously round its length. The midship, or upper, end of the ladder-frame, is held at a height of 15 feet to 25 feet above the deck of the pontoons, by a strong framing, but the lower end can be lowered through the well to the depth required, by means of blocks and ropes attached to a bridge-like framing, called the “gantry,” on the end of the well. The gantry is so built that the ladder can be hauled entirely out of the water. The buckets discharge their contents, when they have passed their highest point, onto a shoot which directs the wash to the revolving screen, if that is employed, or to the sluice-box.

The Revolving Screen.—The revolving screen, open at both ends, revolves slowly on its axis, which is out of the horizontal, the end which receives the wash being higher than the other end by 1 foot to 2 feet, depending on the length of the screen. As the screen revolves, material put in at the higher end will in due course be delivered at the lower end. Water plays on the wash in the screen from end to end. The screen is perforated with holes as close together as possible, consistent with strength, and varying in diameter between $\frac{1}{4}$ inch and $1\frac{1}{4}$ inch, according to the coarseness of the gold which it is expected to catch. The larger material is delivered from the lower end of the screen into the elevator. All the gold and smaller particles of the wash are washed through the holes, and fall directly on to the tables, which have a width equal to the length of the screen, and a length of about 8 feet or more, if space allows. The tables are covered with plush or felt, having a protection of "expanded metal" laid over it. The fall of the tables may be $1\frac{1}{2}$ inch in 1 foot, and the water frequently flows over the tables with a depth of $\frac{1}{2}$ inch. When once the gold and finer product are on the tables, the separation of the gold is effected by gravitation. The water thoroughly disintegrates the product on the tables, and, at the first opportunity, the particles of high specific gravity, such as gold and heavy black sand, fall through the expanded metal on to the plush, where they are caught. The lighter particles at the same time are carried away by the water. The stream of water must be so adjusted that it is not sufficiently powerful to move gold particles, and yet is too powerful to allow a mass of fine wash to accumulate on the tables, for if this happened the gold could not reach the plush and would be carried away with the tailings from the tables. The tailings are generally allowed to run into the "paddock" behind the dredger. The tables are "cleaned up" at least once a week, and, if much gold is being caught, as often as once a day.

The Elevator.—The elevator consists of a frame, somewhat similar to the ladder-frame, the lower end of which is supported on the stern of the pontoons, the upper end being held by means of ropes suitably attached to the pontoons, at the required inclination to the horizontal—generally about 35° or 40° . A continuous chain of buckets travels up the elevator, and as each bucket reaches the top it discharges its contents over the end.

In general, dredging may be divided into two classes, viz., river dredging, and what is commonly called "dry-land" dredging.

In river dredging the elevator is frequently dispensed with, or is thrown out of gear, since the dredge works up-stream, and any

stones deposited from the screen over the stern are quickly carried out of the way and do not interfere with the working of the dredger.

In "dry land" dredging, a dredger frequently has to be built to work into a face of auriferous wash or gravel which stands 10 feet to 15 feet above the water-level. In such a case a pond or paddock must be dug, so that the pontoons can be conveniently launched into it. It must be so large that the pontoons can be turned round, with plenty of room to spare. The smallest diameter of the pond should be 40 feet longer than the dredger, for by having extra room much time is saved in "opening out" when commencing work. There is, of course, a limit to the height of the face into which it is possible to work. An elevator cannot deposit gravel masses as closely as nature has done it. A dredger, well managed and having no other special difficulties to cope with, should take down a face of x feet in height, from the surface-level to the bottom which it is proposed to clean up, and deposit the same material, less that which has escaped through the screen-holes, in a vertical height of $\frac{3x}{2}$ feet. Thus if the water-level is 20 feet above the bottom, and a dry face is exposed for a height of 10 feet above water-level, a total face of 30 feet in height is to be dredged, and this when stacked behind should not occupy more than 45 feet vertically. Of this height, 20 feet will be below water-level and 25 feet above it. Tailings-elevators, as at present used, become very cumbersome and expensive if designed to stack more than 25 feet above water-level. Matters can be assisted somewhat by bringing an artificial supply of water into the paddock and keeping the water above its natural level. Under certain circumstances it would be possible to reduce, say, a 20-foot face above, and a 10-foot face below water-level, to a face all below water-level; but this is an extreme case never likely to occur, and such a claim should be proceeded with very cautiously, for, if the natural water-level is so low, it is quite possible that at some previous time much of the ground may have been drained and worked by mining. Moreover, should the water suddenly escape from the pond or paddock, the dredger might become stranded. The dredge attacks a face and deposits it behind, thus continuously moving the pond or paddock onward in any direction it is desired to work. It is always advisable to keep the paddock as wide as possible and to work on a definite system, as this is more economical in every way than working haphazard. If no system be adopted at the start, it may be found at some future time to be

impossible to work part of the claim without going through old tailings again. In dry-land dredging there is little danger of stoppage due to the dredge being carried away by floods. That, however, is not a very serious item in river dredging, for most dredges can be pulled up by dropping the ladder. Rivers do not lend themselves so readily to prospecting as dry land, and results in river dredging are generally more irregular than those in dry-land dredging, the weekly returns from the river being sometimes very large and sometimes very small.

Difficulties in Dredging.—It may easily be conceived that gold washed down a river may lodge in a crevice in a rock bottom, and may be absolutely irrecoverable by means of a bucket; for this reason a hard bottom constitutes a serious defect in a dredging-claim. Moreover, gold in a face loosened by undermining may fall down and be lost, as far as the dredge is concerned, and thus both the gold on the bottom and that in the higher strata may be lost. Perhaps the most important part of a dredge-master's work is to see that the bottom is cleaned up, and a few inches of it brought to the surface, for gold appears to work its way into a soft bottom. If the bottom is composed of rock no bucket can clear it effectively.

The presence of too much soft clay, or even of any at all, may prove a source of considerable loss. In general, it has been found in New Zealand that in very clayey ground better results are given by a sluice-box than by a revolving screen in the matter of saving gold. It is not difficult to find a reason for this. In a sluice-box, any gold in the wash not mixed with clay has an opportunity, immediately after the disintegration of the wash under the action of a powerful stream of water, to fall to the bottom, between riffles, where the clay lumps cannot reach it. In a screen, however, the gold cannot be expected to go through the first hole it comes to, and that it does not do so in any ground is amply proved by the distribution of the gold across the width of the tables underneath the screen. Until it does find its way through, it will be in constant danger of being picked up by a lump of clay and carried to the elevator and lost.

If a dredging claim happens to be situated in a river into which trees might find their way, and into which much sluicing has been done, there is a strong probability that there will be a certain amount of buried timber. This, if in large quantities, involves a tremendous loss of dredging-time, and may even make a claim undredgeable which without buried timber might be considered ideal dredging-ground. Again, a tree carried away by a flood may occasionally get foul of a dredger or its lines. For this and other

reasons, if possible, the dredger is frequently drawn into a sheltered position during a flood. A forest on the land to be dredged causes serious inconvenience in many ways. Of course it must be cleared before the dredger can get to work, and as many as possible of the roots should be taken out. These frequently are entangled, and may prevent ground which is undermined from falling in, and generally cause great inconvenience and loss of time. Nevertheless, a forest does not necessarily condemn a claim, for there are claims in New Zealand with thick virgin bush on them, which are now being worked with handsome results. Part of the timber can be burned as firewood, but not all of it lends itself to this use.

In certain rivers, such as the Molyneux, in New Zealand, dredging can be carried on with advantage only during about 7 months in the year; in summer this river is fed by melted snow, and rises and becomes a torrent until cold weather sets in again. A dredge working in a flooded river may have its buckets coming up full and be apparently treating a huge quantity of stuff. Yet this may be only river silt, containing almost no gold, which is being continually washed into the paddock. Sometimes the dredger may even be unable to prevent its paddock from becoming filled up with silt. In some localities, also, severe frost may cause a stoppage of several months every year, or the ground may be undredgeable altogether on account of the severity of the climate, as in parts of Siberia, where the summer thaw only reaches a depth of 6 feet from the surface, the ground below that depth being perpetually frozen. Probably a few weeks for an overhaul once a year are necessary on every dredger, and this, if possible, should be done during a forced stoppage; but, if the stoppage is due to frost, it may be impossible to carry out the overhaul.

If in summer the water-supply runs short, the gold-saving appliances will be seriously affected and considerable loss may result, for the tables require clean water, particularly if the gold is fine. Care should be taken to prevent the dredge touching the bottom in case of shortage of water, as it might easily be ruined through straining, if it grounded.

If the gold to be caught contains large nuggets, and a screen be used, some of the nuggets may be too large to pass through the screen-holes and may become deposited with the tailings. This may be more or less overcome by placing a small sluice-box between the screen and the elevator, so that the material delivered from the screen must pass through the sluice-box before being elevated. A more likely occurrence, however, is that the gold is too fine to be saved easily, and no system of gold-saving applicable in the

limited space available on a dredge has yet been evolved to meet this case. The device of treating the wash on a separate pontoon has been suggested, but the Author has never heard of its being carried into practice. Heavy black sand frequently accompanies gold in alluvial ground. On the west coast of the South Island, New Zealand, certain dredging-claims exist which are sea-deposited and are even now only a few hundred yards from the sea. Here the gold is exceedingly fine, and black sand abounds, so that gold-saving operations are rendered exceedingly difficult. Some progress has been made recently, chiefly by using a large spread of tables, a good flow of water, and a distributing arrangement which makes every part of the table do its work. Large quantities of sand might also present another difficulty, as sand when run into the paddock behind the dredge might run in underneath it. In such a case arrangements might be made to elevate it to some distance away from the dredge.

The regularity or irregularity of deposits can only be ascertained by actual prospecting. The fact that the head of a creek has been drained by a race or by pumps, and has been worked for gold, does not prove that gold exists in the flat below, although, of course, it is an excellent indication. The "lead" of gold worked at the head of the creek may be only a lead running across the present creek bed, deposited by some previous water-course. The creek below may be almost barren until another cross-lead is met with. If the expense of accurately fixing the position of such runs of gold is not prohibitive, it should be done.

Every dredger must be built to suit all the requirements of the claim it is intended to work. Many claims have proved apparently valueless when worked by one dredger, which have afterwards given excellent returns when worked by a more suitable dredger. This has been due mainly to the fact that the first dredger was either not sufficiently powerful or else was unable to dredge deep enough, and had to leave the best part of the wash on the bottom untouched. In designing a dredger for any claim, it is always necessary to ascertain the greatest depth which it may be required to dredge. If the bottom is just so soft that it can be cleaned up easily, it may yet be uneven, or on a regular slope, and so cause difficulty. A ladder of such a length that it will dredge the deeper ground of a claim on being lowered until it approaches a vertical position, has, when in that position, the stresses supported at both ends. If, however, the same ladder be hauled up to dredge much shallower ground, it approaches a horizontal position, and, except for its weight, the principal working-stress will be in the direction

of its length, and thus the stress will be sideways instead of downwards on the tumbler-frame which supports the upper end. In such a position the dredge will frequently "kick" as each bucket impinges against the face. To get rid of this trouble, ladders are sometimes made telescopic, so that they may be lengthened or shortened 4 feet or 5 feet. The deeper ground may be expected to carry more gold than the shallower ground; it should therefore not be missed.

Although a well-designed dredger will probably only need two men per shift, *i.e.*, six men, or eight men including the dredge-master and the engine-man, yet frequently roads to the ground must be made, and, if timbered, the timber must be cleared, and possibly cut up for firewood; the cost of labour, therefore, must not be dismissed without thought.

It may be possible to do away with expenditure in fuel by the use of electricity generated by water-power. Water-power has been used for dredges with good effect. If, however, steam has to be generated, the proximity and cost of coal or wood-fuel must be reckoned with. The cost of getting machinery on to the claim must receive as much consideration in dredging as in any other mining proposition.

The wash should not be too coarse, nor should it be excessively hard, due to cement; the proper coarseness is somewhat difficult to specify. Roughly, however, if the boulders do not exceed 18 inches in diameter, the ground is dredgeable. Occasionally boulders of 2 feet in diameter may be allowed, and although it has been stated that boulders of 10 tons weight have been lifted, they occasion serious inconvenience, and stoppages, if not breakages, will occur. However, it certainly seems that if the wash be coarse the gold has a tendency to be coarse also, and collected in pockets, so that it very frequently pays to move a large boulder, in order to recover what is underneath it.

Prospecting frequently constitutes a most expensive item, and nearly always a most unsatisfactory one. It has been said that the only way to prospect a river is to dredge it. Where that can be done it is undoubtedly a satisfactory test, but it is generally out of the question. Wing-damming is an expensive operation, and very liable to failure. Bore-holes have been put down in a river, but the Author does not consider boring-tests satisfactory. When it is considered that a bore-hole of 30 feet in length and 5 inches in diameter contains rather less than $\frac{1}{8}$ cubic yard, and that gold nuggets up to $\frac{1}{2}$ ounce in weight may easily be encountered, it is easy to see how misleading a boring-test may prove, and no one

could expect to get any kind of accurate result. Should the gold be fine and the rods well managed, somewhat more reliable results may be obtained, but even then they cannot be expected to be more than a guide. To prove that gold exists in a claim, boring-machines are quite sufficient. An experienced borer with a good machine may obtain valuable information about a dry-land claim, and as he probably takes his own men with him wherever he goes, the danger from "salting" is minimized. If, however, some idea of the contents of the ground is required, then a shaft sufficiently large must be sunk, and drained either by pumps or by a drainage-race. The pump method is not always satisfactory, for with water streaming into a shaft it is quite possible that loose gold may be washed out of the walls, unduly enhancing the result.

Dredging procedure has been likened to a ready-developed mine in which the battery goes about and lifts the auriferous material *de situ*, but it suffers from one serious drawback from which battery practice is free. In a battery, a check on the battery manager is always possible through the medium of the assayer. It is not so in dredging, however, for it is absolutely impossible to sample the wash as it is lifted, and so the owners are absolutely dependent on the honesty of the dredge-master. That being the case, the dredge-master should for his own protection insist on one of the crew being in his presence all the time he is cleaning up, and before leaving the cabin the gold should be put in a bag, weighed, and sealed. So, too, a dredge-master is very dependent on the honesty of his crew. It is easy during a night-shift to place a handkerchief, spread out, on the table, and when lifted it leaves no mark.

The remarkable progress made in dredging in New Zealand during the last 5 years has been due in a measure to the excitement caused by the deserved success attending the efforts of a certain party of gentlemen in dredging the Molyneux River. This river has now been found, with the exception of a few miles, to be dredgeable for nearly its whole length, or about 100 miles, and as the river flows for about half its length through very rocky gorges, such a result is remarkable. The river flows from Lake Wakatipu, and, to give two instances of its character, its source is a fine waterfall, and about 35 miles below this is a natural bridge of rocks. So rocky is the Molyneux in parts that one dredge, built for convenience on an adjoining claim, was unable to dredge on to the right claim. A large number of claims, which were at their initiation termed "wild cats," are now proved successes.

Judging by this, a prospector should not term a gorge undredgeable at first sight, for it is not unlikely that it may have a bottom composed of some kind of clayey material, which may prove very rich in gold. From the fact of a river having eaten its way through a rocky gorge, one concludes that it must have been flowing there for many years, and if it reaches the gorge after flowing through an alluvial flat, it is not unlikely that each mile of river-bed may be nearly equally rich in the total quantity of gold it contains, and that a mile of gorge may contain as much as a mile of flat; and if so, the wash in the gorge is concentrated so as to contain, bulk for bulk, much more gold than the flat. Dredging has been accomplished to a depth of 60 feet below water-level, and elevating to a height of 60 feet above it. These are extremes, and as the machines to do this work are very costly it is advisable to secure claims somewhat easier to work. At the same time a new type of elevator, in which centrifugal force is turned to profitable account, is now being tried, which, if successful, will greatly reduce the cost of elevators. In general, a depth of 35 feet and an elevation of 30 feet are quite convenient for a dredger to work.

Claims in New Zealand, which when prospected gave results of 6 grains, over 6 grains, and 1 dwt. to the cubic yard, respectively, have proved failures on dredging; in these cases the prospecting was probably tampered with. The Author, without going into details, believes that 3 grains per cubic yard will give, under favourable conditions, good results on 100 acres in New Zealand. There, a claim is nominally 100 acres, but generally not more than 70 acres of it is dredgeable, which may mean a life of about 8 years only, and during that time the first cost of the dredger must be paid, as well as a fair rate of interest on the capital expended.

The Author regards dredging as the most speculative of all mining industries, and, except under special circumstances, more suitable for private individuals than for large companies, and he ventures to assert that from its nature it will never attain the precision of battery and cyanide work.