

INTRODUCTION.

The survey of the Lefroy field was carried out during the months from July to August. Since all the Mines were closed and most of them abandoned for a long time, it was difficult to make a close examination of the reefs and workings, and most of the details of mine workings are taken from old reports.

TOPOGRAPHY.

The country is one of general slopes and slow streams. The highest part of the area is in the south where near Specimen Hill the country rises to a height of about 650 feet. The valleys are about 200 feet above sea level.

GEOLOGY.

Summary: The oldest rocks in the district belong to the Mathinna series of the Cambro-Ordovician system. In the south west portion of the area permo-carboniferous sediments, mainly conglomerates, occur. Tertiary river deposits are the next in order of age, these being overlaid by basalt flows which are again covered by alluvial materials and gravels.

Cambro-Ordovician: This series consists of predominating sandstones and some slates. The sandstones are sometimes uncleaved and fairly soft, but usually they are strongly cleaved and rendered almost schistose by the development of secondary mica. The strike of the sediments varies from 320 degrees to 340 degrees and there is a general dip to the west, but in proximity to faults these relations may be disturbed.

Permo-Carboniferous: The rocks of this age are mainly conglomerates and can be traced on the surface by the pebbles derived from them. Some sandstones, some of which can be seen on the east side of Slaty Creek, also occur.

Tertiary and Basalt: The deposition of the tertiary material is closely connected with the movement of the subsidence which the land was undergoing at the time. At the end of this period of subsidence basalt flows occurred in the valleys. The result of the subsidence and basalt flows was a lowering of the grade of the streams, so that the deposition rather than erosion occurred in the stream beds. The topography before the basalt flows and subsidence occurred must have been very rugged, and in the Pinafore deep alluvial mine near the Morning Star Lode there was an average grade of 1 in 5, and at the same spot the sides of the gutter 2 in 1 showing that precipitous conditions prevailed.

The leads have been worked on the surface and have flat grades up to that point where they pass under the basalt, and give the appearance of having been formed in the period which elapsed between the flows of basalt and so running on to the earlier basalt flows instead of bed rock. In the bores which have been sunk, two basalt flows can usually be recognised, and in one bore these were four.

Pleistocene and Recent: These consist of stream gravels and surface deposits. Since the basalt flows deposition has been occurring in the streams, so that the stream courses are on a bed of their own deposits. A fair amount of surface gravel, much of it auriferous, has been spread over the surface during recent times.

On the hills of trig points C and A, near the last Pinafore shaft and east of the township respectively, and also on the west of the Monkland Road, there are very rounded gravels which at one time were deposited along a stream bed and their present position on the hill tops is a good indication of the amount of erosion that has occurred subsequent to their deposition. These gravels rest on the top of the basalt and evidently have acted as a protective capping to denuding agents.

The Demijohn Lead is above the present level of Sludge Creek and may represent an earlier bed of that stream.

Structural Geology: The most striking feature of the structural geology is the very open folding of the Cambro-Ordovician rocks and the prevalence of faulting. The rocks as previously stated dip to the west throughout the field. At Back Creek six miles to the North East they have the same strike, 320 degrees to 340 degrees, and dip to the east showing that there must be at least one anticlinal axis between these two places. This very open folding does not necessarily mean that a great thickness of rock is exposed, since faulting is so prevalent and consequently much of the series may be repeated.

The faulting is the important structural feature of these rocks and most of the reefs, including all the large ones, have been formed along fault planes. The auriferous reefs are remarkably parallel and have a direction to bearing about 80 degrees. Most of the reefs dip to the south, but the Native Youth and other smaller reefs dip to the north.

Often the faulting movement has taken place in a shear zone between two fairly well defined walls, between which the reefs may occur usually on either the hanging wall or foot wall or sometimes in the middle of the shear zone. These shear zones may be as much as 200 feet wide, and may be termed lode channels; locally they are called formations. The remainder of the space between the two walls of the lode channel is filled with crushed and twisted country rock, veined with buck quartz.

Many of the reefs show signs of repeated movements along the fault plane in the formation of slickensides and the crushing of the quartz and country rock first into a fault rubble and finally into a pug. The reefs often show the effect of repeated openings of the fissure with the introduction of more quartz, the auriferous quartz being the earliest since it has often been found on the walls of the fissure with valueless quartz adhering to it.

Besides the auriferous fault channels there are two other sets of fractures which have directions approximately N.W.-S.E. and N.E.-S.W. and generally dip to the west. These faults are younger than the auriferous reefs and displace them. These faults or slides often have a low angle of dip and it is possible that some are over-thrust faults. They are usually filled with quartz or sometimes pug, and the country rock becomes converted to a dark

slatey rock. This rock has a crinkled surface along the cleavage planes which gives it the appearance of a rock which has been squeezed. When wet this rock appears black and it is a good indication of the proximity of a fault, since it can easily be distinguished from the normal country rock.

The main reefs lie in a belt of country which runs to the west of north. As this direction corresponds with the strike of the Cambro-Ordovician rocks, the reefs may be connected with a particular series of strata. The rocks in this belt are sandstones, which have been rendered somewhat schistose by the development of parallel planes of mica, which may have developed whilst the faulting movements were taking place.

There is one auriferous reef, the Golden Point and Crown, which runs N.E. and does not have the normal course. The country rock is extremely shattered and probably represents an area of intense local shear in which a cross fracture formed at the same time as the normal E.-W. fractures.

ECONOMIC GEOLOGY.

Quartz Reefs: The auriferous reefs can be distinguished by the fact that the quartz is slightly crystalline and has small vughs with protecting crystals. The non-auriferous or buck quartz has a hard vitreous appearance and there are no crystals developed; this is the quartz which is found in the later faults or slides, strain cracks, etc.

The mineral with which the gold is found more abundantly is stibnite and its decomposition product cervantite. Pyrite, chalcopyrite and arsenopyrite also occur, and the sulphide concentrates have been roasted and treated to yield quite appreciable quantities of gold.

Secondary Enrichment: The reefs at Lefroy owe most of their values to the effect of surface enrichment which is effected by the gold moving downwards into the reef in solution as the upper parts of the reef are worn away, and hence becoming concentrated in the portions immediately below the surface. None of the mines have been payable below the 400 feet level, and in the history of Lefroy mining the manner is very striking in which the gold values have become unpayable at the 400 feet level.

The values of the reefs below the 400 foot level is never more than one or two dwt. per ton, and comparing this with the relatively high value obtained in the upper parts of the reef, it is seen that a considerable amount of enrichment must have taken place. At least 2,000 feet of the upper parts of the reefs must have been eroded away and most of the gold passed down into the successive surface portions to enrich the reefs. If at any time the rate of erosion of the upper parts is greater than the rate at which the gold is moving downwards in solution, the gold will be washed from the reef, which will become correspondingly poorer. Since Tertiary times deposition has been occurring in the valleys while the higher parts have been eroded. Thus most of the enriched portions of the reefs in the higher parts have been eroded away, whilst those in the valleys have been protected. This gives an explanation of the fact that the richest mines have been situated in valleys or hollows.

Since faults crossing the reef provide easy passages

for the downward movement of the solutions, it would be expected that a greater amount of enrichment would take place in their vicinity. This is actually the case, and many of the shoots of gold which have been worked in the field were formed in relation to faults. While there is a general improvement in values on each side of the fault, the values on the footwall side of the fault are usually better than on the hanging wall side.

Alluvial Deposits

(a) Pre-Basaltic: The pre-basaltic alluvial deposits seem to have been formed at different periods, the later ones when the valleys were becoming filled with deposits and perhaps the earlier flows of basalt. The earliest may be called the Deep lead, since it is the only one which has been worked underneath the basalt. The Lefroy Deep Leads Co. sunk a shaft to 287 feet when work was discontinued when the war broke out. In the shaft of the East Pinafore Mine bedrock was struck at 236 feet from the surface with 8 feet of wash with good gold values. The shaft was not in the gutter and the bedrock dipped to the east, and the water was so heavy that work on the alluvial material was discontinued. The gutter was tested in the Golden Era and New Golden Heart Shafts and the prospects obtained from the wash in each case were satisfactory. The Pinafore Company sunk a shaft in 1914 near the head of the basalt along Sludge Creek, but work proved unpayable owing to the immense boulders and blocks of sandstone which were jammed in the wash. The gold was patchy, but some beautiful coarse samples were obtained. As mentioned before precipitous conditions prevailed at this point and gave ample explanation of the occurrence of the enormous boulders in the wash. These conditions would be bad for the concentration of the gold, only the very coarse pieces being capable of concentration in such a swift stream as this would have been.

From these workings was seen that there is a possibility of good gold values in the gutter since in most of the cases where the wash has been tested it was found to be satisfactory. The best place to test the lead would be probably just below the junction of the two sub-basaltic branches, the Sludge Creek and Blacket Creek branches, since the Sludge Creek branch, having a steeper grade and hence being a faster stream, would drop its gold on entering the slower moving Blacket Creek branch. This effect has been observed at the junction of two branches in the deep leads of Victoria. Of course, a considerable amount of boring would have to be carried out to determine the position of the junction, possibly indicate the values of the wash. In the upper parts of the Sludge Creek branch conditions seem to have been too steep for the efficient concentration of gold.

Other pre-basaltic leads have been traced on the surface to the point where they pass underneath the basalt where the workings were discontinued. It is unlikely that all these are branches of the deep lead as they seem to have been formed at different periods in the filling of the original deep lead valley. The principal leads which

belong to this type are the Pinafore, Golden Point and Native Youth and Kerrigans Lead with other less important leads.

(b) Post-Basaltic: The post basaltic alluvial deposits may be divided tentatively into the Pleistocene and Recent, the Pleistocene are those occurring away from the present stream courses, but are younger than the basalt flows. The Demijohn Lead, where Mr. T. Lanham has lately been sluicing, and Poverty Gully belong to this class.

The alluvial deposits in the stream beds are generally not payable, probably owing to the absence of a bedrock bottom on which the gold can become concentrated. The surface gravels are often slightly auriferous, and also the rounded gravels which occur in some of the hills. Alluvial work has been carried out in some of the gullies and also on some of the surface gravels, but these are all unimportant.

Recommendations: The most promising venture which could be carried out on the Lefroy field seems to be the testing of the sub-basaltic deep lead deposits to ascertain if the values are sufficient to warrant exploitation. This already has been discussed.

Apart from this the future development of the field depends on the discovery of new reefs. The most likely place for future prospecting seems to be between Den Creek and Lefroy. At the Den Creek a fair amount of alluvial gold has been obtained, some of it very ragged and with adhering pieces of quartz but no reefs have been found. The country between here and Lefroy consists of the usual slates and sandstones, and reef quartz with traces of gold have been discovered.

In any future mining development the effects of surface enrichment should be borne in mind. The history of the field has shown that small veins of very rich ore near the surface are apt to lose practically all their value less than a hundred feet beneath the surface. In any case the values always fall to unpayable amounts at about 400 feet in depth and provision should not be made in this district to develop a mine below this level.

BACK CREEK.

General: Back Creek is situated six miles in the north-easterly direction from Lefroy. The geology, except for the absence of Permo-Carboniferous rocks, is almost identical with that of Lefroy. The dip of the Cambro-Ordovician rocks is to the north-east, opposite to that of Lefroy. Faulting is not so prevalent as at Lefroy, and most of the reefs occur in fissures along which hardly any faulting movement has taken place.

Economic Geology.

Reefs: The reefs have a general direction the same as at Lefroy, except that they strike a little more to the north of east than the latter. They are not quite so regular, however, and seem to vary in direction more than the Lefroy reefs. The reefs in this field seemed to be confined to a belt running to the west of north and agreeing with the strike of the rocks similar to those at Lefroy.

The modes of occurrence of the reefs are not always the same. In the Franklin Mine there are a series of small gold-bearing veins up to two or three inches thick, and probably numbering about twenty. At the Union Mine gold is found in white sandstone traversed by numerous small quartz veins in the hanging wall of a vein of quartz from two to three inches thick. The width of the gold-bearing zone varies from 10 ft. to 15 ft. The other reefs are similar to those at Lefroy, but there are no wide mullocky lodes like the Pinafore, Volunteer, etc.

Secondary Enrichment: The reefs in the district seem to have undergone surface enrichment similar to those at Lefroy. The greatest depth mined was at the Franklin mine where a cross-cut was driven at a depth of 170 feet. From a winze connecting the 100 ft. and 170 ft. levels thirty tons of ore are said to have given 22 oz. of gold (14 dwts. 16 grs. per ton). Many of the reefs, however, seem to be very rich near the surface but rapidly fall off in depth till at about fifty feet from the surface they are unpayable.

Alluvial Deposits: Most of the gold from this field has been won from the alluvial deposits, mostly from four leads, the White, Red, Blackman's and Cardigan Leads. These all have a general direction to the south of east, and at their lower ends they pass underneath the basalt along Back Creek. It has generally been considered in the past that the deposits in these leads pass down to bed-rock underneath the basalt, but it seems more likely that they pass onto earlier of the two flows of basalt which have been proved in the bores. The reasons for this are as follows:-

- (1) The lead deposits would have had to escape destruction by denuding agents for all the time between and subsequent to the two flows of basalt. In some of the bores 70 feet of alluvial deposits were found between the two flows, showing that a considerable time must have elapsed.

- (2) The bore records show that the bed rock near the edge of the basalt has a very steep slope which does not agree with that of the leads where they are exposed on the surface. Hence it is probable that the steep sub-basaltic slopes represent an earlier more rugged stage of the topography which existed long before the present lead deposits were formed, and these were formed when the slopes had become modified by erosion and the filling up of the valleys with sediments and the early basalt flow.
- (3) In Blackman's lead gold has been found on the bed rock beneath a false bottom from which most of the gold had been obtained, showing that two stages of concentration has occurred. The deposits beneath the false bottom probably represent an earlier system of lead deposits which has mostly been eroded away.

The origin of the gold in these leads is rather puzzling since no reefs have been found of sufficient quality and size to supply all the gold which has been won from the leads. Some of the gold is rough and adhering to quartz and the more probable origin of this gold is small rich leaders which have been now entirely eroded away. Another explanation is the re-concentration of the gold from an earlier system of leads.

Quality of Gold: The gold from this field is very pure, having a fineness of about 980. This is almost certainly due to refining by the solution and removal of silver, either during surface enrichment or in the alluvial deposits.

Recommendations: The exploitation of the sub-basaltic deep lead deposits is an uncertain proposition. The sub-basaltic deposits were worked by the Back Creek Deep Leads G.M. Co. but starting with totally inadequate preliminary boring to determine the position of the gutter; a lot of money was wasted to no purpose.

It was not certain at any point in this Mine whether the gutter has been struck. As the surface leads probably do not continue on bed rock underneath the basalt, the occurrence of good gold in these does not necessarily mean that the sub-basaltic deposits are rich. The gold which passed down from the present surface leads onto the basalt would not have much opportunity to concentrate in a definite stream course and hence it is not likely that any payable deposits are to be found there. At present the possibility of working the deep lead deposits is indefinite since there is not enough information.

The Major Reefs are an isolated pair of reefs, parallel to the general system of Lefroy and Back Creek reefs, occurring a little over a mile on the east of the other reefs. It is a possibility that further parallel reefs might be found along the line running N.W. & N.E. along the strike of the beds. The supposition is derived purely by analogy with the reefs at Lefroy and Back Creek, which be in echelon along similar directions.

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