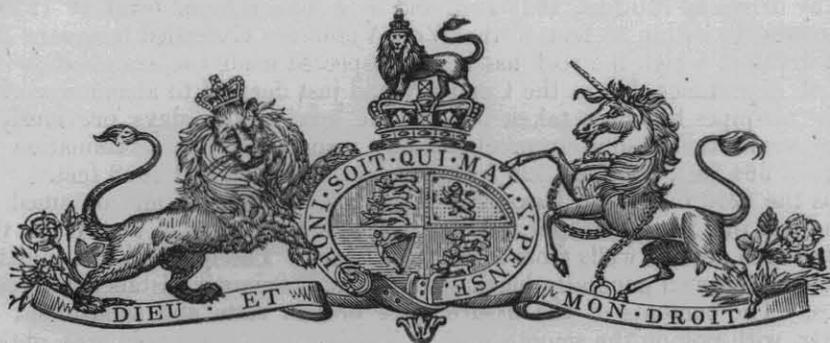


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VOLUNTEER GOLD MINING COMPANY.

REPORT BY THE GOVERNMENT GEOLOGIST.

Government Geologist's Office, Launceston, 25th August, 1899.

SIR,

PURSUANT to your instructions, I proceeded to the Lefroy Goldfield on the 12th instant in order to examine the deep shaft of the Volunteer Gold Mining Company, and I now have the honour to forward to you the following Report thereon:—

Situation.—The property held by this Company at the 9-mile Spring, $1\frac{1}{2}$ miles from Lefroy, comprises 87 acres, being Sections 834-87G, 21-93G, 4-93G, 957-93G, 1332-93G, 960-93G, 959-93G, 958-93G, 1458-93G. These sections are distant 10 miles from George Town on the east bank of the River Tamar, and 26 miles from Launceston, with both of which places they are connected by good roads.

Geology.—The geology of the Lefroy Field has been well described by Mr. A. Montgomery, M.A. (*Vide* Report on the Geological Structure and Mining Development of Lefroy Goldfield, 9th March, 1897.) It is therefore unnecessary for me to do more than briefly refer to the geological features of the Volunteer properties. A series of light and dark slates and gray sandstones strike across the Company's sections in a N.W.-S.E. direction, with varying angles of dip to the S.W. The variation in the angle of dip is, to my mind, suggestive of the bedding lines being parts of great curves. This is a point which needs working out by local observers. Strings and veins of white quartz, called locally "buck quartz," traverse the strata in all directions. From these, ages of sub-aerial waste have liberated innumerable fragments, which have been gradually broken up into small sharp-edged stones, now found on the surface everywhere as a detrital covering. The age of the slates and sandstones on this field is taken to be Silurian, probably Lower Silurian, but no one has ever heard of the discovery of fossils, so there is no precise evidence of age. The gold-bearing quartz reefs cannot well be older than Upper Silurian, and must be prior to the Permo-Carboniferous. Very often reef quartz is seen enclosing fragments of slate, indicating either the consolidation of the quartz contemporaneously with the formation of the fissure, or a process of infiltration into the fracture joints of shattered rock. There are many features of geological interest upon this field which cannot be examined in a rapid traverse.

Mine Works.—A fault reef crosses the Volunteer property in a direction varying in the different mine levels from N. 72° W. to N. 89° W. It was discovered by prospecting some 40 feet below the surface, and has been worked since 1892. The Company state that they have crushed 10,486 tons of quartz, which yielded 27,754 ozs. 5 dwts. gold, being an average of 2 ozs. 13 dwts. 3 grs. per ton, and realising £109,092 1s. 11d.

A well-constructed main shaft has been sunk to the No. 8 level, 628 feet below the surface. This is about 100 feet below sea level. From the shaft levels have been driven E. and W. on the course of the reef, viz., No. 1 level at 105 feet; No. 2 at 164 feet; No. 3 at 225 feet; No. 4 at 298 feet; No. 5 at 364 feet; No. 6 at 463 feet; No. 7 at 526 feet; and No. 8 at 628 feet.

Above the 105 feet the ground was payable; between 105 feet and 164 feet, patchy, with a great blank; between 164 feet and 225 feet, poor; but between 225 feet and 364 feet, good, the

(No. 63.)

best in the mine. Below 298 feet the reef became poorer, until below the 463 feet it practically ceased to be auriferous. To prove the reef at a greater depth, a winze has been sunk from the 628 feet level on the underlay to a vertical depth of 1250 feet from surface. This has enabled it to be tested by drives at 750 feet, 1018 feet, and by a long bottom level at 1250 feet, which has been driven west to within 38 feet of the West Volunteer Extended boundary line.

The great depth at which the reef has been prospected made the examination of the bottom level a matter of importance, but as the Company had just decided to abandon work in that part of the mine, the air-pipes had been taken out of the level a few days previously. The consequent want of ventilation absolutely precluded any inspection. My examination was confined to the workings at 364 feet, 463 feet, 526 feet, 628 feet, 750 feet, and 1018 feet.

As regards the 1250 feet level, I examined the work on the plan and obtained a good deal of information from the Mine Manager. I was told that the drives E. and W. at this level had gone forward between defined walls from 2 to 7 feet apart. The footwall was said to be smooth sandstone; the hanging-wall generally black slate. The maximum distance between walls was 11 feet 6 inches. The contents of the fissure were broken slate and sandstones, bunches and strings of quartz, with pug on the smooth walls. Twice a very little gold was obtained by the dish from patches of quartz. This was all the gold met with in this level—just enough to indicate that gold lived down. In driving the level W., the country was found disturbed, and the lode was missed, but was picked up again after turning the drive north. It is uncertain whether the lode was faulted here or split, and not having seen the drive, I cannot express any opinion; but the result of the crosscut from winze at 1018 feet is against the latter view, unless the small vein of slate and pug seen in that crosscut represents a north leg. For 15 feet behind the end of the level the walls are reported to have bulged and broken, though continuing to carry the same characteristic country rock-filling. The underlay of the reef in this level is stated to be from $2\frac{1}{2}$ to 3 feet in the fathom, and its bearing in the end N. 85° W., which corresponds pretty well with its direction, as observed in the upper levels of the mine. Driving was suspended here on the 29th July this year.

At 750 feet a level is being driven W. from winze. At the time of my visit it was 18 feet in, and this was the lowest horizon at which I could personally inspect the lode, as the short level at 1018 feet has been filled in and the work there is now confined to exploration by cross-cutting. The face of the 750 feet level W. is 6 feet wide and consists of broken slate, somewhat pyritiferous, intersected by numerous small veins and strings of quartz, with a thin layer of pug on the hanging wall.

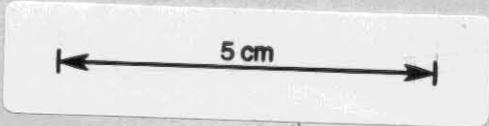
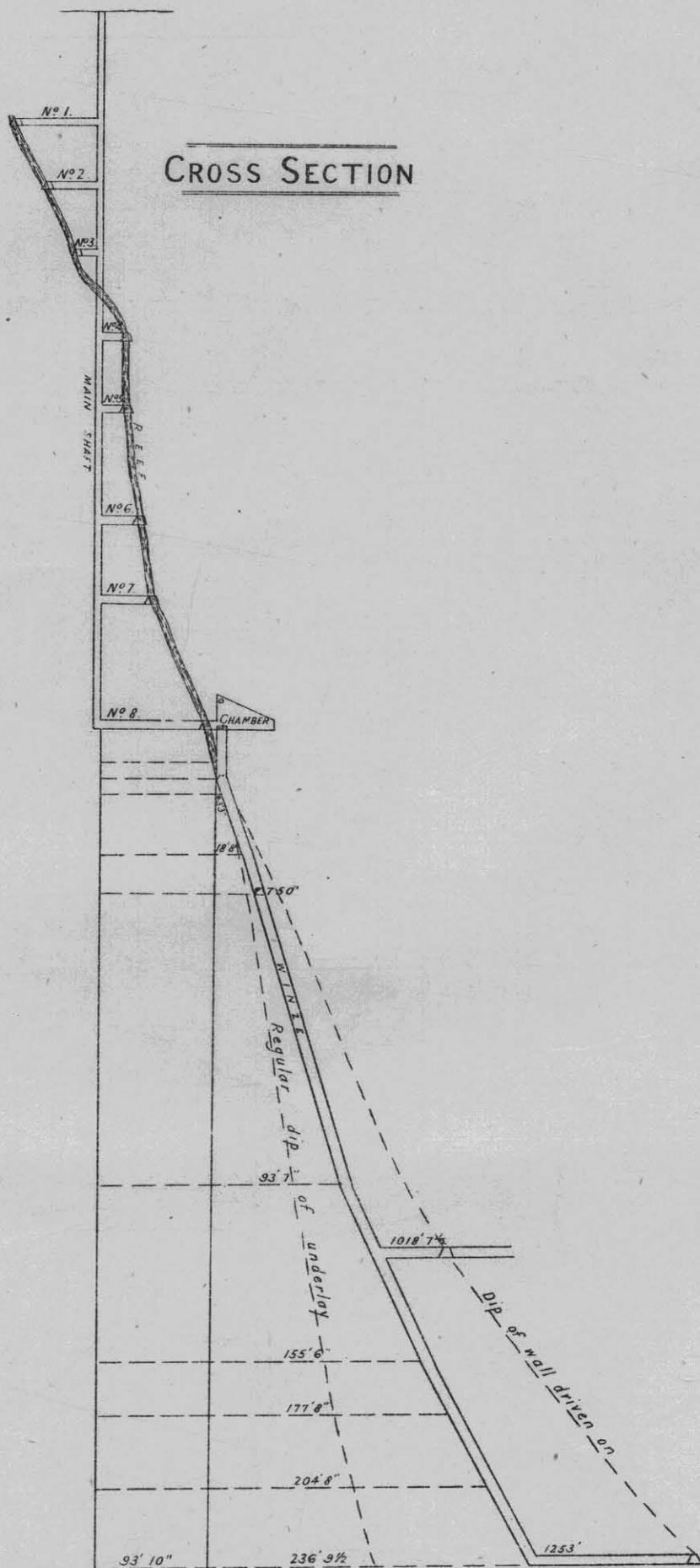
At the 628 feet I found the Company had driven levels on the reef E. and W., mostly between defined walls from 5 to 7 feet apart. The footwall is particularly well-defined and shows the smoothed surface which is so familiar a character in this mine. The long drive W. showed stone now and then, but nothing payable. The face is broken argillaceous sandstone, which constitutes the lode-filling. The channel has here widened on the footwall; the hanging wall is carried in the drive. The reef has its usual underlay. The E. drive shows in the face broken sandstone on the footwall side and disturbed slate on the hanging wall. There is a thin intermediate wall in this filling. About 3 feet of the face is decidedly mullocky. In these drives, though the fissure maintains its usual width, the filling is not veinstone, but country rock shattered and comminuted by movement and pressure.

It is evident that the Volunteer lode is one of a character unusual in Europe, but often met with in Australia. The space between the walls has occasionally been found filled with veinstone, but more often a foot or two, or even only a few inches of quartz lies on the footwall, while the rest of the filling consists of shattered country rock, mixed sometimes with rubbly quartz. In the deeper levels the quartz is more often absent. Where this shattered material is loose and lumpy it may be fitly described as mullock. Of the two walls the footwall is perhaps the best defined; it is the smoothest, and sometimes carries even a polished surface. The principle adopted in driving has been to follow the stone on the footwall. This is a sound plan.

The opinion has been expressed that the Volunteer lode is a wide channel or formation, 20 to 100 feet wide, in which the lode proper, viz. the veinstone, only forms a narrow band, the rest of the channel being filled with shattered country. Under the influence of this idea, doubt has been felt whether auriferous stone might not exist further south, inside the hanging wall of this supposed channel, "the main hanging wall," as it has been called.

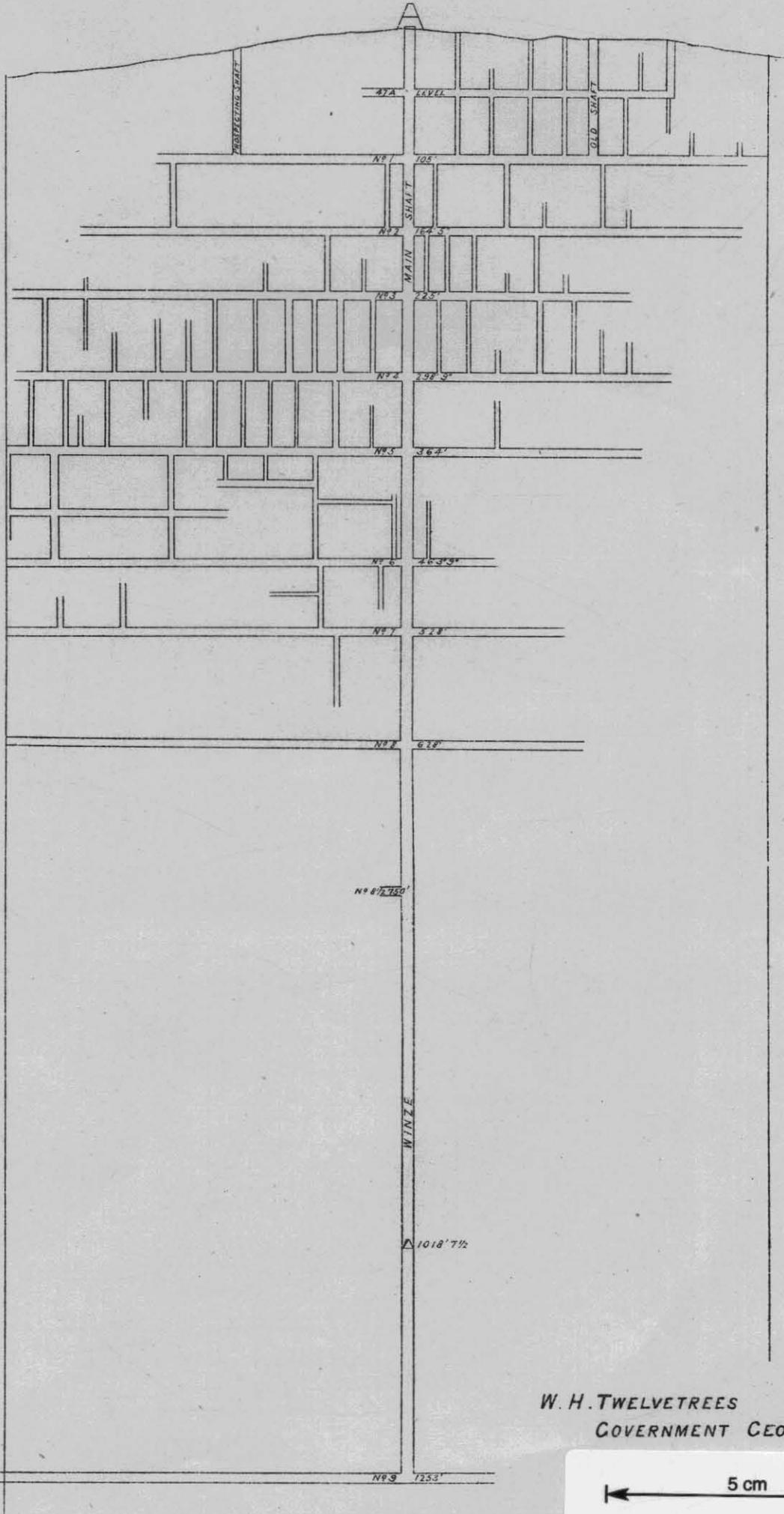
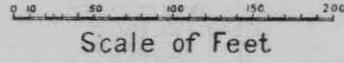
I paid particular attention to this question of a wide "formation," and carefully examined the crosscuts which had been put in to prove it, but I cannot say that appearances particularly favour the theory. Take the crosscut S. in the 364 feet level. At 40 feet from the hanging wall carried in the drive, a vein of soft, black, and calcareous-looking stuff, from 4 inches to 2 feet wide, with pug on both sides, has been intersected, crossing slate rock. All the way back from this point to the level the country passed through is slate and hard sandstone, carrying veins of "buck" quartz. I interpret this quartz as filling strain-cracks in the bedded strata. I could not bring myself to believe that this regularly-bedded country rock is in any sense of the word the filling of a fissure. Further W. from the same level a cuddy S. has been put in to prove the country outside the hanging-wall of the lode. At 24 feet a vein was cut, which perhaps is the same as that met with in the crosscut described above. The ground proved in this cuddy was hard, blasting country; nothing here to indicate lode-filling.

I next examined the crosscut S. in the 463 feet level W. This was advanced to 102 feet, when a small pug vein crossed the face. There is hard, big country all along this crosscut,

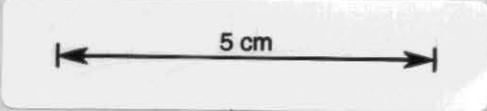


VOLUNTEER GOLD MINE

LONGITUDINAL SECTION



W. H. TWELVETREES
GOVERNMENT GEOLOGIST



undisturbed and massive, veined with buck quartz. No one, unless dominated by a theory, could for a moment interpret this solid country as a "formation." In the 526 feet level I found a S. crosscut extended 46 feet from the lode in hard country rock without any trace of dislocation. At 1018 feet a S. crosscut was driven 117½ feet without intersecting anything. These crosscutting tests appear to me quite satisfactory, and I therefore think that the idea of a main hanging-wall existing at some distance south of the lode-wall carried in the levels may be dismissed.

At 1018 feet an exploratory crosscut N. is being driven from the winze in search of parallel lodes. It has been driven 200 feet in hard slate and sandstone country, first through slate with flat bedding, then dark and grey sandstone. The breast shows horizontally laminated light-coloured slate, with no signs of proximity to any lode. Though this crosscut has not yet intersected any parallel lode, it is proving the country satisfactorily. Though no lode be visible at surface, there may be fissures which have failed to extend so far upwards. Such often remain concealed and unsuspected, even close to known lodes, until disclosed by crosscutting.

The dip of the reef in this mine does not seem to be available as a guide to the distribution of auriferous quartz. Certainly, between 298 feet and 364 feet it became steeper, almost vertical, and poor in stone. But in descending it proceeded to work back to its original underlay, which it now maintains in the lowest level. The country rock, too, has no visible diagnostic value, unless dark slate be accepted as slightly favourable, but then the opposite walls of the lode are generally sandstone and slate respectively. No igneous rock has been encountered in the workings, so that the reef has received no stimulus from eruptive dykes or sheets. The unfortunate part of the business is that in the lower levels the quartz veinstone has virtually disappeared from between the walls, and the lode channel is filled with crushed country rock and lumpy quartz, in places a genuine mullocky lode. This filling, as well as the smooth walls, the occurrence of an intermediate wall in the channel, the leathery black pug and numerous thoroughly typical slickensides lead me to infer that crushing and shearing movements on a large scale have taken place since the fault fissure was filled with its quartz. An isolated patch of polished auriferous quartz (of which I have been shown samples), found by itself in barren reef formation over No. 2 level, is strong evidence in the same direction. The difference in the nature of the lode walls, slate on one side, sandstone on the other, points to vertical displacement of the country along the line of fissure. Hence, as the country, and subsequently parts of the lode itself, have been faulted, it is not surprising to find that the movement has seriously interfered with the continuity of the veinstone. But, on the other hand, so long as the fissure walls are maintained, there will be a chance of meeting with stone which has shifted its position in the lode from a higher to a lower level. This chance is strong while the lode walls keep their normal distance apart; and even if the lode pinches to a mere thread, we may entertain expectations of its recovery in depth, if only we can trace its track. This has been proved in mining experience again and again. In fact, mining cannot be carried on upon pessimistic principles. If underground work were stopped when an ore chute dies out or a vein nips, there would be an end to serious mining. *Per contra*, it is discouraging to see continued search failing to obtain its due reward.

The general experience of miners throughout the world is that auriferous reefs are richer in their present upper parts than in depth. Those interested in mining at great depths may demur to this statement. Productive gold mines in New South Wales and Victoria, at extreme depths, may be cited as instances to the contrary, but the general experience cannot be gainsaid. Hence a despondent feeling when chutes of gold-bearing stone die out at a comparatively shallow level. A good many theoretical considerations may be adduced to show that there is no necessary connection between payable stone and shallow depths. Let us see whether the results of practical experience and the requirements of theory cannot be reconciled. The very fact that the present surface level is purely incidental ought to warn us against appealing to it as a factor in any solution of the problem. I believe that one explanation of the apparent superiority of auriferous reefs in their upper parts is that only reefs which are encouraging at or near the surface are likely to attract attention and induce the expenditure of capital, while those which are barren in their upper portions, and therefore offer no inducement for any outlay upon them, remain unexploited. And whereas chutes of metal in the reef are not indefinitely continuous, the shallow productive zone must give way to a barren deeper one.

To apply this to the Volunteer mine, we cannot conceive that nature has kindly denuded the country to the level of the auriferous zone for our benefit. Auriferous and barren reefs alike have been worn down to the same level, only the former have been exploited and the latter left untouched. The next auriferous body may be at a great depth, but we have deep mines in Victoria which demonstrate that gold-bearing zones do recur before an impossible depth is reached. Though the geology of the saddle-reefs of Bendigo is not on all-fours with that of Lefroy, yet while the mines there go down to over 3000 feet, and while there are more than a score of gold mines in New South Wales upwards of 2000 feet in depth, it is folly to talk about the reefs at Lefroy dying out, in obedience to some law of nature, below 400 feet. The faulting, which I suppose to have removed the quartz from its original position in the Volunteer reef, has been an obstacle to successful mining, but when the veinstone is picked up again the country fault may prove an essential condition of gold deposition in the way of providing a channel in which the ascending silica would deposit its burden.

The pessimists tell us that as decreasing temperature and pressure may be the real cause or necessary conditions of the precipitation of gold from solution, this may be expected to take

place only in the upper zone of a reef, or at least more readily there than in its lower portions. I reply to this that the whole portion of a reef accessible to human observation belongs to its upper part. The most extreme depth to which mining can penetrate is still the upper part of a mineral vein.

Another discouraging statement is that the average gold yield of the upper parts of worked reefs exceeds that obtained from workings at great depths. It is clear that this statement is deprived of much of its force if proper allowance is not made for the more thorough exploitation at the upper horizons. Accurate statistics alone can support or disprove the assertion. Meantime the remunerative nature of deep gold mining is being favourably effected by improvements in gold-saving appliances. In this connection the following extract from the Victorian Secretary for Mines' Report for 1898 is worth reading:—

"A fair inference may be drawn of the possible success to be expected in the future from the following facts regarding the results of deep mining:—In 1894 the New Chum Railway Company at Bendigo discovered a payably auriferous lode at a depth of 2878 feet from the surface. From 1895 to the end of 1898 this company raised from the lode in question 40,778 tons of ore, and the yield of gold therefrom amounted to 35,551 ozs. 14 dwts., showing an average of $17\frac{1}{2}$ dwts. per ton. The amount realised was £142,248. Each ton of ore was therefore worth £3 9s. $9\frac{1}{2}$ d. Dividends to the extent of £78,391 5s., or £2 2s. 6d. per share, were distributed as profits, in addition to a reserve fund being established. The company is now working the lode profitably at a depth of 3000 feet. The Shenandoah Company worked the same reef at 2782 feet, and obtained 9170 ozs. of gold from 16,728 tons, and from this paid £14,800 in dividends. The lode in its continuation to the south, at a depth of over 3000 feet, is being worked by the Eureka Extended Company, and to the north, at a depth of 2782 feet, by the Shamrock Company, which up to the end of 1898 won 1521 ozs. from 1474 tons of ore, and paid in dividends £3750. The total output of these mines to the end of 1898 was 58,980 tons crushed for a yield of 46,242 ozs. 14 dwts., averaging $15\frac{3}{4}$ dwts. per ton, and the dividends amounted to £96,941 5s."

At the same time it may be admitted that some very careful experiments lead to the belief that the fineness of the gold met with above the permanent underground water level exceeds that of gold at a greater depth. I reproduce Dr. J. R. Don's observations, indicating the dissolution of silver or the re-precipitation of gold in a zone which was once deep-seated, but is now within the vadose sphere of circulation:—*

Relative Fineness of Vadose and Deep Vein Gold.

Surface Samples from Bendigo Gold Field, Victoria.			Samples from Deep Levels (1200 feet to 3000 feet) of Bendigo Gold Field.		
No.	% Gold.	% Silver.	No.	% Gold.	% Silver.
1.....	94.76	5.24	1.....	93.08	6.92
2.....	95.03	4.97	2.....	95.04	4.96
3.....	94.05	5.95	3.....	94.00	6.00
4.....	94.27	5.73	4.....	91.27	8.73
5.....	94.10	5.90	5.....	91.30	5.70
6.....	95.00	5.00	6.....	94.19	5.81
			7.....	93.96	6.04
			8.....	92.95	7.05
			9.....	92.37	7.63
			10.....	94.70	5.30

* The Genesis of certain Auriferous Lodes.—Dr. J. R. Don. 1897, p. 45.

I was not able to examine whether in the parallel lines of lode traversing the Lefroy field ore is found "against ore," as the miner's adage has it. If it is, then it might have a bearing on the occurrence of the gold chutes in the different mines, but it would lead to no reliable conclusions in the case of the Volunteer lode, owing to the faulting which has demonstrably taken place. Still I thought it desirable to inspect the deep workings of the New Pinafore mine for the sake of comparison. The impression left on my mind here was that though the prospects obtained are encouraging, the workings are not quite deep enough to give satisfaction. The horizon of the present deep workings of the New Pinafore has been supposed to be available to some extent as a guide in estimating the probable nature of the reef below the bottom level in the Volunteer. Mr. Montgomery made the difference of surface level to be 258 feet, the Volunteer being that much higher; and it has been thought that the latter must sink another 200 feet to reach the present slightly auriferous horizon of the Pinafore. It is true, the absolute horizon or distance from the earth's centre will then be the same for the two mines, but the history of the reef in each mine is not identical, and no safe conclusion can be drawn.

The suspension of work in the bottom level of the Volunteer is a sign that the present shareholders are not prepared to continue exploring in depth. Yet if the question of the existence of gold here at a reasonable depth is to be settled, the task of deeper sinking must be faced.

The best way of doing this would be to sink a new main shaft, and I agree with the suggestion made to me on the spot, that the proper place for it would be south of the present end of the bottom level. The company would thus avoid a long crosscut through footwall country to the reef. The existing main shaft could not well be utilised. If it were sunk deeper it would be brought down too far north of the reef, and involve an excessive length of crosscutting at the bottom. Moreover, larger poppet-heads would be required, and the manager informs me that not only would the engine have to be shifted further back, but he would have difficulty in finding room for the mullock on the present tip.

If deep sinking be taken in hand, and this is to my mind the only rational course open, it should be carried down to 2000 ft. or 2500 ft. Unless the reef is explored at that depth it cannot be said to be fairly tested; and deep sinking is not sufficient by itself. There must be horizontal search at the deeper levels, and the intermediate ground will have to be prospected. Experience in Victoria has shown that neglect in this respect has more than once resulted in payable ground being passed by.

Briefly, I base my belief that there is no valid reason for abandoning deep prospecting upon the following data:—

1. The reef is a true fissure vein.
2. It is a fault reef. The extent of vertical displacement cannot be ascertained.
3. Subsequent movements have taken place within the reef itself. These movements have displaced the veinstone, and removed it, inferentially, to a lower horizon in the vein.
4. As the walls are being carried down, enclosing a well-defined channel, there is a likelihood of the fissure recovering its original filling of quartz.
5. I cannot say that the lode exposed in the deeper workings affords the means of predicting the reappearance of the auriferous zone at any given horizon. When the quartz is recovered the discovery of gold must be looked upon as a mining risk. It is usual for metalliferous zones in veins to recede at different levels, and I do not see any reason why the gold under Lefroy should form an exception to the rule. A point of some importance is whether the gold-bearing stone in the upper levels died a natural death or was violently displaced. The signs are in favour of the latter being the case, and, if so, it may be the first to reappear.

The Lefroy Goldfield has yielded a good deal of gold in times past. In Mr. L. Jolly's paper (Notes on the Lefroy Goldfields, Trans. Aust. Inst. M.E., 1897) the output up to 1897 is stated as 177,075 ozs., and from all I can learn this has been increased to date to over 179,000 ozs. But this production is all from the shallow zone, and the field is now languishing owing to the non-discovery of gold below the 400-ft. level.

In my work at Lefroy I was greatly assisted by Mr. J. G. Payne, manager of the Volunteer Mine, and Mr. W. H. Stubs, manager of the New Pinafore, whose courtesies I desire to acknowledge.

Appended to this Report is a cross sectional plan of the Volunteer reef and longitudinal section of the workings, prepared from plans furnished by the mine.

I have the honour to be,
Sir,

Your obedient Servant,

W. H. TWELVETREES, *Government Geologist.*

W. H. WALLACE, *Esq.,*
Secretary for Mines, Hobart.