NOTES

ON THE QUARTZ REEFS, OR LODES OF SANDHURST,

VICTORIA, AUSTRALIA.

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In forwarding the following notes relating to one of the most extensive and important quartz mining districts of Victoria, I think I should commence by explaining what has prompted me so to do. It has often occurred to me that there was a great similarity in many respects between our quartz reefs and the lodes I had seen in the St. Just mining district, Cornwall. But what more forcibly drew my attention to this subject was a letter which appeared some time since in the *Cornish Telegraph* from the late much-respected Captain Truran, of Ding Dong Mine, relative to some peculiarities of lodes which he had observed, such as the sides of lodes, or some portions of them, being polished and striated, &c. I may state that exactly similar circumstances to those he mentioned occur in our reefs or quartz lodes of this district.

My object, therefore, is to give what little information I can with reference to the formation of these reefs and some of their peculiarities, believing it possible that you might look on your lodes, in connection with our quartz reefs, from a new point of view. Should I succeed in this, if there is any analogy, there is a remote chance that some light may be thrown on their origin.

I will now proceed to give a few particulars concerning this gold-field from notes I made some years since whilst a resident there. The Bendigo gold-field is situate in what may be considered a large basin, formed by rounded hills composed of Lower Silurian clay-slates, through which run the gold-bearing quartz reefs. From the extensive denuding of these hills were derived those fabulously rich deposits of alluvial *débris*, and detritus discovered in the gullies. These gullies have been worked over and over again in a manner very similar to your streams for tin ever since the opening up of this gold-field in 1851.

The palmy days of alluvial mining have, however, passed away, and the alluvial miner now makes his £2 or £2 10s. per week only, by very hard work and long hours. The importance of this district has for many years depended increasingly on quartz mining.

Bendigo Creek, which runs through the centre of the basin above-mentioned, takes its rise near the Big Hill, one of a range of hills which run irregularly to the north-west, and is a portion of one of the many spurs thrown off from the Great Dividing Range which runs across Victoria from east to west. On this creek, and about six miles from its source, is situate the town of Sandhurst. The granite of which the Big Hill is composed is of a translucent bluish-white quartz, very little felspar, and mica in minute particles. It is an extremely durable rock to all appearance, and has been extensively used in the construction of the railway bridges, &c., in the vicinity of Sandhurst. In comparison with the granite of Lamorna quarries, I should consider it to be much finer grained.

In the immediate neighbourhood of the granite, *i.e.* within three miles, the clay slates and sandstones are of a firmer texture than further East. The gullies have yielded many large nuggets, some of them exceeding 100 ounces in weight; in fact, the gold is generally what the miners term "shotty," or "heavy gold," and consequently is found near its original source, the finer gold having been carried farther down the valley. The quartz reefs really deserving of the name are very few, the quartz occurring as a rule in irregular spurs or veins varying from one foot down to one inch in thickness or less. Small veins, the width of which would be from about one to three inches, I have seen extremely rich, insomuch that they might be considered veins of gold rather than veins of quartz (of course, the quartz predominated); but these veins have no regularity either in their direction or continuance of gold or quartz.

From between these three miles of hard crystalline strata and Sandhurst township occurs a softer formation, in which are found some of the richest reefs of this colony, and perhaps of the world. The average bearing of the strata and reefs is 23° West of North. The outcrop of the slate and sandstone is often taken as a guide by persons travelling in the bush. Its use in this respect is not confined to the neighbourhood of Sandhurst, but is general in a large portion of the colony. These slates and sandstones are of the Lower Silurian age, the slates containing graptolites in great abundance.

In September, 1863, I forwarded to the late Dr. Couch, for your Society, thirty-two specimens of minerals and fossils, which, I have reason to believe, were delivered. These will illustrate some of the fossils, &c., which are found on the Bendigo gold-field and in the neighbourhood of Melbourne. Among those from Sandhurst were Didymograpsus Murchisonii, D. Sextans, Diplograpsus Folium, &c.; specimens of slate and sandstones, and of the slate immediately adjoining the reef or lode; of slate and sandstone, showing the lines of deposit and lines of cleavage crossing each other; specimens of quartz; and antimony and quartz from the antimony reefs near Heathcote, about thirty-five miles South-East of Bendigo. These antimony reefs are worked for gold and antimony, the antimony being of secondary importance.

The water-level in the quartz reefs varies in depth with the rise or fall of the surface, but in the gullies it was usually met with at about seventy feet in depth. I refer to it as in the past, in consequence of the numerous pumping-engines having destroyed the original level. The water is brackish, and not fit to be used in engines.

Beneath what was the original water-level the slate and sandstone quickly alter in colour, from the soft brown pink and muddy yellow to a dead heavy-looking grey and slaty-blue. At a depth of 200 feet, the major portion of the strata, or country, beyond a few feet from the reef, consists of an extremely hard metamorphic rock, with here and there a band of softer slate.

Both slate and sandstone in the vicinity of the reefs contain isolated cubes of iron pyrites, and frequently faces of slate of great extent are covered by them. About 50 feet east of the Johnson's Reef, and at a depth of 140 feet, there is a stratum of these cubes (size $\frac{1}{16}$ of an inch) held together, or cemented by slate, at least two feet in width. I should judge the proportion to be two-thirds iron pyrites. This is considered a good indication of the vicinity of quartz, and might be called "kindly country."

Below the water-level these cubes of pyrites are in good preservation; but above, near the surface in the lighter coloured strata, usually the only sign of their having been, is the empty cubical impression of them in the slate or sandstone, in which they have been imprisoned and have been decomposed by the ever-varying supply of moisture. Surrounding each of these empty cavities is found a red or reddish-brown stain.

In the country, or strata, the pyrites occur as a rule in isolated cubes, but in the quartz reefs it is very often observed to be massive.

Both slate and sandstone contain large quantities of whitish mica. It is also frequently found in the cavities and laminations of the quartz reefs, and is very deceptive, from its close resemblance of gold by candle-light (underground).

The mode of testing it, made use of by the miners, is through its refractive powers. From the peculiar flat form of mica it reflects light only in one direction, whilst gold reflects the same shade on all its sides. In mining phraseology, when the substance under observation will not "stand the light," it is decided not to be gold, and any one can decide with certainty which is gold and which mica after a little practice and observation. Of course, under the light of the sun this doubt is less likely to occur, but the above remarks hold good in this case also.

Mica throws off a silvery-grey; light gold generally a deep and rich yellow; but there is also what is termed "pale gold" of a much lighter colour; and again, a third form, "ruddy-coloured gold," which appears to be coated by copper. When cut with a knife, this ruddy colour is seen not to prevail through the gold, but only on its surface.

The strata immediately adjoining the reef, on each side for about six inches in thickness, are quite altered in appearance. Above the water-level it is called the "ironstone casing," from its colour and weight. It is of a red ochre, or brick-colour, and its weight about three times that of the slate or sandstone against which it abuts. This casing is gold bearing. In former years, the early days of quartz mining, the casing of the reef was broken separately (from the quartz), and thrown away with the mullock, or rubbish, on the burrow. The term used by the miners for breaking the casing in this manner was "stripping the reef."

This operation is always a tedious one; for it is usual to take only the outer portion, leaving about one inch standing against the quartz; this, combined with the extreme hardness of the casing, which was found to blunt the picks and gads as fast as breaking the quartz, made me often think there was little economy in separating them, although the price of crushing at that time ranged from 25s. to 35s. per ton, and the carting to the machine about 5s. more. I had another reason, and that was my having observed that between the casing and the reef (or the face of the quartz adjoining the casing) was often the richest portion of the reef, and consequently stripping the reef was a work which required either great care and judgment or a loss of much gold.

As a proof of the large amount of gold that was thrown away in this manner, I may mention that all the old mullock heaps, or burrows, which were about the shafts, have been crushed, and that they very frequently yielded handsome returns.

I think it probable that this altered slate, or casing, and the peroxide of iron which is found in such large quantities between the divisions of the quartz, have been formed by the same operation, viz., from the water percolating through the reef being laden with the decomposition of iron pyrites in the upper portions of the lode. I feel more confident in making the above statement with reference to the formation of the peroxide of iron, from having observed in a level through which water from a reef had been flowing undisturbed for many months, that the portions of slate over which the water had passed were covered by a red deposit of about the eighth of an inch in thickness, and that this deposit had, I might almost say, precisely the same flowing lines as those so commonly found in the peroxide of iron formed in the natural divisions of quartz reef, the only apparent difference in the lines being that those deposited in the level were less waved. This, no doubt, would be caused by the greater strength and power of the constant stream flowing over them.

Below the water-level the iron-stone casing disappears, or is changed into a soft black clay-slate, frequently containing brilliantly-polished faces, which, on being rubbed, stain the finger in a somewhat similar manner toplumbago. I have seen miners, who had been working in this casing, look almost as black as they would have if they had been working in coal.

Quartz reefs, I may say, are entirely formed of quartz; the quantities of iron pyrites, galena, manganese, felspar, mica, and gold, &c., contained in them bearing but a very small proportion to it. And more especially the latter-mentioned article—gold, for I never heard of any miner grumbling at its excess, although it has been found in what I have heard Cornishmen call "great thuds." The gold that called forth this remark was found in the Energetic

Claim, North Victoria Reef, just about the original water-level, and the greater portion of it was covered by a coating of peroxide of iron. The gold in this case occurred in the cavities of the natural division of the quartz.

The common term expressive of the shape of the upper portion of a reef is "saddle-formed." Reefs vary very much in their width, but the average of the principal and most permanent ones is about three feet.

Quartz in the cap of a reef I have known to exceed 23 feet in thickness, and to be of sufficient richness to work the whole of it (in Latham and Watson's claim, Hustler's Reef).

On the Victoria Reef, in the old Albert Company's claim, I saw a cross-cut driven through a body of quartz, which I measured to be between 60 and 70 feet in thickness, from one wall or casing to the other. This large body of quartz was very coarse and poor, no portion of it being payable. I have no doubt that it was the cap of the eastern and western Victoria Reefs, two of the richest reefs in this district.

"Quartz boils," as the miners term them, of nearly as vast a size, are, or were, to be seen on the New Chum Reef, the Windmill Hill, the Sheepshead, the Hustlers, and many others, but have been found to be too poor to work; only occasionally have the two or three feet next the casing been found to be payable. The Victoria Reef attained an immense width in the Endeavour Company's Claim at 200 feet in depth, being 40 feet in thiekness. The average yield of gold for this width was one ounce per ton, but this is an exceptional instance.

The back of the reef (behind the casing) as a rule we find to be formed of sandstone and the footwall of slate. The back frequently presents the appearance of having been water-worn, just like the smooth faces of the rocks on a sea-shore.

The quartz about the cap of a reef has no regular structure, but it is merely a great mass of hungry-looking quartz, containing but little gold or any mineral; yet as we get deeper and farther away from the saddle of the reef, the quartz decreases in width and assumes a laminated formation.

The laminæ run parallel to the walls of the reef. On fracturing a piece of quartz with one of these faces, it would, as a rule, be found to be partly covered by slate, iron pyrites, galena, and gold.

Galena appears to be a most kindly mineral for gold; for most rare is the instance of any reef containing it, which is not found to contain gold, and that, too, in payable quantities. This remark will, I believe, apply to all the reefs of this colony.

It is a generally received idea that all reefs containing iron pyrites contain gold, and I do not believe there is one reef in which iron pyrites are not to be found; consequently, all our reefs are auriferous, and no doubt they are; but unfortunately a few solitary specs of gold, or cubes of iron pyrites, will not make a payable reef.

Experience goes to prove that the richer the reef is in minerals the richer it is in gold, and *vice versâ.*

It is a common circumstance to find gold intimately associated with iron pyrites and galena for the very best of reasons; viz., that by far the largest quantities of these minerals are found to occur in the laminations. I have often seen gold and pyrites so mixed that I could not discern where the junction was. Auriferous pyrites sometimes so nearly assume the colour of gold that at a glance one is apt to say that it is pure gold, but on closer inspection the difference is easily observable; for it presents too brassy a look. At the same time, pyrites and gold seem to stare at you from the same spot, separately, and yet in one. In a specimen contained in the auriferous quartz collection of the Mining Department of Victoria there is a cube of decomposing pyrites of a dark colour, through which traverse tiny veins of gold distinctly visible to the naked eye. This specimen is No. 266, and is described in the catalogue presented to your Society. It was extracted from the Victoria Reef, Sandhurst, at a depth of 200 feet, the depth of the water-level being 150 feet.

I have very often seen gold traversing galena in a similar manner to the instance above referred to. This is owing more, no doubt, to the greater difference between the colours of galena and gold than in pyrites and gold, and not to its being more frequently the case.

Perhaps the best proof I can give you, in lieu of the specimens themselves, in corroboration of the correctness of some of my statements, will be to refer you to the catalogue (which I have already cited) of auriferous specimens in the collection exhibited by the Mining Department of Victoria at the late Intercolonial Exhibition, held in Melbourne in 1866 and 1867. In this catalogue you will find specimens of quartz from all the important reefs and gold-fields of this colony described, together with a large amount of valuable information which has been collected by the mining surveyors and registrars' officers of the department, under the direction of Mr. R. Brough Smyth, Secretary for Mines, Melbourne.

The general strike of the reefs is northerly. At nearly right angles to the strike, both the quartz laminations and casing are striated, caused apparently by a gradual motion and attrition of the strata. These lines do not show themselves in isolated spots only, but generally throughout the reefs.

They are well marked, and run in an uniform direction, as above stated. In no case have I observed these lines more distinctly displayed than in the Williamson's Reef—a thin, small, but most regular reef. Where the quartz had been reduced to between two and three inches in thickness, it was composed of what might be called corrugated quartz. The laminations were only about the sixth of an inch distant from each other. This peculiarity I found to obtain for over 200 feet in length, and it gave the reef the appearance of having been deposited in a like manner to the adjacent strata.

Of course, this quartz would naturally fracture with its laminations; and when so broken, it presented a dry, unkindly, pale appearance, possessing no minerals or variations in colour. I need hardly say that we found no gold in the reef whilst it retained these characteristics. But in the short length of twelve feet it would burst out into a width of about three feet, composed of a pure white, fine, rubbly, and unlaminated quartz, containing the usual minerals, and yielding as much as twelve ounces of gold per ton. This reef was most regular in its bearing and underlie (eastern).

West of the Williamson's Reef is the Sophia (western underlie), which proved to be rich, the first crushing from it yielding over ten ounces of gold to the ton, but I never saw a more wayward vein. The strike of this reef was northerly, and about two feet in six feet. This could be most distinctly seen, in consequence of the reef taking a sudden bend, and running off to the west in an undulating, graceful manner, not much admired, as you may readily conceive by the mining manager, when I tell you that with every wave it decreased both in size and richness, as if bowing itself out of sight, which it eventually did in the roof of the drive put in to follow it. Whether it went away to surface again I never knew, nor am I aware that it was ever tested in its vagaries any farther than when last seen by the then manager, whom I may perhaps just as well inform you was myself. The back of this reef, as is usually the case, was composed of sandstone. Between the sandstone and the casing we found a little highly-polished slate. The sandstone was irregularly rounded and very smooth, and looked as if it had at one time been exposed to the wearing influences of water. When the reef ran away flat, it carried the sandstone with the margin of slate still on its back. In the contorted portion of its course the quartz was thickest, and richest, in the hollows of the bends; in fact, they seemed like small inverted gutters.* The lines of deposit in the slate of the footwall followed, or ran parallel with, the undulations of the quartz line for line with wonderful accuracy. I am enabled to state this from the circumstance of this being the first instance in which I saw clearly the planes of cleavage running at right angles to the lines of deposit. (These lines were most distinctly and beautifully defined, in consequence of the strata being composed of thin layers of a very dark blue and a white slate.) I, therefore, paid very minute attention to everything connected with the reef and the strata in its vicinity, making it as much as two or three visits daily, in order that I might see the slate adjacent to the quartz as it appeared freshly broken. This slate contained a fair sprinkling of very bright and perfect cubes of iron pyrites of uniform size, being nearly the sixteenth of an inch square.

I have found felspar in the Victoria reefs, and have in my collection the best specimen of it that I have as yet seen. In this specimen fine crystals of felspar occur on a crystalline face of quartz. I had a very beautiful specimen of small delicate crystals of fel-

* The name given to the deepest and richest portion of auriferous alluvial deposits.

spar held together by gold, which was found in the same reef. This was the only instance in which I ever saw gold in felspar.

I have noticed in the Johnson's Reef that where the reef ran out in a wedge-like form, its place between the walls of the reef was supplied by a formation of slate, very thickly studded with fine cubical pyrites, until the quartz again forms and takes up its rightful position.

A similar formation to the above occurs in the Great Extended Coy's mine at Eaglehawk, which has proved to be very rich, yielding by the ordinary method of crushing alone as much as 5 ozs. 12 dwts. 12 grs. of gold per ton. On the Johnson's Reef the formation showed evidence of being laminated, as if it had been deposited in a similar manner to slate: the laminations were parallel to the strata on each side.

The lava-streaks (local name) or dykes present us with some of the most singular features in connection with quartz mining. They are composed of a soft amorphous clay, and have a dioritic appearance. They vary much in colour, from a dull, heavy, absorbent brown to a bright yellow or green, the yellow often forming a band on each side of the brown centre. Both the yellow and green I have often found to be striated, and to have polished faces. They consequently have the appearance of being partially laminated, but are not so in reality.

On all the main lines of reefs these lava-streaks have been met with, but are rarely welcomed; for at their junction with the reef they materially affect it, either by cutting off the quartz abruptly or by destroying its regularity, and rendering it thin, poor, dry, hungry-looking, and much mixed with foreign matter.

In an oval shaft, sunk on a lava-streak on the Victoria Reef, I observed that, through the lava being softer than the adjacent strata, it had crumbled away; that permitting its tortuous course, as it ran across the shaft, and back again, in about every 20 feet of depth, to be distinctly seen.

But the general direction it observed, *i.e.* its underlie, if I may so call it, was very true. At the surface this lava-streak entered the shaft on the western side, making its exit out of the shaft on the eastern side at about 170 feet in depth. At 200 feet in depth it intersected the reef, and completely destroyed what had up to that time been a well-defined rich reef of from two to three feet in thickness.

On the Johnson's Reef a lava-streak, underlying west, cut out one reef at the top, and, at a greater depth, another at the bottom. I thought it very probable that these so-called separate reefs were originally one and the same, which had been displaced at the time of the intrusion of the dyke, or lava-streak; but this is merely conjecture; for I had not, at the time of my visit, any leisure to examine this interesting fault. At a still greater depth, on the course of this lava-streak which was sunk on for communication between two levels, it was found that a number of quartz spurs, underlying east, intersected it, and formed a large reef on its back, and thus accompanied the lava-streak on its course as deep as it was then prospected. This last feature rendered these lava-streaks more incomprehensible to me than ever. They certainly appear to have a very close connection with quartz reefs, and, from my experience of them, may be followed as infallible guides to the reefs, which at the same time would afford very easy sinking.

The contour of the hills of this district can, I believe, be accounted for by the form of the quartz reefs. Viewed from the north or south, they are rounded and almost always gently sloping. From the east or west they may, in a measure, be considered to be serrated, or saw-formed. Each hill has a length or breadth, the bearing of the length being similar to that of the reefs, about 50° west of north the slopes from the summit to the north being very gradual; whilst to the south, in comparison, they are abrupt and precipitous. You will observe in the longitudinal sketch-section of reefs forwarded herewith that they have a general strike to the north. On the tops of the north slope of the hills the quartz reefs are generally found to crop out on the surface, and, as a natural consequence, being harder than the country in which they are situate, offer greater resistance to the denuding elements. On those ranges in which the quartz does not crop out, as a rule there will be found the ironstone casing or "burnt sandstone" of the miners, which is extremely hard, and offers just as much resistance to denudation as the quartz itself.

From the top of the hills to the south the "crown" or "cap of the reef" is broken through, and the strata, or country beneath it, is exposed without any protecting cap, and so is the more readily acted on, and presents a bolder declivity.

In the early days of this gold-field, before quartz mining was commenced, fine tors, or immense bodies of quartz, occupied the summit of nearly all the hills, and must naturally have added very much to the picturesque appearance of the then wooded country. And as the face of the country got cleared of the timber, they must have stood more boldly out, breaking that smooth, even rounded, appearance which the hills now have. I am informed, from reliable sources, that in those early days when quartz mining was not dreamt of by the majority, it was the usual pastime of the diggers on Sundays to take hammers, go up to these beautiful outcrops, in most of which gold could be seen, and break out specimens.

The only remarkable one of these which I recollect stood out on the north side of New Chum Gully. The sole reason of its not having vanished like the others before the advance of the Anglo-Saxon race must have been its exceeding poverty. I have often watched it, when passing near, with a jealous eye, fearing that some speculative miner would, notwithstanding its poverty, be sufficiently enterprising to peg off the ground on which it stood, and eventually destroy the last of the race of quartz outcrops left on this field. But it was destined to be placed on "the roads"—a rather ignominous term in this colony;

and I must own I was sorry indeed to find that such was to be the case. On the morning of the 26th August, 1862, to my surprise, I found some men had commenced boring operations, prior to blasting the quartz; they proved to be road-contractors, who were about to make my old friend into road metal, and, as I could not prevent them doing so, I decided on doing the next best thing, viz., making a sketch of it as it then stood. At the present time there is scarcely a vestige of it left. Its dimensions, as roughly measured by myself, were—height, 20 feet; length, 36 feet; width, 4 feet 6 inches; underlie east, about 1 foot 6 inches in 6 feet. These outcrops were slight evidences of the immense denudation the face of this district has suffered in past ages.

In bringing this paper to a conclusion, I would beg to draw your attention again briefly to the facts before stated, that all our reefs in this district are of a laminated structure, *i.e.* a little below the cap of the reef; that in these laminæ most of the gold and minerals are found, in addition to slate, mica, and sometimes felspar, and that it is my belief that such is the case throughout the reefs of Victoria. (In making this remark it will be as well that I should state, that although my experience of quartz mining has been gained in the Sandhurst district, I have examined and described good average quartz specimens from every other mining district in this colony.)

The reefs of the Sandhurst district run parallel to the adjacent strata, and the upper portion of every reef terminates in a cap, or, I believe, did so prior to its being denuded of it, so their formation has the appearance of an inverted V. At more or less distance, directly beneath the upper reef, another occurs, so far as I have observed, totally distinct and separate from one another, and this supposition holds good to the greatest depths as yet proved in this district.

The quartz of nearly every reef is striated in its laminæ, or on its sides.

The slate and sandstone adjoining the reefs (and sometimes the reef itself) have, more or less, polished sides. These phenomena appear to be evidences of a consistent and regular movement in the strata in which our quartz reefs are situate.

I may state that I am a mere gatherer of such facts as are presented to you, holding no special theory or theories of my own on the formation of quartz reefs.