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The Royal Society of Victoria, 134, 7–44, 2022
10.1071/RS22001

GEORGE ULRICH'S CONTRIBUTIONS IN GERMAN ON VICTORIAN GEOLOGY, MINING AND MINERALOGY (1859–1864)

Thomas A. Darragh

Museums Victoria, GPO Box 666, Melbourne, Victoria 3001 Australia

Correspondence: Tom Darragh, Museums Victoria

ABSTRACT: Translations of four German publications on Victorian geology, mining and mineralogy by George Ulrich are provided. The hitherto unknown 1859 publication is the earliest detailed account of central Victorian geology and includes descriptions of the techniques for separating gold from quartz and comments on the loss of gold in the tailings and the inefficient mining practices of the time. Ulrich also discussed theories on the origin of auriferous quartz reefs and recorded 19 minerals occurring in the quartz reefs, as well as 14 in basalts with detailed descriptions of many of the minerals. The other three publications continue the geological and mineralogical topics raised in the first with new information gathered since the time of its publication.

Keywords: Victoria, geology, mining methods, mineralogy

INTRODUCTION

Descriptions of the Victorian goldfields in the 1850s in contemporary articles and books are not uncommon; however, most were written by educated individuals, who had little or no formal training in mining or geology. Apart from a few very short accounts of a general nature written by the few who did have a background in geology or mining, there were no extensive scientific or technical accounts written in English until the 1860s, when more substantial, though limited, accounts were published as essays associated with the exhibitions held in Melbourne in 1861 and 1866.[1]

As late as 1859, the Austrian geologist, Ferdinand Hochstetter (1829–1884), commented on the reluctance of the Director of the Geological Survey to publish accounts of the geology of Victoria as known to that time.[2]

The most comprehensive account of geology and mining in central Victoria was first published in 1859, but not in English. It was written by George Ulrich (1830–1900) and published in 12 parts in the German mining periodical *Berg- und Hüttenmännische Zeitung* from January to June 1859. This publication does not seem to have made its way to Victoria and as a consequence Ulrich's work was completely unknown to, and overlooked by, Australian geologists. I can find no publication in which it has been cited.[3]

Ulrich's account describes the bedrock geology and associated mining, as well as the igneous rocks and the minerals found in them and the quartz reefs. He had intended to describe the alluvial rocks, but this part was never published, though two further accounts were published in the same journal: a short extract from one of his letters in 1861 and a short account of later discoveries in 1864. These three accounts, as well as a letter to Hochstetter published in 1861 which complements the others, have been translated and presented here.

George Ulrich was a graduate of Clausthal Mining Academy in the Harz mining region of Germany. At the time when he wrote these four accounts he was employed as a geologist on the Geological Survey of Victoria.[4] He had worked on the Victorian goldfields since his arrival in Victoria in 1854 and so was well qualified to make comprehensive and detailed observations on Victorian geology and mining, as can be seen from this translation. Though his account is now well out of date, it is important in outlining the prevailing knowledge of local geology and the thinking of local geologists, as well as stating contemporaneous theories on the origin of gold. Of greater importance are his descriptions of the mines and their workings at that early time in the development of the Victorian goldfields, before mining on a large scale destroyed traces of earlier operations.

Ulrich was the only Victorian scientist to take an interest in mineralogy prior to the 1890s and to publish in detail on mineral species with classical descriptions and in some cases illustrations of mineral crystals. Ulrich's first paper on the subject was published in Melbourne in 1857 on pharmakosiderite (sic) (cube ore) and scorodite from Tarrengower. In his 1859 paper he describes 19 minerals from quartz veins, as well as recording other minerals, including gemstones, found in Victorian igneous rocks, with 14 described from the basalts. Thus his 1859 paper is a major original contribution to Victorian mineralogy. It is also significant in revealing Ulrich's theories on the origin of auriferous reefs and also his ideas on methods of extracting gold from quartz.

Having been brought up in Germany, which had a highly regulated mining industry to ensure efficiency and to prevent wastage, Ulrich was horrified at the unmethodical manner of working and the laissez-faire attitude to mining in Victoria, resulting in waste of time, money and lives.

Ulrich sent his 1859 paper to his former lecturer Friedrich Aldolph Roemer (1809–1869) for publication. It had been drafted at some time in the first half of 1858 to allow time for it to reach Europe to be typeset and have the first part published in January 1859.[5] There are several errors in the spelling of place names throughout the paper, probably owing to the German typesetters misreading Ulrich's handwriting when dealing with the unfamiliar names. These are usually obvious and the correct spelling is included in square brackets. In a few cases a guess has been made as to the most likely name.

CONTRIBUTION TO THE MINING AND GEOLOGICAL KNOWLEDGE OF THE GOLDFIELDS OF VICTORIA*

By George Ulrich from Zellerfeld, at present Assistant of the Royal Geological Society at Melbourne.[6]

***Berg- und hüttenmännische Zeitung* 18 (1859):**

* We are indebted to the kindness of Bergamtsassor F. A. Roemer at Clausthal for this essay, under whose direction the author had previously made geognostical studies. The Editor.

No. 4 (24 January 1859), pp. 26–27.

While trying here to give a succinct survey of the most noteworthy matters relative to the mining and geology of the diggings, it is necessary to have some statistical notes precede it for the understanding of particular points. I forgo relating anew the first history of the goldfields, the romantic circumstances of their discovery, the social turmoil, gold fever &c, these points having already been made the theme of many good publications, of which those of Messrs Phillips, Westgarth, Eades and Wathen[7] are probably the best known. In addition, *The Golden Colonies* by Wathen (London, 1855) allows another very good insight into the economy of Victoria.

As on any newly opened mining field, the first place rarely remains the only one on which the underground riches are developed. On the contrary the most careful exploration after new traces of the mineral ensues and as a result fresh discoveries mostly pay off, so we see this on the goldfields here probably on the grandest scale. With a diggings population of 180,000 souls, of whom on average 100,000 are always occupied with gold digging, it should not be surprising if the desire to make a good find causes new places to be tried daily and causes searching for other localities similar in position and form of the surface to the old rich diggings, whereby renewed success is not long in coming. The most inaccessible mountain regions, the steepest of terrains show the efforts of the diggers by small shafts and tunnels and one finds even places already abandoned as completely worked out, where it is scarcely to be comprehended how the people could exist with lack of water and obtain the gold from the wash stuff.

Generally every year since the first establishment of the goldfields, new large gold localities have been found, of which those since 1853, Tarrengower,[8] Avoca, Maryborough, Alma, Fiery Creek, Linton, Dunolly, Mount Ararat and currently Pleasant Creek are the most prominent. Quite recently the latter two places experienced a march through of 60–80,000 people and magnificent treasures were taken from a good many claims there. With the reports about such discovered riches becoming known overseas, it is now quite natural that a generally favourable opinion of such a rich gold country formed. Many even believing with the greatest certainty every gold digger must become either very rich soon, according to the prevailing expression 'make his luck', or surely at least do very well. The falseness of these views will easily become clear by the following facts. According to the government reports, the gold returns of the year 1857 amounted to 2,757,047 ounces of gold or to the value of £11,028,188 Sterling; the average number of 100,000 diggers divided into this sum gives somewhat over £110 Sterling per man as total yearly income.[9] Now sustenance, clothing, accommodation &c according to the local prices cost at least £60 Sterling per year, and the outlays for miner's tools, the moving from one place to another &c are hardly brought to account. Therefore in the most favourable case there would be scarcely £1 Sterling remaining over as weekly earnings. If one compares with this the day labourer's pay amounting to £1¼–1½ Sterling, including board and lodging, the unprofitability of gold digging already attracts attention without needing to take into account the inconvenience of house-keeping for oneself and in many cases very difficult and hard work.

This calculation is based on the assumption of an average return, the true position of the matter is somewhat as follows: of the assumed number of 100,000 diggers, approximately 1000 make excellent yearly earnings and another 3 to 4000 owners of machines make a good wage, as it emerges from a comparison of diggings reports. Now if one assumes that close to 10,000 diggers work for the machinists or larger rich companies for good pay and that among the remaining 85,000 gold seekers likewise there is an equal proportion between good and bad earnings, it becomes clear why in spite of the large gold yield such a general and bitter poverty can prevail, as even the most superficial observer will perceive in a tour of the goldfields.

When sums, such as the nugget of 140 pounds weight = £7000 Sterling recently found in the Kingower diggings by four men,[10] or such as the yields of the rich gutter claims in Ballarat usually varying between 1500 and 3000 ounces and to be divided among eight men, as well as the rich proceeds of some of the claims in other goldfields, that are divided among few persons, are subtracted from the total yield, then the average earnings for a large number of those remaining in consideration must inevitably become smaller and smaller. From this standpoint it is obvious why just in the years when many excellent gains of individuals or smaller companies were obtained, the yearly gains and worker numbers still tallied with the earlier, a relative greater poverty among the diggings population prevailed than in the times when the earnings were made more equally.

Figure 1a: Blanche Barkly nugget as depicted in *Melbourne Punch*, 3 December 1857, p. 3.

Figure 1b: Model of Blanche Barkly nugget (65 x 25 x 14 cm), registration number BM.81630. Courtesy The Trustees of the Natural History Museum, London, All rights reserved.

No. 5 (31 January 1859), pp. 35–36.

In regard to the cultivation of the land, the Colony of Victoria is still well behind the neighbouring colonies South Australia and New South Wales. The city of Melbourne has certainly changed in the short period of six to seven years from a poorly built, dirty town of 20,000 inhabitants into a city of international trade endowed with palatial dwellings and fine public buildings and parks with nearly 100,000 inhabitants. Railways and telegraph lines are opened in the neighbourhood of Port Phillip and factories of every kind are in operation. Nevertheless if one goes only a few miles into the interior, sombre, uncultivated stretches of pristine forests appear. A distressing situation for Victoria would certainly arise in the case of the sudden cessation of work on the diggings or in the case of large failure in the Australian or foreign wheat lands, because the main source of food of each colony, farming, has been so very much neglected. Whilst the above-mentioned neighbouring colonies are so far advanced that they produce all that is necessary for their own requirements and still can export large quantities of wheat and fruits to here, there are now only 179,982 acres of Victoria's 50 million cultivated so far that their produce would scarcely extend to keeping only the eighth part of the colonists. The principal blame for this great failing is ascribed to the impractical land law, which offers a chance to become a land owner only to the rich capitalist, the money man. With the exception of building sites in towns or localities, pieces of land smaller than 300 acres, usually 650 acres (1 square English mile) are seldom offered at Government land sales, at which the Government sets various prices with regard to the position of the relevant piece of land. The lowest price is £1 Sterling per acre. Therefore it is obvious that it must be already well off people, who can purchase such a tract of land at the adopted cheapest price and then can change it into a productive condition. The less well off farmer is a mere plaything of the capitalist. Either he has to pay a very high price for a desired small piece of land or he is compelled to lease it from the speculator for a certain time. With great effort and work the virgin forest is transformed into a flourishing field of wheat or a garden and a good harvest permits hope for the future. Then suddenly the end of the lease period draws near and the speculative land holder has not forgotten the appointed time and heedless of the circumstances of his lessee, he either forces up the rent disproportionally high or he sells the now really valuable piece of land to the highest bidder or secretly to any high bidder, who, if he himself is a farmer, evicts the original cultivator without more ado or places such hard conditions on him that continuing is not to be thought of at all.

However, no condition derived from the land law probably hinders the rise in prosperity of our Colony more and causes greater dissatisfaction than the privileges that are given to the rich squatters (colonial expression for sheep and cattle breeders) and which they still enjoy only because they have the means, that is the money to maintain them. You see as rich influential people, they formed the largest part of the previous government — 'The Legislative Council'[11] — and thereby established their position, as one might expect, such that even the present government, a Parliament similar to the English one, could not change anything material in favour of the less well-to-do up to now, as unfortunately the squatters make up a strong party in the Parliament in consequence of wealth and influence. So now the largest part of this Colony is still to be regarded as divided into large districts called 'runs', of which each is to be considered as pasture ground either for a sheep station or cattle station. The survey of these runs occurred since the first attempt at colonisation here and the first squatters of course chose the best and the largest of them for themselves. On the Murray River, there are sheep and cattle stations of 120–150 English square miles; the smallest are generally probably not less than 30 square miles. At first the lease price that the squatter had to pay as tenant (tenant of the Crown) was £10 Sterling for a whole district; however, so large it might be, later it was raised to £10 Sterling for each 25,000 acres and until recently it consisted in addition to that sum another tax of three pence for each sheep and six pence for each head of cattle, which were kept on the pasture. At the present time, the land rent is abolished and instead the price for each sheep is fixed at nine pence for each sheep and three shillings per head of cattle and six shillings for each horse.

In the authorisation of the large grazing grounds, the Government does now reserve for itself the right of sale of the land to be exercised at any time, but because the squatters, as mentioned above, make up the largest majority of the legislative body, they entrenched and modified the old, deplorable land sale law completely in their favour, that is the sale in large areas, and in addition that for each station they got another one English square mile, naturally the best land as a so-called right of priority (Pre-emptive Right) for the purchase price of £1 Sterling per acre with certainty. They even made another recently that the whole remaining land of their extended territory be subject to a similar procedure. The outcome of their victory in this point is quite clear: it will not only be a 'minor princely dominion' with their oppression of the poor in a free colony then only in name, but also an incalculable loss for the public treasury will arise, when the bidding at public auctions is totally abolished with the payment of £1 Sterling for each acre of land.

The object of my essay does not permit this matter to be gone into further and to describe the manifold efforts which are being made both on the part of the men of the people as on the part of the squatters, by the former to frame a liberal land law, by the latter to prevent it. So much is certain that the future prosperity or adversity of this Colony depends completely on the solution of the squatting question.

No. 6 (7 February 1859), pp. 43–44.

Just as with the farmer, so also is the digger obstructed in his work in many ways and oppressed by the privileges and speculations of moneyed men. Whereas the squatter leased gold bearing land since before the beginning of the diggings and little by little purchased it, the speculator sought to buy up at such localities where it was foreseen that alluvial gold deposits or quartz reefs would occur. If now it came to be, and recently it has happened very often, that rich gold veins actually were traced under such ground, the digger either must pay for his legal area (claim) (that is in dry flat ground with four men 24 x 24 square feet or in deep wet ground 40 x 40) respectively £5–10 Sterling or the owner denies the working of the place entirely, counting on future better speculation. By this procedure he then prevents not only a major branch of industry of the population, but he also withholds that income to the state, which the latter would have raised as tax for every ounce of gold obtained. Two years ago a great insurrection of the diggers on the Ballarat goldfield broke out over a case of this kind and the government was compelled to uphold the impractical law by violent intervention and with great bloodshed.[12] The Clares [Clunes?] diggings offer a similar example: three very rich quartz reefs discovered in the very first period of the inception of the goldfields here, which, however, could not be worked profitably at the time on account of the lack of good machinery, were bought secretly from a large piece of land by a crafty capitalist. Now recently, ignorant of this purchase, the diggers, who knew the richness of the reefs from earlier, got ready for fresh working with the aid of sufficient machinery, when suddenly they were harassed by that speculator with a demand for compensation. This unreasonable demand came unexpectedly; the diggers doubted the right of possession of that man and the latter, angered about this, completely prohibited the working of the reefs, although their near surroundings is totally unsuitable for agriculture or other purposes.[13] Even here the government was compelled to stand up for the obstinacy of the individual against the benefit to the many.

At present the diggings population is looking forward with great expectation to the proceedings of Parliament, as a very liberal law, so it is said, on mining on private property introduced by the government lies under consideration. If this bill really has the aforementioned character, then the clique of the squatters and land speculators, whose domineering position will be imperilled by it, will probably

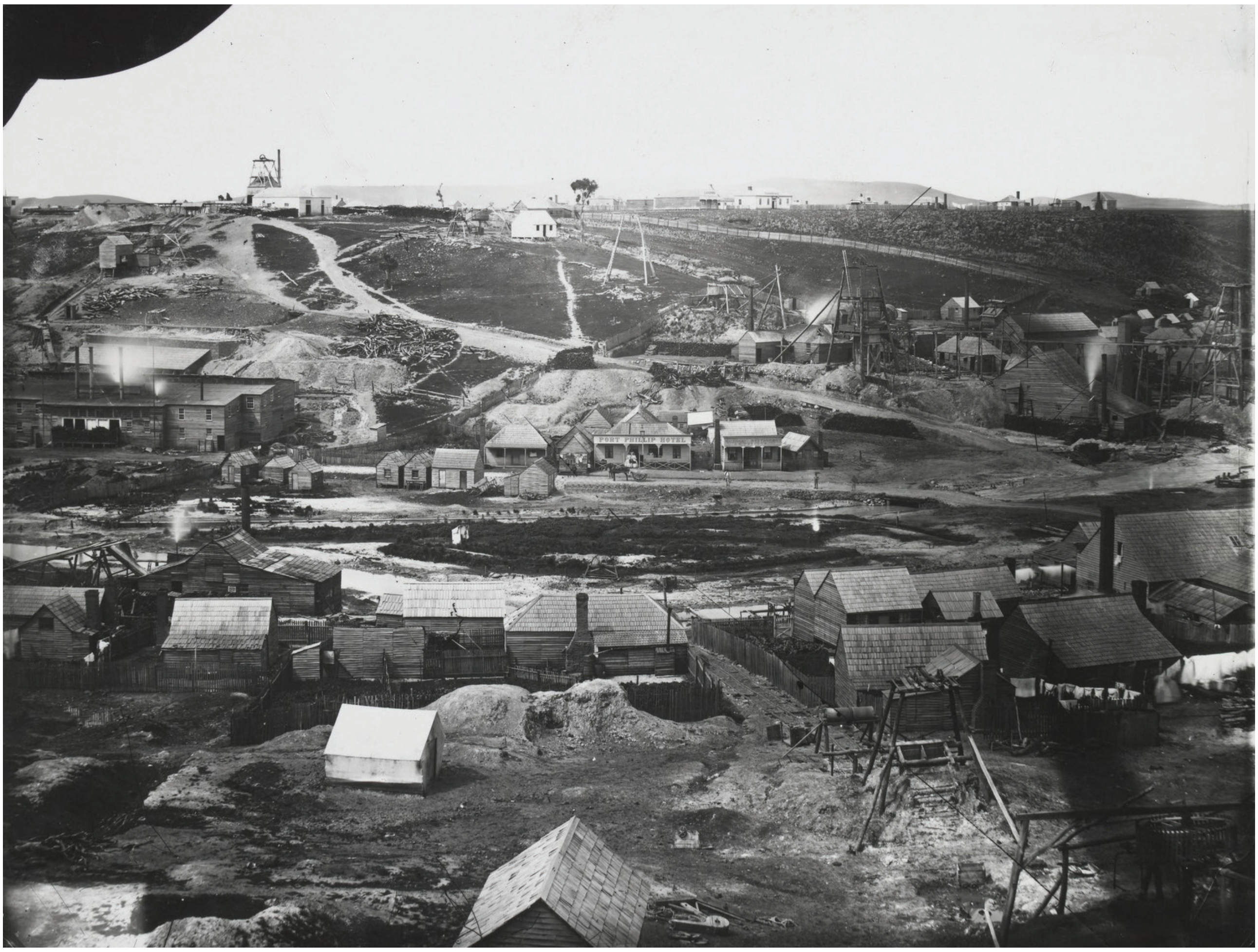

Figure 2: Port Phillip Company Mine, Clunes. Photograph by Richard Daintree about 1861. State Library of Victoria collection.

raise up a very formidable opposition.[14]

The relationship of the diggers to the government in the narrow sense is now a very good and practical one. As previously each gold seeker had to take out a licence from the Commissioner (for one month for £1 Sterling, for three months for £2 Sterling and for one year £8 Sterling) and for control the government was forced to send large parties of mounted and foot police through the diggings to take those working without a license into custody (£5 Sterling or four weeks hard labour punishment). This system engendered much hostility and unrest, so was recently changed so that the government raises two shillings and six pence (20 good Groschen) tax for each ounce of gold that is exported. This amount is already deducted from the trade price of the gold by the gold brokers and banks, so that for example if the price for one ounce stands perhaps at £4 Sterling, one gets only £3 Sterling 17 shillings and sixpence for it. This arrangement is very appropriate in so far as the fortunate and the poor diggers are taxed in proportion to their earnings, whereas previously both had to pay the same amount for taking out a licence, which of course seemed very unjust to the poor. Nevertheless the new system has something inconvenient in it, that the state cannot prevent the smuggling of gold, it not being possible to exercise adequate customs control on the border of the Colony of Victoria with New South Wales and South Australia, which are independent of one another and without a gold tax. On both sides there are still hundreds of miles of virgin forest. If a mint had been established here in Victoria, as is the case in New South Wales, that abuse would cease, not only for the most part, but also the gold would have the same value in the Colony as in England or generally in Europe. Here the ounce seldom comes over £3 Sterling 17 shillings and sixpence, whereas there it is seldom under £4 Sterling 2–3 shillings. One can only ascribe the non-execution of this plan, the advantages of which are otherwise generally acknowledged, to the particular political and economic interests on the part of the government.

The administration of the mining laws on the various diggings is exercised by commissioners or wardens, who are supported by a police inspector with a sufficient squad of men. Every digger, who pays £1 Sterling per year to the government, receives a certificate, the so-called 'miners right', the possession of which assures him the judgement and protection of the warden free of charge in disputes and qualifies him to vote in forming the Parliament. Incidentally, if he has landed property ('freehold property') to the value of £2000 Sterling and is British-born, he is also eligible to vote. Because the purchase of the miners right is not required by law, there are very many diggers who neglect to do it; however, they must always relinquish their ground in law cases, pay the costs, and keep away at elections. In his work the digger enjoys unrestricted freedom. So long as he respects his neighbour's property, he can dig for gold on Crown land and soil how and where he will, and use wood, stone &, everything that he needs for it and in addition is completely free of personal taxes or such like.

Secure regulations or mining laws, according to which disputes over ground are decided, are unfortunately not yet established here. However, in each of the larger diggings districts a certain number of diggers or other persons occupied on the diggings are elected by majority vote to the so-called 'local court', a local judicature, which, with the assistance of the warden, sets up rules and regulations suitable for the relevant district, according to which this official has to act on. It would be too much to quote here all the established regulations of this kind in detail. By and large they are very simple and what is the worst, very impractical from a mining point of view. It will suffice, if the most noteworthy of them are introduced in their mode of application in the special description of the diggings now to follow.

Special description of the diggings

Under the name gold diggings (gold mining), it is really to be understood only such places at which there was or still is seeking after gold by digging. However, this special expression for a particular work of gold extraction is here generally conferred as a name on that part of the Colony or the ground that features the principal desideratum to turn the name into action by the presence of alluvial gold deposits or gold bearing quartz reefs. It is quite impracticable to deal with and to describe the goldfields known so far successively, as unfortunately they still are not subject to a thorough geological investigation, also any good topographical maps of them are still not available at all. Therefore I must restrict myself to giving a general account of them and certainly to give facts derived through the practice of the diggers, in which anything noteworthy or different about the individual gold fields shall find its place. Setting aside the local conditions, this will be completely sufficient, because the geological character and mining of the various gold districts are the same with few exceptions and therefore a general description gives a rather accurate knowledge of the particular.

For a better overview, that which follows may be divided into three principal sections in the description:

I The ground or the bedrock on which the gold alluvium is deposited.

II The quartz reefs set in the ground.

III The gold deposits (alluvial rocks).

I. Description of the ground or bedrock.

It is divided into:

A. Plutonic and volcanic rocks: α. Granite; β. Syenite; γ. Feldspar Porphyry; δ. Basalt and

B. Sedimentary rocks.

A. Plutonic and volcanic rocks:

α Granite.

This shows the same character in its occurrence here as the granite of European countries; steep, hemispherical mountains and wave-like ridges of hills are separated by deep canyon-like valleys, and blocks, partly rounded, partly sharp-edged, are strewn in valleys and on the slopes, or are piled up into the most wonderful monuments. Its colour varies each according to its composition, that is according to red or white feldspar, common white quartz, greasy quartz, potash and magnesia mica standing out. Tourmaline, hornblende, magnetite, pyrite &c are very commonly mixed in as accessories. The first of these occurs in very beautiful crystals in the Dandenong Ranges and the three-sided prismatic form even predominates here in these ranges. At Tarrengower tourmaline is found in balls of 50–60 pounds weight, which on breaking show a concentric radiating structure. Hornblende was observed dispersed only in the granite of Mount Martha. At some places (Tarrengower), the granite shows a spheroidal rindy structure, so that large plates from the blocks can be split off around the stone by merely hitting it, which each again show a granular foliated texture and structure, containing much black mica and tourmaline and generally seem to indicate a transition into gneiss. The rock of these spheroidal blocks never appears on the surface as such, but the spheroids are cemented into larger masses of granite similar to the ball rock (Kugelfels). With respect to both the kinds of mica, a distinction can also be made between granites; however, this probably seems to occur in similar manner as the gneiss-like rock, because specimens occur at one and the same place (Mt Alexander),[15] of which some contain only white, others only black, others again both kinds of mica mixed. In all these specimens oligoclase in very small crystals is very easy to observe. Also porphyry-like granite is commonly found in the same locality. It shows a very strong tendency to weather in this modification and therefore is not suitable for building material, like other kinds of granite. So far as I know, until now only one place (Tarrengower) exists in Victoria, where it can be said that the granite is auriferous; however, this is only indirectly, as here its contact surfaces with a rich auriferous quartz vein, ½–1½ inches thick that is set in it, contain gold finely interspersed. The occurrence of gold similar to cassiterite and iron oxide occurring in the solid mass of the granite is still very doubtful.

Where the granite forms the bedrock of the alluvial deposit, it usually is weathered to a soft, fatty clayey gravel ½ to 1 foot deep, in which the gold as well as the other minerals of the wash dirt are often cemented in up to this whole depth. If specimens of such soft granite are exposed to the air, they harden very quickly and could then be considered like porphyry, in which gold, cassiterite, magnetite &c seem interspersed. Places where the granite forms the bedrock of the alluvial deposits are Tarrengower, Ovens, Steigliz, Forest [Creek], Amphitheatre, Glen Patrick, &c.[16]

β. Syenite.

This rock is known only on the Daisy Hill diggings as bedrock of the gold drifts and shows at the contact surface with the wash stuff a similar condition as the granite.[17] It outcrops massively and the slopes of its hills are like the latter strewn with blocks of the most varied form and size. Its constituents — flesh-red feldspar, dark green hornblende with little white quartz — give it a superbly fine colour that will make it highly prized for building and art works. Zircon, magnetite, titanite, rarely epidote and nepheline are intermixed. Well-formed zircon crystals are very often met with on washing of auriferous gravel, remaining behind with the magnetite and ilmenite and the gold; however, the form is only the common quadrate pyramid with prisms. The gold drift on and near the syenite (Nuggety Gully – Daisy Hill) has produced very hard gold; nuggets of 10–60 pounds were not at all rare.

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γ. Feldspar porphyry.

This is found in wide dykes (elvan dykes) in the strike of strata, similar to the diabase, and its composition and external appearance varies often very strikingly in different dykes.

A very attractive hard porphyry is found on the Denby Hill goldfield [Daisy Hill?], where it can be followed for a fair stretch ascending the slope of a hill as a 12–16 feet wide dyke, through large, rather sharp-edged and piled up pieces of rock along the ridge of the hill.[18] Its constituents are quartz, flesh-red orthoclase, dark green mica and now

Figure 3: Specimen of 'syenite'(actually monzonite) from Daisy Hill. Museums Victoria collection. Registration number E6192. Photographer: W.D. Birch.

Figure 4: The outcropping boulders of Ulrich's 'syenite' of Figure 3. The dyke is now known as Granite Hill and is 6 km southwest of Talbot. Photographer: W.D. Birch.

Figure 5: Alluvial Mining Model of the Daisy Hill, Shallow Sinkings, 1857. Museums Victoria collection. Display representing a portion of the shallow alluvial sinkings of Victorian goldfields as seen at Daisy Hill, etc. (now Amherst). Model made by C.E. Nordstrom in 1857. Copyright Museums Victoria 2008. Photographer: Benjamin Healley.

and then another feldspathic mineral, which judging from the cleavage and the striation, is perhaps oligoclase; the ground mass is a grey-green feldspathic substance. This porphyry is only at the place of the bedrock of the gold drift, where it cuts across a small gully, and here, as with the previous rocks, the surface is likewise weathered to a thin layer of gravel into which the gold has sunk. On washing, beautifully formed crystals of quartz and orthoclase are frequently found. Three to four miles from this place another porphyry dyke is met with that; however, in external appearance and in composition is so different from that just described that probably it can hardly be given the same name. It is quite free of mica, contains little quartz and the greenish-white, often quite white feldspathic ground mass is intermixed with indistinct feldspar crystals. Its hardness is so slight that it is worked loose with the greatest ease with pick and shovel. This dyke has given much loss of work and money to a large number of diggers. Running in the strike of the strata through several small gullies and hills, at one place it was the base of a rich gold drift and because during its working the gold was found deeply sunk into the bedrock and because in its gravel-like structure and appearance, it differed completely from the usual bedrock (the Silurian strata),[19] it was believed to be an alluvial drift penetrating into the dyke fissure that hid great riches on the bottom of the fissure. As a consequence the porphyry dyke was attacked on a 2–3 mile stretch; 100 and more shafts were sunk on it and useless work on it did not stop until the deepest shaft 140 feet received so much water that it would have required large steam engines to cope with it. However, on leaving their shafts the claim owners had the foresight to have them registered with the district warden, so that they could not be taken up (jumped) by other diggers in any new uptake of the supposed gold fissure. Fortunately this new attack has not yet happened and it will probably even be completely prevented when the geological survey has advanced to that place.

The neighbouring rock of the above porphyry dyke is not in the least altered in appearance, also the strata are in no way displaced in strike or dip by the formation of the dyke fissure. Would it not be possible to assume a similar theory of its origin to that applying to greenstone (diabase)?

δ. Basalt (trap).

Of all the eruptive rocks nothing has probably played a greater role in Australia than this. Not only have recent attempts to penetrate the interior of Australia established that the whole northern part at the Gulf of Carpentaria is covered with basaltic lava plains and hills,[20] but it is also known that the largest part of the Colony of Victoria, as well as the neighbouring islands (Norfolk Island, Phillip Island, French Island, as well as Tasmania and New Zealand) show a similar condition.

As far as the very precise investigations of the Government Geologist, Alfred Selwyn,[21] reach, two quite definite geological periods in which the basalts of Victoria appeared can be accepted. One is before the Tertiary, the other rather at the end of it and therefore it would be best to make the distinction into older and younger basalts. The older basalt, perhaps more correctly trap, penetrates the granite, the various porphyries, the Palaeozoic formations and the old Oolitic coal formation, but it carries younger deposits following below, which in Victoria, excluding the intermediate members, only represent the Tertiary rocks.[22] The major area that this basalt occupies here extends easterly from Arthurs Seat to Cape Schanck, as well all islands that the southern coast of Western Port encloses. In the neighbourhood of Melbourne it outcrops only in relatively small stretches, but it can be assumed that the Tertiary rocks along the eastern coast of Port Phillip perhaps hide larger masses of it and that a connection between the basalt of the first mentioned localities and that of Melbourne occurs, because an attempt to bore for coal undertaken on the coast at a distance of 29 miles from the city in the direction of Arthurs Seat reached the Older Basalt at a depth of 246 feet.

Judging from its occurrence, the basalt seems to have issued forth in mass from fissures, because its lava streams lead neither to scoria cones nor craters. From a mineralogical respect it approaches more anamesite (aphanite?), is extremely compact and tough, contains less peridote than the younger basalt and is mostly jointed in columnar form. Before the blowpipe, it melts with considerable difficulty to a black magnetic slag and gives much water in the glass tube. Various zeolites (skolezite (sic), natrolite, stilbite &c), little olivine, native iron, limonite, pyrite, magnetite, various amorphous clay silicates and rarely aragonite are found as accessory minerals.[23]

According to Selwyn the following modifications are to be observed in the Older Basalt.[24]

1. Very hard, black, mostly columnar trap, here and there interspersed with olivine and containing zeolites in cavities. Has never been observed with scoriaceous structure.
2. Layers of a very soft, brown, red or yellowish-green rock, which is either so heavily strewn with pea-sized, fusible clay silicate spheres that it shows the greatest similarity to variolite or it has a porphyritic, sometimes even marbled appearance.
3. Very abundant, decomposed, brown, often steatitic, earthy trap, full of rounded concretions of black hard basalt. These hard pieces were washed out from the soft ground mass on the coast and now lie along the water in thick layers, where with a superficial look they could be regarded as a deposit of round-washed basalt fragments.

4. A stiff white, yellow or red ochreous clay that sometimes contains large lumps of limonite. This ore is most commonly found on the coast east from Settlement Point.

If we now consider the circumstance that the three last mentioned kinds of basalt alternate with the hard lava sheets in manifold repeated succession and that even these as well as those cemented into rounded concretions show clear signs of progressive weathering at the surface, it will probably not be too daring an assumption to find different eruptions. Also to regard the abundant layers as products of decomposition that the scoria, ash and the hard sheet itself underwent in that period, which elapsed between its eruption and that of the hard covering sheet. Perhaps the above modifications are even identical to the basalt wackes of Europe, although neither here nor there is a layered structure, or any fossilisation observed in it.

The auriferous alluvial deposit is only deposited on the Older Basalt in the neighbourhood of Melbourne and there a brown, very fatty clay forms the bed of the gold or wash stuff. Nothing is known about the richness of the deposit or about the other relationships of it in reference to the basalt as bedrock, because the government does not permit gold mining at this place and the ground is also mostly sold and built on.

No. 8 (21 February 1859), pp. 62–64.

The younger Basalt.

If we look from any high point over the northeast [an error, should read northwest] coastland of Port Phillip, the wide plains covered with scoriaceous boulders and the cone-shaped hills and craters rising up from them straightaway tell us that here we have a violently developed volcanic phenomenon before us. The whole appearance of the younger basalt gives undoubted proof of enormous, often repeated eruptions of basaltic lavas, which, breaking through all other plutonic and volcanic rocks as well as the Palaeozoic and Older Tertiary deposits, flowed over the aforementioned rocks in wide streams. Many creeks and rivers of the Recent period have dug deep, steep beds through this cover and as deep gorges often show in the best way the Tertiary beds or the rather steeply dipping Palaeozoic strata outcropping under the lava. The thickness of the basalt cover varies very much. In the neighbourhood of Melbourne it is 10–30 feet; in other places it seems to go even 100 feet or more (valleys and hills of the pre-basaltic surface). Even here, as with the Older Basalt, layers of a hard, crystalline, columnar, very porous lava alternating with soft, variedly coloured, often layered strips are seen. The nature of these, however, corresponds with that of the basalt wackes and tuffs far more than with the Older Basalt. Their large content of lapilli and pumice-like masses probably admits no doubt when we regard them as the last products of repeated eruptions, which take into account the influence of the atmosphere in the quiet periods in between. The basalt hills, which rise isolated from the lava plain, show the greatest similarity to line volcanoes, because the majority of them appear following one another in lines and approximately in the strike of the Palaeozoic strata (hor. 11–12, N15W).[25] However, only the minority of them (Jim Crow,[26] Mount Elephant, Mt Napier &c) has the real volcano shape, that is they have a distinct crater at their top, the others (Mt Holden–Sunbury Hill, Mt Kororoit, Red Rock, Mt Aitken &c) seem to be partly solidified lava blisters, partly scoria cones.[27] As already mentioned, the lava plains are like a sea of rock scattered over with basalt blocks and scoria of most varied sizes and shapes and the idea involuntarily suggests itself by their appearance to attribute the origin of them less to the ejectamenta of a volcano than to a fracturing of the glowing surface during cooling. At many places in the fissures of the turf, enclosing scoriaceous fragments, distinct hexagonal sections of the underlying basalt columns are seen.

Westgarth says in his description of Victoria: ‘All volcanic hills (craters), which I have myself seen are either partially or wholly surrounded at the base by steep heaps of stones, which at many places extend over many square miles. Those mountains that show no crater, seem like large heaps of stone, formed from pumice-like and scoria-like masses. Mt Eccles is one of the most romantic and remarkable craters. Its irregularly rounded depression of 1–2 miles length by ¼ mile width and 100–150 feet depth shows in the middle at the bottom a small fresh water lake with a steep outflow several miles long and 50–60 feet wide, which through the regularity in its dimensions with windings and bends is not dissimilar to an artificial canal cut into the lava. The Warrion Hills between Lakes Colac and Corangamite consist of a number of extinct volcanoes with well-marked craters. In one of the largest of these craters is a funnel-shaped lake of several miles in circumference, whose water has a slight smell of hydrogen sulphide gas. Attractive and lush vegetation covers the sides of the crater and from the edge, apart from the huge funnel with the lake level in the middle, it offers one of the most beautiful views that I know.[28] At Mount Eccles large cavities, which are said to be still warm, and a smell of sulphurous acid can be clearly perceived.’[29]

The basalt hills offer a picturesque contrast with those of other rocks. Whereas the heights of the granite and the old greywackes are covered with the most attractive eucalyptus species (stringy bark, iron bark, gumtree &c) and with often impenetrably thick understorey, the basalt summits seldom show luxuriant forest cover. Only here and there are smaller groups of trees and tea tree conspicuous,

Figure 6: The crater of Mt Eccles, west from Mt Napier. Lithograph by Eugene von Guérard, 1858. State Library of Victoria collection.

whereas the fresh green of their various grasses and herbs brilliant in Spring, Autumn and Winter contrasts splendidly with the dark green background of the forest district and makes a very pleasant impression on the eye. However, it is the opposite in summer: a scorching sun then changes all flora into a dusty quavering yellow and the Bald Hills, like giant smouldering heaps of ashes, seem to radiate the old fire of antiquity anew. The basalt plain is terrible when the north wind, the Australian simoom, blows through it. Already impregnated with parching heat from the interior, the hot blast receives new suffocating nourishment by the blistering dust of the decomposed basalt, which it drives in large clouds towards the thirsty traveller clouding over everything. The prairie fires of America and the steppe fires of Russia find a worthy rival in the plains fires of Australia, and Black Thursday (6 February 1850) will be unforgettable to all those who experienced it.

Salt lakes also occur commonly near craters. They are remarkably shallow and usually dry out in Summer, offering large quantities of fine salt for extraction. Lake Corangamite is the only lake that retains water in the Summer. The rivers flowing into it show no outlet. Judging from their shape, the salt lakes could be regarded at best as large craters or depressions or pits produced by underground revolutions.

In appearance the younger basalt resembles some melaphyres, in which, however, the large amount of olivine, which to some extent seems to make up an essential component, gives it a porphyritic appearance. It melts rather easily before the blowpipe to a black magnetic slag and gives much water in the glass tube. With regard to the nature of its occurrence, it can be divided into the following subdivisions:

1. Hard, crystalline columnar basalt of dark blue (therefore the name 'bluestone') to black colour, at some places dense and compact; however, on average very porous. The common vesicles in it, often very large, only rarely contain well-crystallised minerals. Usually a calcareous sinter-like cast of aragonite with sugary pressings is to be observed in them, at other places more hyalite.
2. Layers of large polygonal or spheroidal pieces of basalt of concentric scaly structure, which are cemented into a white or grey tuff-like mass.
3. Various coloured masses, often seeming layered, of a very soft earthy basalt (as already described above).
4. Basalt scoria. This shows the greatest similarity to the slag of a blast furnace; however, it is rarely glassy, but has a more rough pumice-like structure that sometimes stands out so strongly that it floats on water. The vesicles of this scoria are completely free from mineral coating.
5. Laminated basalt. I recently found this very remarkable variety on the Coliban River and I must admit that

the recognition of its true nature gave me not a little difficulty. The laminar structure of this rock is so perfect and a strike and dip so markedly deceiving, but varying in all directions, that you believe nothing other than it is a somewhat darkly coloured continuation of the silky lustrous Silurian slates that you just left. Only a close examination with the lens reveals distinct crystals of magnetite, augite and labradorite in the greyish-black dense ground mass. This basalt is met with not rarely in columnar form on steep slopes and the jointing shows itself parallel with the hexagonal columns. On heating, the powder gives off very little traces of water.

Up to the present the noteworthy minerals found in the Newer Basalt are:

1. Native zinc. Although as far as I know this metal has not yet been previously found native, no doubt, however, can exist for its occurrence here. On breaking up a large boulder of basalt near Melbourne, a piece of 4¼ ounces fell out of a vugh in its middle. The labourers on breaking it out first regarded it as silver, but afterwards a blowpipe analysis made by me proved its true nature. It did not contain cadmium; however, it strongly reacted on iron. The white crust of the metal as well as that of the vugh consisted of zinc carbonate and aragonite. At one place a small peach blossom coloured fleck of erythrite was noticed. Dr Ludwig Becker gave a detailed paper on the particulars of the find and the analysis in *Transactions of the Philosophical Institute of Victoria* 1856.[30] About two months after the discovery of that piece of native zinc was published in the above paper, the same gentleman received a small piece of metal from a local assay office, which also proved to be zinc with significant cadmium content. The analyst received it from two gold miners, who had chipped it from a fist-sized piece and misled by the white metallic lustre, suspected silver in it. The find occurred on the banks of the Mitta River, four feet under the surface and the sediment there carried other small gemstones (topaz, ruby, sapphire, &c) in large numbers besides gold.[31]
2. Hyalite. Occurs rather commonly in the blue compact basalt, the hollows of which it covers in large, clear drops.
3. Pyrrhotite scattered in small crystals, often also in lumps.
4. Pyrite. Only seen in cubes.
5. Aragonite is the most commonly occurring mineral; however, good crystals are rather rare. The most common occurrences are sugar-like or snow-like soft crusts or concentrically radiating nodules and spheres, the surfaces of which are very often found covered with a thin, hardly noticeable layer of hyalite. This phenomenon easily leads to errors in so far as acid does not attack the surfaces and the mineral could therefore be regarded as natrolite. It is therefore necessary in testing to break the sphere or nodule and to treat the broken surface with the acid.

No. 12 (21 March 1859), pp. 101–102.

Some of these crystalline radiating aragonite specimens have such a similarity to scolecite of the Older Basalts that no difference between them can be noticed even with closer examination.[32] By chance I treated one such mineral from the Older Basalt with hydrochloric acid and as I did not notice any effervescence in the process, I regarded a similar looking specimen from the Newer Basalt as the same, without testing it further. However, during a subsequent test on a content of soda before the blowpipe, I immediately saw the difference and ascertained thereby the above-mentioned property.

6. Dolomite. In small rhombohedra.
7. Olivine.
8. Coccolite [diopside] (easily distinguished from olivine by blowpipe properties).
9. Sulphate of alumina with little lime, ferrous oxide, magnesia and alkalies [sic]. This salt occurs in inch-sized nodules, which on breaking show a coffee-brown colour and opaline fracture. In distinction from the well-known alunite, it melts very easily before the blowpipe; the beads show distinct traces of chromium and the hardness of the mineral is about 3. Pieces and fine powder to half of its weight dissolve in hot water. (I hope to be able to able to communicate the quantitative analysis of this salt soon.)[33]
10. Obsidian. Although this mineral is really cited as trachytic lava glass, nevertheless it is found here in large irregularly formed pieces in the decomposed basalt around Geelong. Also small cheese or button-shaped masses are not rare in basaltic gravel.
11. Sphaerosiderite. Often shows a similar hyalite coating like aragonite.
12. Zeolite. Mesotype, as is generally stated, is said to occur very abundantly in this basalt; however, I have not identified a specimen yet. All samples that I have seen so far that were regarded as mesotype proved to be aragonite with the aforementioned properties.[34] Besides those minerals enumerated so far, there are still various alumina, magnesia and ferrous oxide silicates to mention (soapstone, agalmatolite, chloropal &c) that occur in more or less large nodules and deposits most abundantly in the basaltic trap.[35]
13. Zircons. Are so abundant in several basalts in the upper reaches of the Coliban River that they get an almost

porphyritic appearance from them.[36] If granular, green augite with small white labradorite crystals form the ground mass, as often is the case, the rock can hardly be regarded as basalt, if its thickness defined by a variable number of feet did not indicate its true nature as a lava stream that flowed over Palaeozoic or Tertiary strata. In the younger alluvial deposits on the slopes of such basalt cover (escarpments), the zircon occurs very abundantly on washing of the sand. Its crystal form is mostly a double four-sided quadrate pyramid with prisms; other faces are very rare. Nearly always washed out together with it is:

14. Ilmenite (menaccanite) in granules similar to iserine up to gun powder size with conchoidal, highly lustrous fracture. This iron ore is scattered through the upper sandy layers of the younger Tertiary, often in ½–2 inch thick layers and black streaks and at first it is hard to comprehend how its weight would not produce a deposit on the bedrock. However, if the stuff is examined closer and closer to the basalt escarpment, it occurs even more on the surface and finally with closer investigation is found interspersed throughout in a thin weathered basalt layer developed between the porphyritic basalt.

After enumerating all these details of the appearance and mineralogical character of the Newer Basalt, the question now arises, what kind of origin did this lava have? Did it issue forth under water from large fissures, like the true trap, or did it appear on the surface after breaking through the crust in similar manner to lava today? I dare not express a particular view on this point, although, as it seems to me, the whole structure of this volcanic phenomenon, that is the craters and scoria cones, as well as the more porous and vesicular structure of the mass, are not quite analogous to the properties set out as the norm for the trap rocks. Alfred Selwyn states in one of his reports about this circumstance. 'Each crater and scoria hill can be regarded as eruption points, from which the lava flowed out and they formed with greatest probability volcanic islands in the younger Tertiary sea.'[37] From this it is apparent that this geologist does not strictly follow the accepted hypothesis for the origin of trap, but in this respect adopts a middle way that he accepts volcanoes above the sea that send their streams of lava into the sea. The gold drift divides the Newer Basalt into two distinct divisions, as it overlies the one, whereas the other is deposited on it. Without doubt its eruption stands in close association with the particular nature of stratification of both wash deposits and with the origin of the younger of them, about which section three will give more explanation. Where it forms the bedrock of the younger wash (Ballarat, Daisy Hill &c), it is partly weathered to brown sticky clay, partly it is hard and completely unaltered, whereby it offers some difficulty to the preservation of the wash stuff, because the gold often has penetrated deeply into the fissures and vughs. In respect to the quality and quantity of gold it has certainly exerted no influence, although many diggers believe this.

B. Sedimentary rocks:

Under these stand only the Palaeozic group and within this exclusively the older Silurian System is connected with the gold deposits.[38] The metamorphic part of this will probably be of Cambrian age. In general the strata become younger from west to east and their thickness, according to Selwyn, is said to amount to about 30,000 feet;[39] however, they seem even significantly thicker, because, owing to much repeated synclinal and anticlinal structures, they occupy a very large part of the Colony of Victoria. The strike of the whole system is with few exceptions north–south or between hor. 10 and 12.[40] The dip varies according to their unequal deposition between 20° and 80°.

The metamorphic rocks outcrop very thickly in the Linton and Ballarat goldfields. There dark green, silky shales alternate with green, yellow and red sandstones that are commonly penetrated by thick, often very rich auriferous quartz reefs. In both strata organic remains seem to be completely lacking. A similarity with mica and chlorite slates is also noticeable in several places and there are very commonly in such beds well-developed pyrite cubes with the sloping edge of the pentagonal dodecahedron. The places where gold is found in this rock region form mainly the so-called leads, deep gullies and valleys that are filled from 5–300 feet deep with alluvial deposits. The gold of these leads and also that in the quartz reefs that are worked is the heaviest and purest that was found so far. The diggings of Forest Creek, Daisy Hill &c show for this division far thicker beds of blue thinly schistose chiastolite slates that alternate with brown-red, mica-rich greywacke. In these latter hard, iron and quartz-bearing concretions are not rare; however, fossils have not yet been found.

The largest part of the stratified rocks, however, gives, by its well-preserved organic remains, the key in hand to assign them a more precise place in respect to their relative age. Professor Hitchcock of Harvard University (Amherst College), United States, indeed says in his *Geology of the globe* [41] that undoubtedly all auriferous, stratified rocks belong to the Azoic Formation[42] and he cites as primary proof for this the authority of Reverend W. B. Clarke of Sydney, who asserted such for the rocks of the Australian diggings, but the assistant geologist Mr C. D'Oyly Aplin from here has quickly upset this opinion, he having discovered the first graptolites and trilobites near the village of Keilor near Melbourne.[43]

Figure 7: First graptolites discovered in Australia by C.D. Aplin. Museum Victoria collection. Photographer: D.J. Holloway.
a. (top) P140088. *Monograptus* sp. Field number Ba 27, from 1.5 miles north of Keilor bridge, Maribyrnong River, near junction with creek. Collected 11 June 1856.
b. (bottom) P253. *Monograptus spiralis*. Field number Ba 39, 1 mile north of Keilor bridge, Maribyrnong River. Collected by C.D. Aplin on 11 June 1856.

As far as the very exact geological investigation of Alfred Selwyn reaches, in respect to the fossils discovered according to McCoy the distinguished English palaeontologist, there are the following divisions analogous to the strata of Wales:[44]

1. Bala Rocks.
2. May Hill Sandstones.
3. Wenlock Shales and Sandstones.

No. 15 (11 April 1859), pp. 129–130.

1. Bala Rocks.

They are most thickly developed in the diggings and show a great diversity in their lithological character there. They can be differentiated into:

a) Brown, yellow, micaceous greywacke with great variation in hardness and as a result dependent variety in appearance at the surface. The hard strata form steep ridges with sharp, narrow gullies, in which case the north–south striking thick beds usually are exposed at the surface like veins and thereby give the observer encouragement to find the way in the bush even without a compass. The eucalypts and other trees can only put down roots in the spaces between the hard beds and appear only in regular north–south striking rows as if planted artificially. The softer greywackes form more gentle rounded hills with wide, undulating gullies and in consequence of their greater susceptibility to weathering, are covered with vigorous dense tree growth. Both varieties of greywacke in general stand forth as the highest points of the Silurian and contain many very rich auriferous quartz reefs (Tarrengower). Their cleaved surfaces that commonly show a false dip, changing in various directions, offered the alluvial deposits the best opportunity to deposit the specifically heaviest constituents in the fissures and on the projections, for which the rich places on Forest Creek, Bendigo &c give ample testimony. However, it is a very laborious work, often only with the knife, to strip the deep fissures and hollows of their treasure.

b) Blue, dense slates in not very thick beds alternating with greywacke. They split easily into inch-wide sized plates that are rich in *Lingula*, according to which they perhaps are analogous to the English *Lingula* Flags.[45] On account of their easy ability to weather and clayey nature, however, they are not useable for practical purposes. They also contain many and rich quartz reefs and offer less difficulty in working them than the greywacke. In the contact with the alluvial rocks they are weathered to a sticky blue clay for some inches that contains numerous orthoceratite-like concretions and in which the gold is usually found cemented in.[46]

c) White, yellow, often bluish and pink slates (the pipe-clay of the diggers.). These strata in respect to geology form one of the most interesting phenomena of the diggings. Sandy and at the same time clayey, their aggregate condition is one so unconsolidated that they can be cut away with greatest of ease with the ordinary pick, often even with the shovel. Sometimes pure argillaceous strata alternate with more sandy strata (like greywacke slate) and then on breaking off, one observes in the former a tabular structure and in the latter a stick-like structure. If the latter slates are exposed to the influence of the atmosphere only for a short time, the individual pieces lose their shape completely, the heap of picked out mullock collapses and at last turns into a hill of compressed white, yellow or red earth that every heavy shower decreases in mass, until finally only a large white or coloured patch remains, from which runnels of sediment run out in all directions. Although this softness and the easy disintegration in water is now in some respects very troublesome e.g. for the securing of excavated spaces, the first of them, however, offers so great advantages in the recovery of the wash stuff that those inconveniences are gladly put up with, indeed it can be said that many rather good places were only worth working by virtue of this property of the slate and that the future practicable working of several of the newer diggings even partly depends on it. Further details about this will be given in the third section.[47] The more argillaceous beds of these strata are weathered often several feet deep to a whitish yellow clay (mullock) in contact with the gold drift that sometimes contains all the gold of the deposit and is gladly seen by the practical digger, because it contains few stones on washing and usually more of the noble metal than is to be seen in the case of working things loose. In quartz reefs the pipeclay is just as rich as the earlier strata and its working is very easy on account of its softness; however, here the difficulties for the safety of the shafts and tunnels become more apparent. The fossils are the same as those of the blue slate (b); they are, however, more difficult to recognise and to preserve on account of the softness. Only the graptolites are easy to find, because their bluish-black outlines are very finely delineated in the white mass of the slate.

2. May Hill Sandstone.

This division of the Silurian strata is to a degree a middle member between the younger Caradoc and the Wenlock and links here directly to the Bala Rocks, excluding the fossil-rich intermediate member of the Caradoc. This sandstone is connected with the Wenlock Formation by the thin stratum of the Woolhope Limestone, which is accurately identified at a place on the Upper Yarra River.[48] The thickness of the May Hill Sandstone amounts to about 9000 feet with an average strike of hor. 11–12 and not very regular more easterly dip that varies between 20° and

80°. Synclinal and anticlinal structure is very frequently observed and it occurs particularly in the neighbourhood of Melbourne, which lies rather in the middle of the May Hill Sandstone region. The alluvial rocks and quartz reefs here are far poorer than the Bala rocks. Only the McIvor, Andersons Creek and Caledonian goldfields belong to it and of these only the first produced certainly rich but very small gold places (patches). Likewise the quartz reefs of these localities are only patchily rich and profitable. However, overall the May Hill Sandstone seems to be much more favourable for the occurrence of other ore veins, wide stibnite veins, chalcopyrite and galena lumps being by no means rare in it (McIvor).

The May Hill Sandstone can be differentiated according to its occurrence into:

a) Thin and regularly deposited white, brown, often very micaceous sandstone of variable hardness.
b) Hard, white quartzose sandstone with few fossils. Lumps of tourmaline, mica, chlorite and graphite are very common. Gives a very good building stone.
c) Very hard crystalline, gray, brown and red micaceous sandstone, interbedded with beds of hard, densely foliated greywacke slates (shales) and dark blue clay slates. They are less suitable for building stone owing to their high iron oxide content, because it has been observed that the ferruginous places are corroded by the air and the whole stone very quickly crumbles as a result. The slates are rather easily split; however, they also are so intermixed with ferruginous concretions that probably not a square foot surface can be found from which lumps of this substance do not stick out.
d) Very soft, yellow and brown, clayey–sandy slate, the appearance of which and other properties are similar to the pipeclay of the diggings (1c above); however, the white colour of that is only seldom observed. In their structure they present the most varied jointing and displacements and break down in the open air very quickly to a sandy, brown clay. Many graptolites and crinoids are seen in these strata; otherwise rather the same fossils are found in them as in the sandstones described above. However, on account of the softness of the rock they are very poorly preserved.

3. Wenlock shales and sandstones.

The geological character of this very thick (12–15,000 feet) formation is in general very similar to the above-mentioned. Variously coloured, micaceous sandstones alternate with blue, hard and soft, yellowish and brownish slates, which again contain interbedded foot thick beds of stalky densely foliated greywacke slates (Wenlock Shales). The sandstone beds are usually very thick and fine-grained and at many places show concentric colour bands that turn out to be spheroidal casings in section. The rock usually shows a tendency to weathering in the direction of these coloured strips. The Wenlock Formation is poor both in rich alluvial rocks as well as in good auriferous quartz reefs. Although gold was found repeatedly in the region of the Wenlock rocks, no paying goldfield has yet gained a reputation.

No. 16 (18 April 1859), pp. 140–141.

II The auriferous quartz reefs.

According to the character of vein formations advanced by Breithaupt, the auriferous quartz reefs of Victoria belong to the ‘noble quartz formation’.[49] Their principal filling matter is common crystalline quartz, often intergrown with limonite, rarely with hematite. If the reefs of the Harz, Saxony, England and other mining districts of Europe are mainly distinguished by them intersecting the strata of the country rock in the strike at any angle, this is only exceptionally the case with the quartz reefs of Victoria. A large number, indeed perhaps the majority of reefs known so far, lie in the strike of the strata, but often have a flatter or steeper or opposite dip than the country rock. A certain regularity in their course is somewhat rare and there are very many already abandoned as pinching out at depth. According to my own observations and according to much corresponding data, I have, however, come to the conclusion that such reefs are squeezed to a fine vein for uncertain depth, in order to later emerge again with greater thickness. To confirm this, however, there is still not any conclusive depth reached. The deepest shaft is on the Maryborough goldfield (350 feet),[50] and the remarkable thing about it was just observed that a poor tapering vein was found again rich at greater depth laterally. Perhaps both these reef points are displaced by a barren quartz vein observed by the diggers and here squeezing had taken place at first and then lateral displacement. The pinching out of the reef is often very striking and unexpected. At Bendigo a reef 10 feet wide at the outcrop was completely lost at a depth of 14 feet. In Forest Creek a 12 feet wide reef likewise dwindled away at 20 feet depth. In both cases, however, fine quartz veins extending into the depths were clearly seen. Also in their longitudinal extension the local quartz reefs show a similar irregularity, seeming often to pinch out completely from a thickness of 8–16 feet over a length of 50–60 feet. Brown’s Reef in Break of Day Gully at Bendigo provides an example of this. The reef here was 7–8 feet wide at the outcrop and very rich; gold could be seen in nearly every inch-sized piece of quartz. Its discovery naturally caused a great rush (crowding together of diggers) and the work began in an unbelievably short space of time in the apparent strike direction of the reef for several miles. But only Mr Brown was the lucky one here, as the quartz reef certainly extended at depth, but wedged out at a length of 30 feet on both sides.[51] When this observation was made in the claims lying next to Brown's, the workers naturally quickly left off their work and unfortunately as a result no solution was reached, whether, as I certainly believe, the reef became thicker again at a greater distance, or whether it perhaps was laterally displaced. I have not yet lost hope of seeing our old practical reef theory creating benefits. It would really be a particular freak of nature, if the displacement and dislocation of the local reefs were not to have happened according to similar known rules, as has still been observed in all mining districts.

The shattered material and offshoots signified here with the name leader are irregular in a similar manner as they are also observed in the Harz and in Saxony. Often they lie quite flat, uniting in one lode and often they bifurcate upwards, also often downwards. In Ballarat the case is observed that the thin veins running out are extraordinarily rich, whereas the reef itself is scarcely worth working. Whole stockworks of quartz veins form some hills, of which many are strikingly rich, however, without continuance. At Bendigo hills of this kind are being worked, where innumerable, small, partly rich, partly barren quartz veins run in a confused network. A part of them dips under various angles and are lost at depth. Another part lies flatter and the individual veins dip from all sides towards one another probably to join at greater depth. Now if the saying applies here that leaders contribute to a main reef and that the reef fissures go into endless depths, then the hope would probably not be too sanguine, judging from the rich leaders, to also get gold at greater depth with a main reef. Then for the quartz miner in Victoria it would open another infinitely large field and all the larger as the reefs, mentioned above, that are squeezed in strike and dip would be explored again and he could extract perhaps treasure from an as yet unknown depth, which might put those found so far into the shade.

Very different opinions prevail about the age and origin of the local quartz reefs. Some connect them with the emergence of the basalt, others with the granite and yet others regard them originating contemporaneously with the Palaeozoic strata. It is always a difficult task to answer such a question, so that no objections can be raised against it, all the more so, however, here in a country of which the sixtieth part has not yet been investigated geologically and where therefore geological conditions might still be hidden, whose later discovery overturns rashly formed hypotheses of the above kind with unforeseen rapidity. I will therefore only communicate the opinion of A. Selwyn and some self-made observations.

As A. Selwyn says in one of his geological reports:[52]

> A large number of various theories have recently emerged about the origin of the auriferous quartz veins. I am of the strong opinion that they are the sources from which the drift received its gold content and that their age and their origin or rather those of the fissures and cracks, which the auriferous quartz now fills, either are contemporaneous with the eruption of the granite and the result of raising and shaking that the older Palaeozoic rocks sustained by the former rock, or that they are the consequence of great earth revolutions that acted upon the Silurian formation, before the eruption of those granite masses took place, and that they were cut off by them in the strike. I follow this latter assumption from the fact that, despite the thickness and large number of quartz veins in several districts, they suddenly completely stop before the granite as before a wall, and that the auriferous drifts also disappear with them. This case shows not only that the granite had nothing to do with the formation of reef fissures, but it even proves that the origin of the gold is to be found in the quartz reefs.[53] An indirect example for this is offered by the great granitic horizon, which lying between the Coliban and Loddon Rivers, divides the Bendigo goldfield from those of the Tarrengower and Forest Creek.[54] Not a trace of gold is found in this district, although alluvial deposits also occur in the valleys and on the slopes. Were not one or other of the above assumptions be correct, so it would certainly be lacking a sufficient reason why the granite could not produce gold just as well as the sedimentary deposits.

So much according to Selwyn.

The great granite chain that bounds the Tarrengower goldfield to Barkers Creek, runs northerly in the strike of the strata in a narrow ridge, whose country rock consists, not like at other places of hornfels, but from a white micaceous, often porphyry-like sandstone, which narrow granite veins traverse in all directions.[55] Further and further from the granite boundary the stratification takes on more its original appearance as greywacke slates (Bala rocks) and dips westerly on the west side of the granite ridge and easterly on the east side. On each side of the latter there is only a barren quartz reef that occurs nearly equidistant from the granite in the strike of the strata and also seems rather of equal width. Should not one be led to the abnormal belief by this that this quartz reef is to an extent intercalated into the originally horizontal Silurian strata, broken in two by the emergence of the granite and accordingly being raised up on each side of it? On Bendigo and Maryborough goldfields there exist several points, where a definite anticlinal axis in the middle of a valley can be followed along. The bounding hill slopes carry rich quartz reefs there, the geognostic character of which so exactly corresponds that one is involuntarily tempted to the belief that there are reefs cropping out on one side of the valley side corresponding to those on the other. The case in Tarrengower quoted in section I under ‘A α’ offers a very prominent example for the unequal age of several reefs. We see there a very rich reef that has the usual strike at this place hor. 12 with westerly dip and also shows nothing new in mineralogical character, crossing out of the Palaeozoic strata into the granite directly and without any kind of change, whereas other reefs very close by are just cut off by the same granite wall. As a consequence of this behaviour, the division into ‘post and pre granite reefs’ could probably be best justified, but neither from a geological nor a mining view will particular benefit arise from this, because other differences in the conditions of stratification and in the mineralogical character are not associated with it.

Also I have tested the distinction in systems ‘right and cross’ dipping reefs, but as yet I have not arrived at any favourable result, since, besides the lack of other differences in such occurrences, conditions can still be observed in several reefs that clearly prove the insufficiency of the procedure.

The Kangaroo Reef near Kyneton (plate 2, fig 14) affords an example for this.[56] This wide reef, vertically dipping at outcrop, or rather quartz block, caused a great rush on account of its significant gold content presenting at the surface (60–80 ounces per ton). The reef was uncovered deeper and only a few feet below the surface the remarkable case emerged that the quartz forked into two strong leaders, of which one dipped west at an angle of 52° and the other east at 45°. The vertical quartz block that formed the top of a hill, disappeared completely on both slopes and in the gullies of the hill and on costeaning only two reefs of 3–5 feet thickness were met with, which not only dipped opposite to one another, but diverged more and more, the deeper the terrain became relative to the main reef of the hill. The gold, which was richest in the cap, if I may use this term, went only few Lachter (= 1.92 m) into the westerly dipping leader; however, at depth in the easterly it fell as a regular vein dipping at an angle of 45° and therefore shafts had to be sunk after it progressively deeper the more and more distant they were from the cap.[57]

No. 19 (1 May 1859), pp. 172–175.

In perhaps a distance of 200 Lachter towards the south from the first occurrence of the gold at the surface, a new poorer auriferous vein outcrops that shows a similar property as the previous one and which is now mainly worked, because the depth to reach the previous vein became too significant and too much groundwater came in. Towards the north from the first rich point, the eastern leader is almost completely barren, whereas the western is very rich for perhaps 5–8 Lachter in depth. This content then suddenly almost stops and also has its boundary after 28 Lachter in the direction of the strike, both leaders splitting from this point into numerous small sterile veins, whose quartz allows it to be followed on the surface. Only after nearly an English mile, does one come upon the so named Frenchman’s Reef exactly in the average strike of Kangaroo Reef (hor. 11),[58] which with a thickness of 2–5 feet dips at an angle of 50° west and in which the gold, found only in relatively little extent at the surface, occurs nearly vertically in patches at depth. On first glance the Kangaroo and Frenchman’s reefs could be regarded as completely different, but resulting from closer investigation both fall in the same line of strike and it is therefore to be supposed that the latter reef is the continuation of the previously mentioned westerly dipping leader, or rather, a new opening of the relevant fissure. The appearance of the quartz and on breaking it the metallic minerals such as pyrite, limonite, galena likewise are the same in both reefs, also the strike of the country rock, a reddish-white clay slate with many graptolites and lingulas is constant with that of the reefs, whereas the dip is steeper, about 65° east.

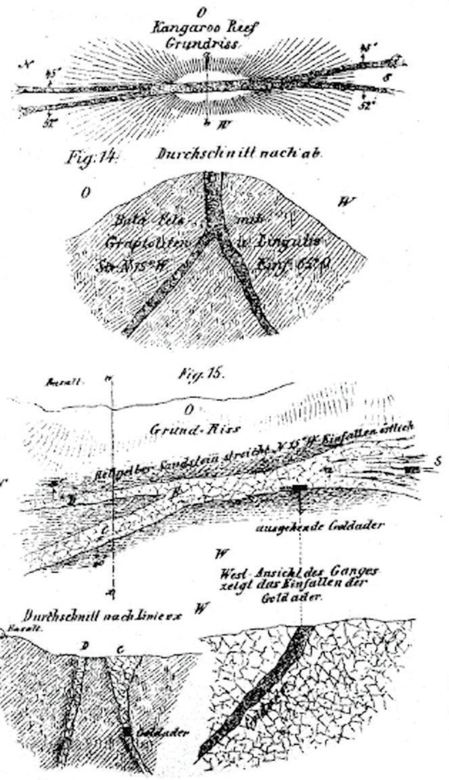

Figure 8: Ulrich’s plate 2, Figs 14, 15 in *Berg-und Hüttenmännische Zeitung*.
Grundriss = plan. Durchschnitt nach ab = section through a b. O = east. Bala Fels mit Graptoliten u Lingulis = Bala rock with graptolites and lingulas. Hellgelb Sandstein streicht N 15° W Einfallen östlich = bright yellow sandstone striking N15°W, dip easterly. Ausgehende Goldader = outcropping auriferous vein. West Ansicht des Ganges zeigt das Einfallen des Goldader = westerly view of the reef showing the dip of the auriferous vein. Durchschnitt nach Linie vx = section through line vx.

If a small deviation in the strike, perhaps 2–3 degrees is accepted, then a thicker reef outcropping towards the east about 60 Lachter perpendicular from Frenchman's Reef and dipping easterly could represent the eastern leader of the Kangaroo Reef; however, this still requires further investigation.

Besides this instance there are several other reefs from Bendigo to be mentioned, which make a regular spiral twist, turning from westerly to perpendicular and finally easterly dips. Russell's Reef near the Coliban River at Malmsbury shows the following behaviour. A quartz reef in outcrop about 5 Lachter wide striking hor. 11 turned out on working as a regular vertical wedge, whose sides dipped towards one another at an angle of 50° until they form a 10-inch wide vein at the apex which extends vertically at depth. This condition exists for about 30 Lachter in extent in Figure 15, plate II from a to B. From a towards the south the reef very quickly breaks up so that 10 Lachter from a only inch-thick small quartz leaders were sunk through with test shafts. However, to the north the quartz block divides into two parts at B, of which one hor. 11 with 2–3 feet uniform thickness and steep easterly dip continues, whereas the other part C with similar wedge-shaped formation as the section a–B, also is compressed to a narrow vein, which strikes hor. 10 and dips at an angle of 60° west. The gold was found about 2 Lachter north from a at the surface of the west side of the quartz wedge 2–3 feet wide and 2 Lachter long interspersed in the quartz and dipping at an angle of 40°. This rich quartz makes the twist of part C also and is now worked in the narrow vertical vein of the extension at depth with good profit. The other part D also contains gold, however, only in unpayable quantity.

The working of reefs by miners here is still in its roughest state; it not only earns the name 'unmethodical working' in the fullest sense of the word, but also is conducted, with only the few exceptions of European mining engineers, completely unsystematically and without any reference to the lithological or stratigraphical circumstances of the reefs and the country rock. Usually a shaft is sunk (6 ft x 4 ft) on the sloping dip of the reef on the hanging wall of it and as soon as the auriferous quartz reef is reached, drives are driven in the strike direction up to the end of the claim and the whole length is sunk deeper with a kind of stope similar to a back in the width of the auriferous quartz reef. In the case of wide auriferous quartz reefs, this working probably will do, but if the reef is only 1–2 feet in thickness as is mostly the case, the back is also only made so narrow and if under this thickness, so much of the country rock is taken for this purpose that at the most 1 foot to 18 inches comes out. In this narrow space, which now continually follows the fall of the reef, timbering is still used, the extraction effected, one another avoided and devices to remove the water are installed. Apart from this restriction of space hindering the work to a great extent, boring in the mass of quartz itself is very impracticable, the constant severe splitting of it not only impeding the boring very much but also scarcely permitting 30% of the bored holes to be effective. Only very few have pointed out the advantage of at first going down in the country rock, which under all circumstances allows easier working, and afterwards fetching in the quartz in large masses, which always has jointing faces, by good blasts. No example of regular stoping upwards is known to me, which would be much better suited for such narrow reefs. Another method is to open up the reef from the surface and so to add to the disadvantages of the previous working, the annoyances of the influence of the weather. The unmethodical manner of working consisting in only taking the good or at best such quartz that is just thought payable by extracting everything auriferous and by mixing with the good to produce a profitable medium kind of quartz for a longer period, is only employed in very few claims. Moreover in the case of thick reefs, which perhaps contain gold on one side of the upper surface, the further investigation of it is pursued unsatisfactorily or commonly quite neglected. They take only that which is exposed by working in the shaft or the backs. Driving cross-cuts into the reef and into the country rock seems completely unknown. There are already many examples where diggers, no longer satisfied with the yield of their gold vein, abandoned the reef, after previously, as generally is the bad habit, they had made the shaft let in rain water and generally did everything possible to make it unusable. Another partnership to whom the yield was sufficient, or even as often the case, the original owners compelled by need, soon after came back to the place and now sinking a new shaft on the other side of the reef, found not only profitable leads, but also met the main reef there richer than in the case at the beginning on the opposite side. Many other faults of management concerning direct or indirect loss of gold could be quoted; however, a less prominent instance, but which according to my opinion is the greatest and which indirectly caused the above-mentioned failures in working, may find a short mention here. It is this: 'the lack of cooperation' and the stubborn maintenance of the individual digger's life, a mistaken independence, for which the legislation in many respects forms the basis. From the first beginning of the diggings onwards, only 1–4 man claims were legally permitted and although their areas of respectively 8 x 8, 8 x 16, 12 x 16, 16 x 16 square feet were increased yearly, they certainly never exceeded 40 x 40 square feet in the case of four men, except in the case of the 3-fold permitted prospecting claims, and parties larger than four men were never tolerated. Until last year this law also applied generally to quartz reefs and it ensured that not only along strike but also down dip (double banking), as far as the speculation extended, many different digger parties became the lords of a share of the reef.[59] Every advantage for the beginning of a correct practical working of a mine was lost by this, only the best, as it were, was plundered from the reef and what could be got in a short time and it continued to a new place with similar working. The change in the size of the share caused by the often varying angle of the dip of the reef made many difficulties for the inexperienced in the decision and gave rise to frequent complaints to the government. Finally a change was made. The claim for an individual was set at 20 feet (40, 60 and 80 feet for two, three and four men respectively) extension on the reef and put a stop to 'double banking' in so far that a quadrangle of 75 feet on each side of the reef was permitted. For companies larger than four men, it is however again not provided for and even recently difficulties were made on the part of some Local Courts when two such parties of four men wanted to 'amalgamate' their ground as they called it and work with only one shaft. In this way, determined to some extent by the mining laws, the individual working of the digger has now become so entrenched that the advantage of cooperative working is not only not recognised, but also any attempt to destroy 'the individual mining' or 'the independent digger life', as they call it, would certainly have bad consequences and now there prevails permanently the colossal waste of time, work and money. Mining according to correct economical principles for the present remains an unknown matter. In order to demonstrate the present system of working in general by an example of the Nuggetty Reef at Tarrengower,[60] one thinks of the slope of a very steep mountain, about 200 feet above the valley floor and running obliquely with the valley a 6–8 feet thick quartz reef outcropping which dips with the country rock, a very hard blue slate, almost vertically towards the valley. If a regular shaft were sunk in the middle of the extent as far as the reef opened, that is about 200 Lachter, and connect from the bottom of the valley with an adit, then the whole reef surface could be worked beautifully by stoping upwards. Instead of this there exist in this space about 20 shafts, each of which has cost at least £250 Sterling to sink; no adit exists and the whole of the water falling from the mountain on the strata as well as the mullock and auriferous quartz must be raised from the shafts in small buckets and the latter must still be conveyed into the valley to the quartz battery.

The Mariners Reef at Maryborough offers another similar example,[61] where on a distance of not quite 100 Lachter, nine shafts are sunk, of which several over 300 feet, one even of 350 feet depth, missed the reef, which makes a sudden turn and only could be found by long cross-cuts. One single good shaft would have sufficed here as well for the working of the reef and a very large sum for useless work would be saved, as each foot in a 6 feet x 4 feet wide shaft costs £10 Sterling to sink at this place.[62] This was recognised by one of the partnerships there, that the use of a neighbouring shaft was offered to them by the owners for £500 Sterling and under the condition of mutual assistance in the haulage, but they elected to sink their own 300 feet deep shaft for £3000 Sterling to reach the auriferous vein. Now if one considers that the number of worked-out quartz reefs and those still being worked on the various diggings runs to several hundreds and that each reef undergoes in greater or lesser degree, like the above example, excessive shaft sinking, then in spite of the great richness of the reefs the reason is easily found why, according to the statistical notes, quartz working on average hardly permits a scant livelihood for their operators, indeed even creates more loss. However, this evil cannot last for long because the government intends to protect the interests of the farmers against that of the miners, so outrageously it may surrender the arable land of basalt tracts under which, as is found out more and more, even greater riches in quartz reefs and auriferous alluvials are hidden, to those abundant agitators. However, a mining industry, for which the protection of the ground surface is the main condition, will by economical shaft sinking with some practicable driving of adits, result in the 'cooperative system' on an extensive scale among such a large number of aspirants.

Now we intend to consider the matrix of the reefs themselves in somewhat more detail. The massive auriferous quartz differs as such in no way from the quartz of other metalliferous reefs. It has a bluish, yellow, snow-white, reddish &c colour and is very rarely quite free of iron. It occurs often in the most magnificent vughs more in outcrop than at depth, whose crystals, rock crystals of the purest water, sometimes reach 10–12 inches in length with commensurate thickness. Completely formed crystals are found cemented in a brown-red, clay ironstone, which fills in larger hollows of the solid reef mass. The crystal form of the quartz of the latter kind is often exceedingly interesting. Not only are three to four of the rare faces observed (x, t, z, u &c) on some crystals, but these faces (x, t) often appear in such size and determine such an unusual form in comparison to the usual form of quartz that it costs no little trouble to consider it and to define it correctly. If the striated prismatic faces recede completely, as is often the case, and thus a more rhombohedral form predominates, which shows combinations of the above faces, then it is often difficult to recognise the mineral as quartz immediately. In rock crystals of Dundly [Dunolly?] diggings, water drops are said to be nothing extraordinary. So far the following metallic and other minerals have been observed in the quartz reefs:

1. Gold. This metal, which on account of its common occurrence, gives the local reef formation the nickname 'noble', is perhaps the purest gold so far discovered on Earth. Many analyses carried out here and in England yield from 96–99.5% gold, up to 1.5% traces of silver, copper and some iron oxide and silicate, the latter two probably mechanically mixed in. The vein gold is usually hooked or globulose, rarely are there crystals; however, the latter are fairly common in the loose detrital mass that borders the vein. I saw a crystalline piece of gold from McIvor goldfield,[63] which was magnificently penetrated with quartz crystals, one of the latter showed a strong hook-like splinter of gold like rutile in the interior, which bore octahedra at both ends. The principal crystal forms that I have observed were cubes, octahedra, dodecahedra, very flat tetrahexahedra, the leucite a:a: ½a (somewhat rare) and various 48 faces. I have not yet noticed the pyramidal octahedra. Cubes and rhombdodecahedra are the most common in single crystals, the other forms more in combination of both these. I possess an undeveloped crystal, the corner of a cube, which shows octahedra, dodecahedra, leucite and tetrahexahedron. Twin crystals have grown together after the octahedron. The ignorance of the diggers in general and the value of the metal itself does not allow a love of collecting gold crystals to occur, otherwise several interesting forms would probably have already been noticed. Some people, who have taken the trouble to collect and who, as is known, possess magnificently well-developed crystals, had them melted down because the dead capital worried them too much. With respect to octahedral gold crystals, it is not unusual to observe the instance that the faces show a disc-shaped accretion or are incompletely formed similar to lead tutty.[64] If such crystals are broken in two, one finds either a hollow in the middle or a core of limonite or quartz. Should not this phenomenon explain the circumstance that crystalline gold on average shows a lower specific gravity than when smelted? In the beginning, gold brokers preferred to purchase crystalline gold, because they regarded it as the purest; however, now, because they smelt it here into bars, they complain generally about the greater loss than is the case with fine alluvial gold. Gold pseudomorphs after quartz?, in double, six-sided pyramids with prism faces are said to have been found often on the New Bendigo goldfield.[65]

The gold appears only dispersed in the quartz and the dispersed particles occur partly as lumps and pockets, irregularly dispersed through the ore mass, partly in regular veins, which are set at a certain angle in the direction of strike of the reef at depth. Only in very rare cases is the reef worthy of working in its entire thickness at its outcropping. If an auriferous vein (course) shows a constant angle of dip (inclination), the depth of a new shaft is often determined with mathematical accuracy from this angle and the distance of the point of outcrop of the vein; however, in the vein itself lump-like rich and poor patches occur and many a calculator often makes a displeasing cross-out through the calculation. With respect to the relative position of the noble particles in the reef, experience has until now taught that the hanging wall is mostly the richer part and that in the case of irregular dipping and striking reefs, the gold content of veins or lumps increases significantly in the turning or buckling points. Thus the Windmill Hill reef at Bendigo,[66] after it had previously been scarcely paying, yielded in such a deflection of dip, in which the reef increased three times its previous thickness, 36 lb weight of gold in 1 ton of quartz. In another reef of American Gully at the same place, the gold content increased at a similar bending in the strike from 6 ounces to 24 ounces to the ton.[67]

No. 20 (16 May 1859), pp. 183–4.

Another remarkable circumstance is that in some reefs where the gold occurs in veins, these are very thin at the outcrop, but at greater depth increase in thickness until finally they comprise the whole thickness of the reef. However, with this increase in workable mass, the size of the gold particles and with few exceptions the relative richness stands mostly in reversed proportion, that is the gold of the narrow rich part at the outcrop is generally coarse-grained (nuggetty), whereas it becomes finer and finer deeper and deeper. All the large world-renowned nuggets of 130–150 lb weight were found not far from or in the outcrop of rich quartz reefs; on the other hand it is also a well-determined fact that the gold produced from any significant depth here (300–400 feet) is disseminated through the quartz on average as fine as flour and down to microscopic motes. An instance is known to me where the outcrop of a reef contains gold in rather heavy nuggets (1–2 ounces) only in the hanging wall margin consisting of bluish clay. Deeper the gold was also found in the quartz and the thickness of this noble quartz increased with gradual decrease of gold content so that at last it amounted to the whole thickness of the reef (6 feet) and was then no longer workable. The relative gold content of the mass may have remained the same in this case; however, they had to work 12 times more stuff than at the beginning to obtain perhaps one ounce of gold.

In consideration of the above-mentioned, the question now arises how to explain this condition in the occurrence of gold and what theory of reef formation must be adopted here? If we accept, as many believe, the reefs are fissures filled from below in a molten manner, although this is very doubtful in the case of quartz, how is the specific gravity of the gold in this case brushed aside in order to lift it, as the heaviest, the highest? If we think according to others that the quartz is infiltrated when in solution without any igneous action, how was the gold at all lodged as such in it and remain floating? The first hypothesis obviously refutes itself without us needing to instance the contrary character of the reef to it and of the neighbouring rock and not taking into account that the occurrence of pyrolusite and other minerals easily decomposed by heat is incompatible with it. The second hypothesis would also have to be rejected; if unchanged it is to be regarded as the only means of filling the fissures regardless of all the phenomena determined by several and varied influences in the occurrence and mineralogical character of the reef mass. However, if we admit a wider field and permit the commonly used mystical influence of electromagnetism to play its role here as well, it is not completely irrational in my opinion. I accept that through the action of hot steam on the flinty country rock, as well as through the intrusion in such a solution from the Earth's interior the fissures filled gradually with a siliceous mass and that a strong electromagnetic current carried the gold from below up here in atoms (sublimating?) through the mass and deposited it at suitable places. I explain the greater accumulation of gold at the outcrop by a greater power of attraction of the siliceous paste, which was already congealed to quartz there, which offered even more opportunity for massive accumulation of metal through the manifold splitting and renting action of the atmosphere. In the course of this process the accumulated gold itself perhaps exercised a similar galvanic-attraction action like the form hanging in a gold solution and already covered with metal shows by further thickening of the coating.

The following experiment communicated by Count J. Dembinksi to the Melbourne *Argus* of 6 November 1859 [1857][68] agrees in favour of the principal point of this theory: 'Fine gold-dust is mixed with moist clay or pulverised slate. The cake is isolated on gutta percha or glass; it is divided by a cut of 1/8 inch wide into two equal halves and the space between filled with silica gel, which is allowed to set hard. If an electro-magnetic current is run through the mass, after 3 or 4 weeks according to the intensity of the current, it is observed that all of the gold disappears out of the slate or clay mass and has infiltrated into the siliceous mass in infinitely fine, vaporous dispersion, only here and there are accumulated visible particles found.' — If this influence of electromagnetism should be confirmed in general by further experiments, i.e. also with other metals and metallic minerals, the idea 'that ore and metal still continue to grow' would not be at all so hard to condemn, because the constant presence of that force in the solid Earth's crust and in larger grade in the deposits of useful fossils [items dug from the earth] has been sufficiently ascertained.[69]

There is indeed still much to be said about this subject and about the origin of the auriferous quartz, but I believe that all hypotheses, which especially have reference to the last point, are far without support and too premature until an extensive geological investigation and more precise study of the reefs here at greater depths have taken place. How can an explanation about a point that still gives lasting cause to one of the most significant disputes between geology and chemistry be required from a young colony with such very restricted means for scientific enquiry?

The extraction of gold from quartz still occurs in a very imperfect manner, although a large number of machines of the most diverse construction were tried for this purpose. The main requirements for a complete extraction are first of all the finest possible grinding of the quartz on account of the fine gold dust and then the separation of the gold, that is pressed into thin small flakes as a result, from the excessively larger quantity of barren material in the shortest interval of time. As crushing machines, the usual stamp battery combined with the Chilean mill, have proved to be the best and to a lesser extent Berdan's roller. The latter machine consists of a large horizontal or inclined iron basin in which two to four iron balls weighing about 4000 lb grind the introduced quartz to the finest flour. The working of the machine occurs either through turning of the inclined basin that is provided with an axle, whereby two balls of different sizes roll always to the deepest point, or four rollers of equal size are moved around in circles in the horizontal and fixed basin by four arms (sweeps) fastened on the axis and set at right angles to one another (Kennear's construction).[70]

If tables, sluices, long toms, cradles &c are employed for the washing of the quartz sludge produced by the above-mentioned machines, it is found that the gold through its platy form has lost not only all the advantages of its specific gravity, but also washing away by the water is made even easier just on account of this shape. The amalgamation, which is now generally in use and which mostly takes place by the rubbing of the pulverized auriferous quartz under water on an iron or stone underlay covered with mercury (Chilean mills), in fact causes not such a large loss of gold as purely use of water, but even with good machines it is still very significant and applies to two valuable substances: gold and mercury, which are carried away by the indispensible water. The following experiment made in Bendigo provides evidence for this. Mr B. [Ballerstedt],[71] a German, who was able to boast two years ago 700 lb weight of gold already as pure earnings from his quartz claim in the reef situated at the head of Ironbark Gully, purchased a crushing machine acknowledged as good and at the same time received with it tailings of the quartz worked by the previous owner heaped up near it.

No. 23 (6 June 1859), pp. 213–4.

Mr B. made some small but important improvements and additions (washing pan) to the machine and tried its operation with renewed crushing and washing of the above-mentioned tailings. He obtained 3–4 ounces to the ton and after finishing the processing of the whole heap had, not only the machine cost free, but even a considerable profit in addition.

At another place in Bendigo the tailings and sludge from two trial tons of quartz which were worked with stamping and amalgamation machines acknowledged as the best and had yielded 42 ounces of gold with them, were given over to another machine for a test reworking. The results of this extraction carried out under supervision were 14 pennyweight = 7/10 ounces of gold and remarkably 5 lb more mercury than had been used in amalgamation. However, this was not all. A sample of this second lot of tailings, taken according to rule, was now analysed and it was found that the whole mass of tailings must still contain about 5 ounces of gold, a content which unfortunately until now is not able to be extracted in a payable manner by any known means. What enormous capital is probably walked over in such discarded tailings? I have lost all hope of a radical extraction of this gold content by mechanical means or with the assistance of mercury, because, as already noted above, firstly the flaky form of the gold produced by the crushing of quartz in any way negatively counters all washing methods based on specific gravity and then in the amalgamation, as I believe, the noticeably unequal proportion of the quantities of gold and quartz are very unfavourable. For example, if we assume 1 tonne (2000 lb) of middling rich quartz contains 16 ounces of gold, the proportion amounting to 1:1999, will not in such a quantity of barren material much of the noble metal and particularly the finer part so vanish or be enveloped that it does not come in contact at all with the quick silver and thus in the rapid working, which only pays here, it will be washed away by the water? The relatively larger gold content in the tailings of poor quartz and in richer quartz seems to confirm indirectly the assumption just given.

In looking over such unfavourable results, one thinks of course that the purely chemical or metallurgical way must be the correct one. However, even here considerable difficulties already stand in the way of tests. If we adopt at first the metallurgical way, the question arises what form of oven would have to be adopted as appropriate with a poor supply of wood and expensive coal in order to smelt large quantities of quartz in the shortest time and what extra charges (material, which of course must be obtainable close by without great cost) and in which circumstance must one use them in order to bring a heap of nearly pure silica into such a thin fluid that the molten gold can easily collect on the floor of the oven? I would regard the roasting furnace corresponding most of all to the former requirements. The high price of coal or the very expensive charcoal production here would, however, reduce the profit very much. The extra charges would each be more or less easy to find according to the position of the relevant reef.

I think a ratio of the slag development between basalt impregnated with calcium carbonate, clayey ironstone and pure ironstone with quartz can easily be found by tests, which determine the required fluidity for good sinking of the gold to the bottom. If this smelting were undertaken only with ironstone bearing substances, the result would be an auriferous iron, whose highly brittle nature, as I ascertained through experiment, permits the finest pulverisation and thereby very much facilitates solution in cheap sulphuric acid. The iron sulphate resulting from this together with the finely divided gold can easily be made useable for technology. If this method of dissolving is not used, one is at liberty to add antimony sulphide, occurring here in wide veins, as a collecting medium for the gold (auriferous iron is very fluid, if the proportion is not too unequal) and thereby the old methods 'by casting and flux' are restored again. I have until now omitted proposing the use of lead in extracting of the gold, because greater costs are connected with it; however, the greater attraction between gold and lead would most easily attain the objective. If we now consider the money paid out, which a trial of the above kind requires, moderately estimated according to local material and labour costs, at least 30,000–40,000 Reichsthalers would be necessary, a sum that probably few would risk on a mere experiment.[72] Those who might like to attempt the work lack the means, and those who have the money here understand nothing of such things and prefer easier speculations of a good scorification.[73]

Last year an Englishman made his method of extraction 'By smelting' the general theme of discussion by grandiose announcements.[74] He set up his apparatus, a kind of block oven, at first at the Bet Bet quartz reef and used the usual white clay slate mixed with potash as flux. At the beginning the matter went reasonably well, as only the quartz from freshly taken up claims came for smelting. Eventually, however, a company of diggers gave three tons of quartz for smelting, which was broken from a place previously worked for a long time. As only the fourth part of the gold was obtained out of it, which a quartz mill and amalgamator yielded shortly before from the same quantity of average quality, the miners were alert, examined the slag thrown to one side and on breaking it to pieces found quite good quantities of large and small beads of gold in it, which had caught in the tenacious mass. On crushing it the deficit of this test remained again with small loss and on the whole a credible gold content was realised from the remaining mass of slag, which the participating quartz miners took with them. Now a considerable blow has been dealt to quartz smelting by this failed experiment and the basic extraction of gold in this manner will probably remain a problem until such time as a beneficiary of fortune risks another throw of the dice in a new trial. The problem is certainly solvable and the profit must be enormous, when one considers what huge quantities of tailings of similar content are represented on all the principal diggings and are thrown away as mentioned above.

Besides the methods and experiments of gold extraction just mentioned, still very many other kinds have been proposed, of which, however, none yet have found favour in a good test.[75] Thus a certain Count Dembinski made known as new the generally known fact that quartz is soluble in soda by boiling. He intended to obtain the gold falling to the bottom of the solution just as a by-product, the principal product was said to be either the sodium silicate or the silica gel produced by the introduction of carbonic acid into this solution coupled with reproduced sodium carbonate. Both products of the silicic acid were to be used for various technical purposes such as glazing, water glass painting &c as known.

No. 24 (13 June 1859), pp. 220—2.

The expression 'gold as by-product' would now certainly instigate a trial, however, transport and procurement of the immense mass of requisite alkali, as well as the rapid accumulation of the main product form a great impediment. Count Dembinski certainly does not seem to have contemplated that he needed at least 1½–2 tons of soda for the solution of one ton of quartz and that the investment in no way yields a profit, unless at least 10–12 tons of auriferous quartz could be worked daily. Another proposal of the same gentleman is to use the property of chlorine water dissolving gold for extraction of gold from quartz.[76] This property was long ago discovered by Plattner,[77] but here likewise announced as new. Now although thin gold leaf dissolves rather easily in strong chlorine water; this is, however, otherwise with thick massive gold particles as they occur in quartz here. Also the great abundance of iron oxide, which accompanies it, will cost a good part of the chlorine water before the solution of the gold is properly done. The said gentleman indeed proposed to grind the quartz properly first, to strip it of its principal gold content by mechanical washing and then to fill a very capacious funnel with the tailings, after which letting the chlorine water run through, pumping again upward into the funnel and repeating this process until (?) all the gold is extracted. However, if we disregard the time and circumstances, which firstly the preparation and then a radical extraction with weak chlorine water (no digger would want to operate with strong chlorine water on account of his health) would require, the expenditure for manganese dioxide and sulphuric acid for manufacture of the chlorine is so considerable here that it would nearly run just as high, even perhaps higher, than the value of the gold to be extracted. Count Dembinksi knew of a remedy for this too, in that instead of sulphuric acid in the chlorine extraction process he intended to use pure quartz (silicic acid). The chemical model in this projected operation can be depicted in symbols indeed very plausibly, but because the Count had not even made a test, the proposal was very poorly supported and slumbered peacefully like the first process despite all the writing for and against in the newspapers.

Some time ago the idea of a Mr Wilkinson 'to smelt the quartz before an oxy-hydrogen gas blowpipe' caused a great sensation, although as far as I understand it, it is the greatest nonsense that perhaps ever was done in the field of metallurgy.[78] Indeed Mr Wilkinson speculated on the different melting points of metals as well as those in ores even if occurring separately in vein stone and he believed not only that when galena was brought before the blast pipe, firstly all the sulphur melted out and then the lead afterwards, thus both result in themselves, but he also maintained that the gold ran through the quartz, when he heated it above the melting point of gold. Despite this absurdity a rather large company formed here, which did not spare a good sum for a large-scale test.

So much for the local gold and the present state of its various methods of extraction. Up to now the following minerals have been found that appear in the auriferous quartz, some very common, some rare:

2. Arsenopyrite. It occurs very commonly and mostly interspersed, as lumps, rarely in free crystals. The form of the latter is always the short columnar faces (m) on the two octahedron faces (r) and they are grown together as twins and triplets. The compact arsenopyrite is very inclined to decomposition and contains more or less gold, which is interspersed as microscopic particles up to noticeable grains. The extraction of this gold content, although rather significant in many pyritic ores, is until now still not attempted and will also probably not take place for a long time, because the expenses are too great and the toxicity of the roasting process will not be to the Australian digger's liking.
3. Iron pyrite. (Tesseraler). This so very common mineral is also to be observed here in the auriferous quartz reefs, often in large masses. It extends through the quartz in veins, forms lumps and occurs very commonly thickly interspersed. The form of the crystals, which are mostly found in the crust/wall of the reef, are cubes with narrow pentagonal–dodecohedral truncation faces.

Pure cubes or other forms are rare. A gold content of this pyrite is to be observed in similar manner as in arsenopyrite.

4. Stibnite is found in many reefs interspersed here and there; however, on the McIvor goldfield in the middle of a reef as a 1–2 feet thick vein. According to reports it has not yet been found in crystals and is said to contain only extremely small traces of gold. A piece that I saw showed the usual radiating structure and was covered with a bright yellow crust of antimony ochre.
5. Galena is found in insignificant lumps in many diggings and in small veins at the McIvor. It is very coarse grained, contains traces of silver and gold and often is found in small vughs (cubes with octahedra) grown together with gold.
6. Covellite. This otherwise rather rare mineral is often found as fine crystalline crusts on chalcopyrite and chalcocite, rarely massive in small nodules and rounded pieces in the Steiglitz–Forest quartz reefs.
7. Chalcocite. Not yet observed in distinct crystals; however, more often in small crystalline grains intergrown with gold at Steiglitz–Forest, Tarrengower, Forest Creek and so on.
8. Chalcopyrite is found at the McIvor and in the Steiglitz–Forest district like chalcocite. The last three mentioned minerals were observed in the Steiglitz reefs mostly always intergrown with each other and it seems many such specimens give a clear picture of the process of a mineralogical metamorphosis. One can see quite clearly how chalcopyrite firstly is coated with a thin layer of covellite and with lustrous particles of covellite between where the latter overlays more thickly. In what manner the iron disappears at the same time, is not yet quite clear to me; however, the frequent appearance of corroded pyrite and iron ochre is probably related to it.
9. Cupro-plumbite. (Cuproplumbite?). This mineral was found recently in very small quantities at McIvor. In fracture and appearance it is not quite dissimilar to fine-grained galena, has a hardness of 3–4 and judging by its cleavage seems to point to not tesseral, but rather to a rhombohedron. An investigation that I began with a very small piece of the ore showed that it had quite clearly the reactions of cuproplumbite according to Plattner except a minute content of antimony. It differs from bornite by its very small antimony content, from tetrahedrite by the large lead content. An exact qualitative analysis gave lead and sulphur, a middling content of copper and little antimony. Unfortunately until now this mineral was observed only once and in very small quantities intergrown with quartz, and therefore an exact quantitative analysis for its closer determination must remain suspended for a further find.[79]
10. Native silver and native copper. Both these metals were found in a specimen intergrown with gold in the quartz reef of Specimen Hill near Forest Creek.[80] They show toothed structure without distinct crystal formation and the copper at many places bears a slight coating of malachite. It is certainly a remarkable case to find three of the noble metals in the native state together in a small specimen and arranged chemically in such a way that none of the metals contains more than an insignificant trace of the others. So the copper was nearly chemically pure, the silver contained only a slight trace of gold and the gold only a faint trace of silver. What is one to think of the origin of such a specimen, particularly when as in this case the metals are completely grown together?
11. Gold amalgam is found in the German Reef at Tarrengower interspersed in very small particles and also as incrustation.[81]
12. Cinnabar is said to have been found in small amounts in a reef at Bendigo. A small piece of it that I saw had an attractive radiating crystalline structure.
13. Cupreous manganese occurs as a narrow vein in a quartz reef of the Dunolly diggings. The mineral shows a weak reaction to cobalt on testing and in the solid mass contains small spherical or knobby pieces of white quartz cemented in like conglomerate.
14. Azurite and malachite are found in many reefs as thin coatings and in small nodules. Steiglitz–Forest has produced the best specimens of it. However, still no perfect crystals of both minerals have been observed. Malachite is more common than azurite and is highly priced when it is intergrown with gold and quartz crystals in small specimens. They are worked into brooches, rings and bracelets &c.
15. Pharmacosiderite (cube ore). It was discovered a short time ago by me in the auriferous quartz of the Beehive Reef at Tarrengower.[82] The quartz, in whose hollows it was found, is intermixed densely with arsenopyrite, which has a strong tendency to decomposing. The crystals of the cube ore are on average only very small, the largest perhaps 1/16–1/20 of an inch and show a yellow to attractive emerald green colour with iridescent shimmer. Only on very few specimens could I observe a faint hemihedral face of the cube edges (pentagonaldodecahedron). More common were very faint tetrahedral truncation faces. The emerald green variety showed mostly the larger crystals with curved cube faces, the yellow-green and brownish are smaller with flat faces, which have diagonal striations. This mineral is found very commonly intergrown with gold

and many vughs of the emerald green kind, in which arsenopyrite stands out more brilliantly alongside gold, offer a very interesting appearance.

16. Scorodite occurs in crystals and amorphous or earthy in the Beehive and German Reefs at Tarrengower. I discovered very small crystals of the first kind of ½ line[83] in a vugh of the Beehive auriferous quartz together with pharmacosiderite. They are bright leek-green and covered with a bright yellow to brown crust and partly cemented in it, which could be called an arsenopyrite ochre. This substance contains in addition to significant not constant quantities of arsenic acid and sulphuric acid a variable content of gold, which is divided into microscopic brownish-yellow particles. The earthy scorodite is found in narrow veins together with arsenopyrite or as efflorescence on the same in the solid quartz of the German Reef. It has a remarkably lamellar texture, which appears not dissimilar to weathered slate, is very soft and shows mostly an apple-green, rarely dirty yellow colour. Before the blowpipe in tweezers, it is remarkably light with weak arsenic smell and bluish flame melting to black magnetic spheres. On the charcoal block the same reactions take place, but the arsenic smell is much more distinct and the ready fusibility stands out so much that even the slightest touch with the tip of the flame causes it. In the partially closed glass tube the mineral gives off very much water and after long blowing deposits a white sublimate of arsenic acid. On a thin silver sheet a weak reaction on sulphuric acid is noticed after the test in question. The beads show pure iron colour. Hydrochloric acid dissolves the powder very easily and without residue. In comparison nitric acid shows no reaction. The formation of the pharmocosiderite and scorodite is undoubtedly to be attributed to the decomposition of the accompanying arsenopyrite and the arsenopyrite ochre mentioned before would amount to a kind of residue, in which the gold originally contained in the pyrites remains behind in powder form.
17. Sphalerite is found together with iron pyrite and galena in the round 20 feet thick Coliban quartz reef.[84] The very rare complete crystals are rhombdodecahedra with tetrahedral truncation faces.
18. Pyrolusite (brownstone) was recently discovered as a vein in a quartz reef at Steiglitz–Forest. Crystals of it have not yet been observed; however, the usual radial crystalline structure is very pronounced. This brownstone vein is partly enveloped by auriferous quartz, partly it contains the same in small leaders that are often very rich.
19. Apatite. Until now only a single specimen of this was known, found at the Dorolly [Dunolly] diggings. In a small piece of white quartz three bright green grains are intergrown, of which two show a clearly hexagonal cross-section, the third a more rhomboidal face with a small piece of gold in the middle. I could get only a very small piece for testing from the owner, Ludwig Becker; however, I was thereby able to prove the reaction of the phosphoric acid as well as that of lime very clearly. The beads and the solution that was very easily and completely produced with hydrochloric acid showed besides a strong reaction with iron.

As far as is known to me through practical experience and reliable information, the total mineral riches of the local quartz reefs are already exhausted with this small number of minerals just described. Without doubt many other, particularly non-metallic, species will turn up; however their becoming known will only be a lucky chance, in that the digger looks only on gold, or at most on that which glitters or is heavy. Many a beautiful crystal of some kind of rare mineral may be mutilated as quartz in the rapid working. Hitherto I always had the hope of finding some of the rare gold tellurium combination, which characterises the gold reefs of the Siebenbürgen,[85] but it seems it shall have no success, in the same way the absence of silver ores (pyrargyrite &c) is conspicuous.

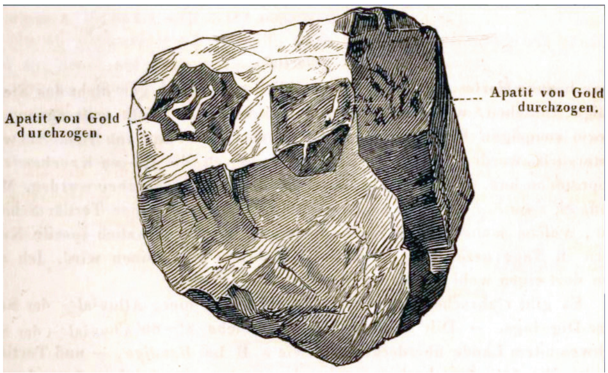

Figure 9: Becker sketch of apatite specimen. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde* 1857, p. 699.

Considering all the mineralogical and geological features mentioned earlier, I think therefore that the quartz reefs of the diggings of Victoria represent the 'noble quartz formation' of Breithaupt as a clear type and that their predominating character as 'auriferous quartz reefs' stands in the closest relationship with the particular divisions of the Silurian strata, in which they occur here. Wales in England and northern California show in their slates and sandstones of the gold districts, they are quite analogous to the local ones both in geological age and in lithological character. In finishing the description, in many respects deficient, of the auriferous quartz reefs, I cannot omit expressing again as my firm conviction that the generally adopted view: 'auriferous reefs run out at depth and become poor' will be completely disproved by deeper sinking of the shafts or generally by further pursuing the always visible fine quartz veins after every pinching of the reef, as many examples in Maryborough, Bendigo &c already now show: 'The local quartz reefs, despite in many points departing from the general behaviour of reefs, certainly follow the understood laws and rules of experience. Concerning the imaginary reduction of the noble metal contents, on the one hand the lack of good methods of extraction in many cases the fault of inadequate extraction of gold that becomes very fine at depth, as well as generally an inadequate observation, allows the gold in a reef to be considered as run out, when after sinking through of an auriferous quartz vein dipping at some angle (pocket) the underlying barren or very poor mass was reached.'[86]

(Continuation: Description of the alluvial rocks.)[87]

ULRICH LETTER TO HOCHSTETTER 1860
(published 1861)

***Jahrbuch der Kaiserlich-Königlichen geologischen Reichanstalt* 12 (1861–2): 23–28.**
Meeting of 26 February 1861.

Professor Dr F. von Hochstetter gave information from a letter of Mr Georg Ulrich, geologist of the Geological Survey Office in the colony of Victoria in Australia dated: Geological Survey Camp, Strathloddon Nov. 20 1860.

Since your departure nothing has changed in the system of our geological surveying.[88] Parliament has granted the old salaries again and approved Mr Selwyn's arrangements and so we are still progressing in the same way, as they see it, with our map making. Strathlodden, our camping place for some months since is 6 miles south of Castlemaine and in the middle of our new 54 English square mile map area, in which I have already climbed nearly all of the hills and hastily perused the gullies.[89] Silurian sandstones alternatively bedded with thin quartz reefs and the soft white clay slates form the same old strata and, with exception of some fucoids and of *Graptolitus folium* in general rare, but here common, the fossils also remain the same as those of Castlemaine.[90] I must, however, mention that the imperfect impressions that we previously regarded as *Lingula* were recognised by McCoy as *Hymenocaris*

Figure 10: Graptolites collected by Aplin and Ulrich, Locality Ba 78, Barker St, Castlemaine. *Isograptus* and *Didymograptus mundus* T. S. Hall. P33a reregistered as P327363a. Museums Victoria collection. Photographer: D.J. Holloway.

vermicauda after some distinct examples were found on the Loddon — a crustacean that is found also in a similar manner in the Silurian strata of Wales.

In this district the gold deposits occur in far greater development than in the neighbourhood of Castlemaine and their closer investigation has now completely confirmed my former opinion that one can place the drifts not like Selwyn in five, but in three divisions — and these representing scarcely worth mentioning periods of the Tertiary epoch(?): older, middle and younger gold drifts.[91]

Of these the older division includes only dome-shaped crests of hard conglomerate or very compact pebble beds of completely rounded pieces of quartz (fragments of other rocks are rare) on mostly isolated Silurian hills.[92] The second division includes likewise rounded drift tops on isolated hills; the latter are, however, much lower than the older division, further deposits of drift on the hill slopes of the older hills and the so-called deep leads. This division is generally different in character from the previous in that the material in respect to size and weight of the rock fragments is less regularly deposited and is very rarely firmly conglomerated and in that clay beds, which are completely lacking in the older division, occur here frequently and in that particularly the ‘gravel’ is a mixture of rounded and angular quartz and other rock fragments, between which are commonly larger and smaller pieces of the older hill conglomerate.[93] The whole seems generally to be the product of a second strong erosion of the adjoining heights, mixed with the remains of broken up older drift deposits. Finally the third or younger division is the deposit called by the diggers ‘alluvial’, which occurs in every gully and flat, consisting of sand, clay and mostly angular gravel beds alternating without regularity. Only if gullies or flats run along close by older drift deposits or have cut through the latter, does it also contain rounded gravel. The following two sections will render these relative bedding conditions clearer.

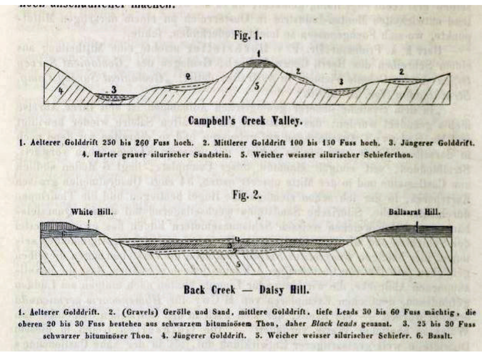

Figure 11: Sections of Campbells Creek and Back Creek. Ulrich’s figures 1, 2.

1. Older gold drift 250–260 feet high. 2. Middle gold drift 100–150 feet high. 3 Younger gold drift. 4. Hard grey Silurian [i.e. Ordovician] sandstone. 5. Soft white Silurian clay slate.

2. Older gold drift. 2. (Gravels) pebble and sand, middle gold drift, deep leads 30–60 feet thick, the upper 20–30 feet consisting of black bituminous clay, the called black leads. 3. 23–30 feet black bituminous clay. 4. Younger gold drift. 5. Soft white Silurian slate. 6. Basalt.

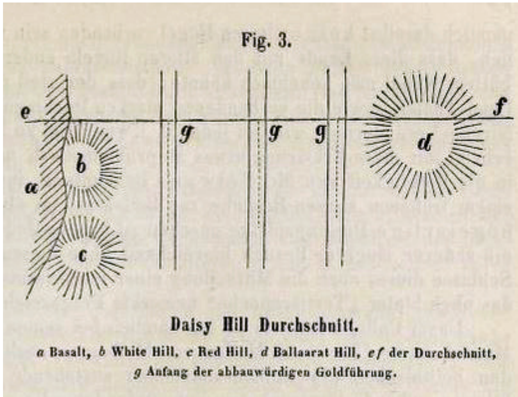

Figure 12: Section through Daisy Hill. Ulrich’s figure 3.

Daisy Hill section.
a) basalt, b) White Hill, c) Red Hill, d) Ballarat Hill, e, f) the section, g) beginning of the workable gold-bearing material.

The one-sided terrace-shaped contour, which the main valley of Campbells Creek shows, is also repeated completely in the same way at Fryers Creek, Creswicks Creek and several other places and is a remarkable phenomenon in as much as the erosion of all these existing creeks just has taken place in the hard Silurian sandstones. The gap in the level between the older and middle gold drift is particularly striking at Fryers Creek. There for example the Welsh Mountain forms a rather steep blunt cone,[94] whose flat top 20–30 Ells [95] in diameter bears a 12–16 feet thick summit of quartz conglomerate and heavy rounded quartz gravel, from which much and large gold was obtained and which lies at least 150 feet above the middle gold drift, which extends as a narrow flat at the foot of the hill, which is bounded laterally by the valley of Fryers Creek filled with the younger gold drift and further on is overlain by the basalt. Pieces of conglomerate, large quartz balls and wash gold (i.e. once to be found before the diggers washed it out!) are found everywhere on the side of the hill down to this drift flat. Traces of this destroyed older alluvium, that is the whole cover, form a so-called ‘surface patch’. With respect to the Daisy Hill section I must remark that the wide plain (‘flat’) cuts through the line of the older drift hill nearly at right angles and that the three indicated deep leads (gutters) running parallel to one another only begin to contain payable gold in this crevice, in plan somewhat like Fig 3.

The main reason that induced me to regard the deep leads as contemporaneous with the younger hill deposits is as follows. In all places where deep leads occur with older hills, the younger hills are lacking, and vice versa where these occur no deep leads are to be found. I maintain therefore that both forms of deposit are the product of one and the same combined periods of denudation and deposition, appearing modified only at present in layers, in consequence of locality and other conditions (character of the soil, &c), which exert an influence on the kind or manner of deposition of the younger gold drift. Indeed the reason on which this assertion is supported is an indirect one, but is given weight by the fact that the other assumption, namely of two different periods of time for the formation of the younger hills and leads, cannot be, at least as it seems to me. Because how could one for example explain that the floods, heavy or light, that erode the valley of Campbells Creek and form the younger hills there, or rather the period in which this was accomplished, leave no indications of similar actions at Daisy Hill, which is hardly 11 hours distant. Or that on the contrary the agents that formed the deep leads at this place were only local without influence on the nearby Campbells Creek goldfield?[96]

The circumstance that the leads are only found in very wide flats, whose basement on average consists of soft clay slates, lets me therefore explain the difference in the conditions of deposition of the younger hills and leads respectively to the younger gold drift that as the extension of the lead flats demonstrates, perhaps heavier floods acted on these places. Or that even in the case of lighter floods the effect in the soft slates was much vaster and far-reaching in reality so extended that the later floods of the newer gold drift period had space to spread and so to deposit their material over the lead detritus, without, as in Campbells Creek &c, digging lateral channels.

A not insignificant influence on the formation of that particular condition of deposition of the drift might also be ascribed to the eruption of extensive streams of the younger basalt happening at this time. Some of the wide lead flats show for example quite obviously that they were previously dammed up by basalt, therefore to the alluvial period and so long small lakes formed to some extent, in which not so much a denudation as a quiet accumulation must have taken place, until the now present narrow channel was broken through the basalt. At other places the watersheds of the creeks seem to have been completely altered by the streams of basalt. Only on one, namely the Ballarat goldfield, am I doubtful in reference to the age of deep leads occurring in large numbers there. According to Mr Selwyn no older hills occur there and it would be therefore possible that these leads had the same age as the older hills of other diggings, whereby one could assume that the steep ravine-like character of the lead valleys, as well as the present considerable covering of basalt prevented a similar change of level as with the latter that is from valley to hill. However, this explanation seems to me to be somewhat too problematic and I have some doubts about the correctness of Mr Selwyn's assertion, as I remember on an earlier short visit to Ballarat to have seen hill-like digging places. At any rate another longer visit in the future will inform me sufficiently on this point. Yet just to conclude this, the news of an interesting discovery in reference to the question mark above behind 'Tertiary epoch'.

You see our colleague Daintree during his investigations in the Bacchus Marsh district (30–40 miles from Melbourne towards the goldfields)[97] has found quartz conglomerate outcropping under the oolitic(?) carbonaceous sandstone resting directly on the Silurian.[98] Setting aside a gold content (but not proved), they do not differ from the conglomerates of the older hills and, what is the most remarkable, those in the hilly districts at times still thinly covered with carbonaceous sandstone, however, mostly quite free, form the tops of hills, which, as Daintree expresses it 'look for all the world like the old drift hills of the diggings'.[99] Now if one connects the others with this fact that in a basin of the Coliban valley near Kyneton and 1800 feet above sea level, a small patch of carbonaceous sandstone occurs, then the question is raised do not the older hills occurring on the Taradale goldfield only a few miles from this point stand in the same relationship to the Coliban carbonaceous sandstone as the conglomerates of Bacchus Marsh to the carbonaceous sandstones there? Daintree and I are of the same opinion about this. Doubt about the Tertiary age of the older gold drift hills seems justified to us. Messrs Selwyn and Aplin vacillate and do not venture to express themselves decisively. Reverend W. B. Clarke from Sydney on the contrary, to whom I have communicated my opinions during his visit here some months ago,[100] was at that time much in agreement and mentioned himself an occurrence of auriferous conglomerate of the coal formation on the Sydney side. His recently published book on the Sydney goldfields shows me, however, that unfortunately he has misconceived my idea, by saying that a 'member of the geological Survey of Victoria' had told him that it was very probable the older gold drifts of the diggings were partly the remains of destroyed 'Carboniferous Conglomerate'.[101] If Daintree finds gold in the conglomerates on his survey now begun again at Bacchus Marsh and he can connect it with the old gold drift hills of Mount Blackwood, the next goldfield, I will certainly give that interpretation of Clarke approval. However, only so far as I would understand the younger hills and leads under Clarke's older gold drift, which partly consist of the material of destroyed older, that is Carboniferous hills.

On the latest mineralogical new thing, the discovery of diamonds on the Ovens goldfield is of particular interest.[102] The first found of pea size even caused a discussion in Parliament. The stones would almost have disappeared, had the lustre not acquiesced with the report of Ford the chemist, who proved the hardness and specific gravity of the stone as agreeing with that of diamond. Besides the crystal form, a pure pyramidal octahedron with octahedral truncations as well as the particularly characteristic convexity of the faces allowed recognition of the diamond at first glance. The occurrence of gemstones in the gold drift on the whole aroused great attention here recently and sapphires, hyacinths, topaz &c have already been made known from various diggings.

Also recently in this regard I have done the 'Mining Community' a service by directing the attention of the diggers through the newspaper to the extraordinarily common occurrence of sapphires and hyacinths, rarely oriental rubies in the older gold drift of the Loddon River.[103] These gemstones are found mostly in every tin dish, which is washed from the base of the alluvium, and by no means seldom clear, of fine colour and lentil to pea size. Of the latter I am particularly convinced that even fine large specimens will be found, in that the most grains that I saw to judge from individual crystal faces and cleavage originated from larger crystals broken by the abrasion, perhaps even by the work in the drift. The zircons are mostly complete, however, only very simple crystals. I have one, which, certainly not common, is a pure quadrate octahedron. Another rare occurrence of zircon, which I have not found remarked on in any mineralogy, are columnar crystals that show dichroism. Seen from the side they are water clear, but in the direction of the column beautiful emerald green. In respect to the original deposit both of the sapphire and the zircon I entertain no doubt that it is a very old strongly weathered basalt on the upper Loddon River, because I have already washed out zircons previously and rare small sapphire grains both from the basaltic clay of the basalt escarpment and also from a soft whitish decomposed trap enclosed between hard basalt layers. Of other minerals hitherto unknown to us I can mention chabasite, which I found in small nests with aragonite in a very hard basalt resembling anamesite in the neighbourhood of the Clunes diggings. Furthermore I recognised analcime in an office hand specimen of amygdaloid basalt from Phillip Island. The crystals are tolerably water clear and nearly the size of a pea. The most interesting find and only made recently by Mr Wilkinson in a basalt quarry near Melbourne is, however, a zeolite species of the chabazite family completely unknown to me if not a new one.[104] The crystal sent (so isolated they are, however, a rarity) will show you the regular occurrence, of which I have not yet seen any deviation, except that the faces indicated in the corners of the hexagon stand out more distinctly as small triangles (rhomboid faces?) by flexure of the erect faces. Were the various re-entrant angles (which you will find by close inspection) not generally clearly to be seen on every crystal, I would be inclined to regard the mineral as gmelinite without the prisms; however, in this I have never seen re-entrant angles as far as I can remember, although one admits that its form also originates from rhomboidal intergrowth. In the case of levine the twinning formation is totally different. Herschelite and particularly lederite probably are closest to the mineral in question; however, without a reflection goniometer no determination can be made. Furthermore a particularly remarkable property of the crystals is that they develop into the most beautiful simple- and double-cross-like harmotome; prehnite-like intergrowths after the erect end faces, as herschelite is said to show, are very rare. I have not been able to produce cleavage with the greatest trouble and care.[105] The mineral gelatinises by employment of superficial qualitative analysis and I found much clay and lime, little alkali (consequently again only approximation to the gmelinite series). On an imminent visit to Melbourne I hope to make a quantitative analysis and will then be able to give you better results. Another find of mineralogical importance is that of a piece of native zinc (chemically pure according to Dr Macadam), now the third, in the younger gold drift of Creswick Creek.[106]

In addition beautifully preserved plant impressions suggestive of Oolitic age have been found recently at Queenscliffe where there is boring and costeaning for coal, among others several species of *Taeniopteris* of which one, I believe *Nilssoniana*, precisely characterises English and German Oolitic (Keuper?) coal measures. McCoy has named a new species *Taeniopteris daintreei* after my colleague Daintree, who first found them.[107]

EXTRACT FROM ULRICH LETTER 1861

Berg- und Hüttenmännische Zeitung 20 (45) (1861) p. 424.
Correspondence.

Notes from a letter of the government geologist, Georg Ulrich, dated: Geological Survey Camp, Strathlodden (near Melbourne), 4 June 1861, communicated by Bergamtsassessor Römer of Clausthal.

The region, which the author currently has to investigate and map geologically, likewise contains gold drifts and among these are distinguished newer Pliocene deposits, apparently covered sometimes by basalt. The region consists also of Silurian slates with graptolites and some fucoid beds. The slates are commonly broken through by basalt masses.

The author has recently found steatite pseudomorphs after quartz; likewise sapphires and splendid zircons, both in the older gold drift and the latter with dichroism, showing a beautiful emerald green colour parallel to the shorter axis. Diamonds were discovered recently in the Arena [Ovens?] goldfield. A large crystal of blue topaz has caused a veritable gemstone fever. In the Ararat goldfield quartz with gold and bromargyrite was found quite similar to that from Huelgoat.[108] In a basalt quarry near Melbourne a zeolite new for Australia was discovered, probably a twin form of chabazite.

An expedition, equipped with camels that departed eight months ago from here for the exploration of the interior has completely come to grief. In the beginning four men, among them our fellow countryman Ludwig Becker, died of fever. There is no further news and indeed the party took provisions with them only for three months. Now new expeditions are being equipped to search for those missing. One from here to Coopers Creek, another from the new colony of Queensland to the Albert River and a third per steamer to the Gulf of Carpentaria have departed some days ago.[109]

ACCOUNT OF DISCOVERIES 1864

***Berg- und Hüttenmännische Zeitung* 23 (42) (1864): 345–8.**

Mineralogical, geological and metallurgical items from the goldfields of South Australia by G. Ulrich*

** From an account by G. Ulrich from Zellerfeld, presently Field Geologist of the Geological Survey in Melbourne, to Bergrath F.A. Roemer in Clausthal. We are already indebted to Mr Ulrich for several interesting communications in this journal (1859, p. 26; 1861, 424). The editor.*

My present field of investigation, respectively mapping, is the Yardrit [Yandoit] goldfield[110] and the surroundings of Mt Franklin, one of the youngest basaltic craters, which has only poured out its lava stream after the present valley was already formed, that is this basalt covers not only the older and newer Pliocene gold drifts (stream gravels), but also the post Pliocene. The other lava streams cover only both of the former drifts and the valleys are washed out in them. It is truly astonishing what riches in the old auriferous drifts these basalt streams hide. New gold deposits (auriferous leads, drift leads) are continually being discovered. These are nothing other than old fully washed riverbeds, whose course on average is quite different from that of the present valleys (creeks) and rivers. Some even have quite an opposite fall. At the junction of Jim Croco [Crow] Creek with the Loddon River, it even seems that the old Loddon drift lead crosses the present Loddon valley, in fact originally higher, but at this point already lying about 10 feet deeper than the present riverbed.

On the Yardrit [Yandoit] goldfield, sapphires (blue and dirty green, the latter often the size of a hazel nut), zircons and a black mineral are frequently washed out; the latter according to its great hardness (over 5) should be regarded as corundum. It occurs in roundish grains at times in incomplete octahedra, which speaks very much for pleonaste. Cleavage is not noticeable and a chemical analysis has resulted in only iron oxide and alumina.[111]

From the Mt Eliza goldfield, 20 miles southeast of Melbourne, in a sample of black sand (collected in gold washing), I have found admittedly small, but complete crystals of ilmenite, a piece of wolfram, a beautiful rutile and also a noble ruby together with zircons.[112]

Concerning fossils, I discovered on the Yardrid [Yandoit] goldfield three excellent locations of graptolite slates, whose genera and species as far as I can judge exactly agree with those that Salter has described from the Skiddaw Slates (*Quarterly Journal of the Geological Society* 19 (1863).[113] However, there are some new forms as well. One of the localities (1–2 feet thick clays, separated by 6 feet sandstone, black and thickly fissured slates, very similar to the Harz Kellwasserkalke, but containing scarcely a trace of lime) is particularly noteworthy in that both the slate beds are tilted over and displaced several times by ramifications of a peculiar syenite and, although completely cemented into this rock in several places, seem only quite insignificantly altered (one can hardly say metamorphosed). I have collected a large number of good voucher samples, which show half syenite, half slate with well-preserved graptolites, particularly *Phyllograptus*.[114] The syenite takes up hardly six acres of space and the spot lies quite isolated in the middle of Silurian rocks, probably 25 miles from the nearest granite. The rock itself is remarkable by the diversity in the structure, which it showed in the 8 or 9 small shafts I had had sunk in it. From one shaft the rock looked like feldspar porphyry; the feldspar is without doubt albite, from another shaft it had the greatest similarity to granite, a third shaft showed nearly pure kaolin and the remaining shafts the syenitic character (hornblende and feldspar with little quartz) predominated.

In one of the richest auriferous quartz reefs here in the vicinity, the Eureka Reef,[115] I have discovered that the hanging wall of the same consists of a 1–2 feet thick basalt dyke (vein), which in places is porphyritic and includes large hornblende and mica crystals.[116] This dyke also seems to have exercised little or no influence on the adjoining rock and the reef, because in the latter pyrite and arsenopyrite have remained completely unaltered.

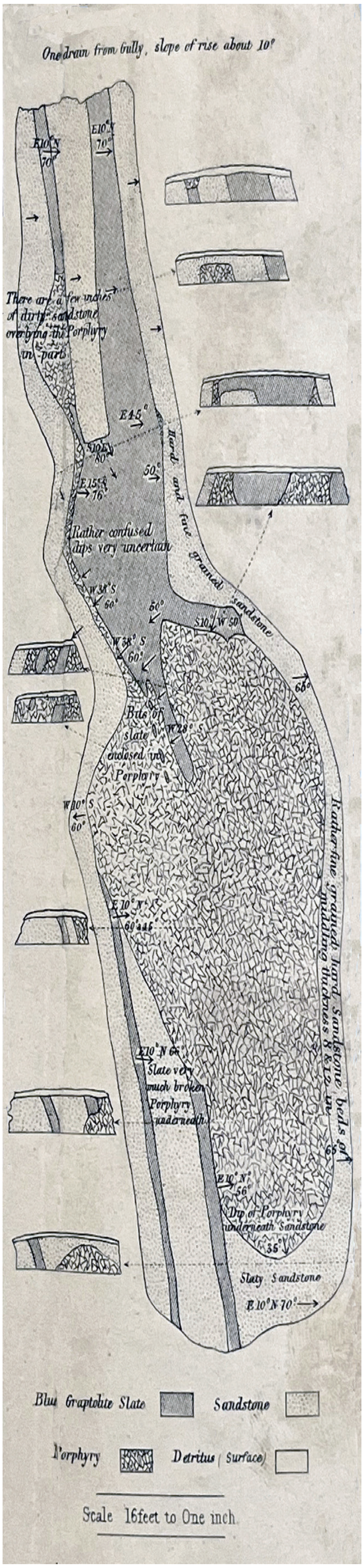

Figure 13: Sketch map of dyke drawn on the edge of Quarter Sheet 15 NE.

Some time ago in the vicinity of the Pick-pocket goldfield (part of Yardrit [Yandoit]),[117] my colleague Aplin and I found hausmannite and magnesite in the older drift (Hard Hills).[118] The former mineral forms the cementing material of the hard drift conglomerates, similar to limonite in other places and not rarely contains cemented gold. The drift, which lies around the old gold miners shafts, shows this manganese ore in numerous black grains and on closer inspection these appear in thin, often over one inch long, concretions, which completely have the appearance as if they would still continue to grow or would continue to creep through the drift. The magnesite is also remarkable on account of its formation. It is found on the slopes of a small hill of drift, which has not been washed down as far as the remaining drift deposit. However, its formation only has taken place where a 2–3 feet thick bed of white clay containing magnesia silicate and probably also magnesia hydrate is exposed to the atmosphere. Internally the clay bed is unchanged. The first appearance of the formation of the magnesite, undoubtedly by the carbon dioxide of the air, has great similarity to that of the small white spongy mould for which at first we also regarded the mineral. Each spot, where the clay in question lies free, is covered in a short time with numerous white specks, which show imperfect rhombohedral faces. At some places pea-sized grains are cemented together in fist-sized pieces. Some speculators have now leased the place from the crown to extract the magnesite for the production of magnesia salts.

Some miles from here a remarkable quartz reef, the Blacksmiths Gully Reef, is being worked,[119] which has produced a large number of very beautiful rock crystals (quite perfectly developed). The quartz of this reef contains on average 1 ounce of gold per ton and in it large cavities filled with brown clay occur, in which the rock crystals lie. In addition to these crystals in the quartz reef, albite and pholerite are also found, which I regard as particularly remarkable, the former often in quite good crystals. Some pieces of quartz can really be regarded as porphyritic binary granite. There is no doubt that in this case the feldspar was formed in a wet way.

In December last year I was sent to the St Arnand [Arnaud] goldfield to make an official report on the local greatly trumpeted silver ore reefs.[120] Of over 20 reefs that I investigated I found only one, the so-called Silver Reef, which really contained silver ore, in fact embolite, with gold. This reef is worked by the St Arnand [Arnaud] Silver Mining Association. The extraction of the silver and gold occurs only by the Freiberg amalgamation process and from the argentiferous tailings by means of sodium thiosulphate (according to Patera's method).[121] The latter process improved by Mr Foord,[122] the chemist of the company (and this improvement is patented) in so far that the boiling

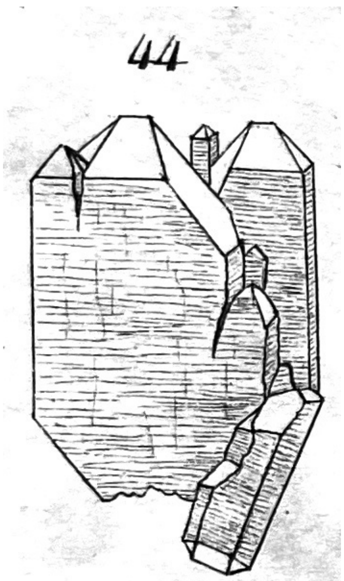

Figure 14: Quartz crystal from Blacksmith's Reef (2.8 cm high) (MV M9579) and sketch of the crystal from A.R.C. Selwyn & G.H.F. Ulrich, 1866. *Notes on the Physical Geography, Geology and Mineralogy of Victoria* (Melbourne). *Intercolonial Exhibition Essays 1866–67*, no. 3, plate 5, figure 44.

hot sodium solution (the manner of heating is secret) is conducted onto the tailings. Several large vats are each charged with one ton of tailings, 150 gallons of the solution of 1.2 specific gravity is led into each one and let stand for six hours. The argentiferous solution is drawn off into barrels; the silver precipitated by sodium sulphide, thereupon the dried silver sulphide is carefully roasted thoroughly in an oven and melted down. The tailings were leached with hot water (100 gallons) until such time as hydrochloric acid no longer produced a precipitate of silver chloride in the solution, the weaker solutison concentrated by evaporation and after that combined with the rich solution. The final tailings contain hardly ½ ounce (about 1 loth) of silver per ton.[123] The solution of sodium thiosulphate is used until the continually increasing admixture of sodium chloride makes recrystallisation necessary.

The silver reef strikes N35°W with a westerly dip of 70° and its thickness varies between 5 and 15 feet. Until now it is only opened up by three shafts, of which the deepest is hardly 150 feet deep. The reef, where it widens, consists of an irregular network of quartz veins and black reef clay slate. The quartz is generally friable and corroded. The embolite, cubes with octahedra, is found in the cavities together with mimetite, not uncommonly in spear-shaped crystals (columns with pyramids) of white or yellow colour. Cerussite, malachite and scorodite are found in very small crystals. Except pyrite and arsenopyrite together with some chalcopyrite, no sulfurated ores occur. Galena and probably silver sulphide and pyrargyrite will probably be found at greater depth. In the hard quartz native silver and a gold–silver alloy together with gold is also found. Pyrolusite is the youngest formation, since it incrusts the above minerals when in contact with them. The yield of the reef is on average ¾ ounce gold and 45 ounces of silver to the ton.

Another very interesting reef is the Wilsons Reef, two miles south in the strike of the Silver Reef. It is nearly 400 feet long and at the surface 100 feet thick. To the south it divides into three 4–20 feet thick breccias; to the north it disperses into countless small veins. Its strike is N35°W (in the strike of the strata) and its dip is 76°W. It is opened up to 300 feet deep, where its thickness still amounts to 65 feet. Payable gold has until now only been found 6–12 feet wide in the hanging wall of the reef; 10–12 ounces per ton from the surface to 40 feet deep. From there down it rapidly becomes poorer and at 300 feet the quartz hardly pays ½ ounce to the ton. The thickness at this depth is 15 feet and the mass consists of hard and corroded quartz veins and black, very carbonaceous reef clay-slate. The former contain the most gold and besides are sprinkled with pyrite and arsenopyrite. In the corroded veins, there are small leaders and nodules of galena, pyrite and arsenopyrite and the cavities are filled partly with friable galena, which contains grains of native sulphur, and lined with adamantine lustrous crystals of cerussite and mimetite, rarely with anglesite. Also sometimes fine grape-like olivenite, and the black reef clay-slate is rich in dendritic particles of native copper (somewhat auriferous), which are composed of small twin crystals (cubes, octahedra and dodecahedra). The remaining mass of the reef consists of hard quartz, which gradually becomes richer in arsenopyrite and pyrite at depth.

The St Arnand [Arnaud] United Mining Company, which works the Wilson Reef, has a very fine battery with 24 stamps according to the latest construction. The stamps have iron shanks and self stirring. The battery box is solid cast iron and has hollow beds, under which the most and heaviest gold collects. The sludge overflowing at the front and on both sides goes firstly through two mercury troughs then over 16 feet long slime tables, five each for 12 stamps and finally through a third mercury trough. The table slime is amalgamated in rotating barrels. Despite careful stamping under water and proceeding in the former manner, much gold is indeed lost, almost as much as is obtained in consequence of the weight of the ore, mainly the galena, which very soon accumulates in the mercury troughs and on the tables and makes the fine gold wash away. Nothing is done at all for the recovery of this ore, despite the galena containing about 12 ounces gold per ton.

The Chrysotile Company, which works the three rich southern leaders of Wilsons Reef, has little galena, but all the more pyrite and arsenopyrite, which according to assays contain up to 100 ounces of gold to the ton. Also here nothing is done for getting it and for extraction of the gold. The battery of this company had 12 rotating stamps (Stephenson's Patent) and the frame is completely of iron. The gold extraction apparatus is the same as in the previous company: only three troughs are at the foot of the tables. The rotating stamps have come into use very much here in the last two years. It is true that they haven't such a large crushing surface as the rectangular ones have, but have the advantage that the surface remains flat through the constant rotation going on with each stroke and therefore in the long term has a better efficiency than the other stamps, which wear out irregularly. Recently an improvement of the latter has been made in that they are cast completely square and the shank forged round at some height over the battery box, whereby the stamp, when raised, can be turned round 90° or 180° as desired.

In addition I must mention some mineralogical and geological news. In a basalt quarry near Melbourne, a new zeolite has been found, which without doubt belongs to the class of chabasite, but according to the crystal form matches exactly neither with levine nor gmelinite (ledererite, herschellite &c), to which it is otherwise very similar. The crystals, thin hexagonal plates, are often perfectly round, but occur usually in vughs, not rarely intergrown like harmotome.

In the older basalt of the Wirribee [Werribee] River, 50 miles from Melbourne near Ballan, my colleague Daintree found beautiful chabazite. My colleague Aplin recently brought in very beautiful zeolites from a small island (Phillip Island) that lies in Western Port (60 miles south east of Melbourne), as well as nodules of chalcedony, which occur there in an amygdaloid basalt (older basalt). The zeolites are natrolite, analcime and much rarer gmelinite. At the same time veins of ankerite occur in this amygdaloid. At the McIvor or Hathcote [Heathcote] goldfield, antimony ochre is found very abundantly in the commonly rather thick (1–3 feet) stibnite reefs there, but chalcostibite and cuproplumbite are rather rare. However, all these ores have not yet been observed as crystals. The interest in the occurrence is that they are frequently sprinkled with native gold. In the vicinity of Heathcote, chromite and chrome ochre are also found. Earthy vivianite and covellite are found at the Dunally [Dunolly] goldfield; beautifully pink rhodochrosite like calc sinter and philomelanite are found in the Clunes quartz reefs. Molybdenite in rather good crystals was recently discovered at Beechworth goldfield in a quartz reef, which intersects the granite. This ore was regarded as graphite and has bitterly deceived several speculators.

Another interesting occurrence is the extraordinarily rich quartz reefs (?), which were discovered some months ago at Woods Point in Gippsland. These form more or less flat beds of 2–8 feet thickness in a 2–300 feet thick diorite reef, which lies in the strike of the Silurian strata. The diorite stock outcrops on the slope of a very steep mountain (Woods Point) and the auriferous reefs, of which there are already four, are found one under the other, and were mined by adits. The quartz pays from 10–50 ounces per ton and the four owners of the All Nations claim earn on average £600–800 Sterling per week each. In ten days 1640 ounces were obtained. In the quartz, I observed stibnite, pyrite, galena and pyrrhotite interspersed. The latter mineral also occurs heavily interspersed in the rich quartz reefs of Raspberry Creek, some miles from Woods Point.[124] The Australian Alps in Gippsland seem to harbour astonishingly rich golden treasures and are now being investigated with great enthusiasm.

On the Ovens goldfield (Morses Creek)[125] beautiful almandines are found in the alluvial deposits and the occurrence of diamonds there recently has been put beyond all doubt by the finding of several of ½–2 carats weight. However, the most interesting occurrences on this field in a clay or in the granite are irregular pseudocrystals of carnelian with liquid and air bubbles of needle head to pea size. [126]About 80 such specimens have been discovered. According to an analysis by Mr Foord, the liquid is said to consist only of water. With reference to the formation of these crystals (polyhedra without any regularity), it is not improbable that the clay in which they are found originally consisted of feldspar crystals or contained them in large numbers and that the silicate of the pseudocrystals gradually precipitated in the interspaces of the feldspar crystals (from outside to inside), until finally closing the inflow opening and the last remains of the silicic acid crystallised out as quartz (all crystals show it) on the inner walls of the cavity and the water remained behind. Strangely the pseudocrystals are much harder than topaz, as they strongly scratch the latter.

At the Lal Lal River, 13 miles easterly from the town of Ballarat, a bed of lignite 105 feet thick was discovered, entirely solid and, as far as bore holes and shafts prove, of 1½ square miles in extent.[127]

Through the success of my colleague Daintree in the photography of geologically remarkable spots, fossils &c, Mr Selwyn hit on the idea of providing each field geologist with a good camera and landscape lens and so I also have a very good one and have already made a number of very nice photographs.[128] We prepare the plates according to the tannin or dry process in the Melbourne laboratory, 1½ –2 dozen at once and take and develop the pictures afterwards as the opportunity offers. The development of the pictures occurs often months later without the slightest deterioration of the plates, which particularly is a feature of the tannin process. Lithographs are to be made after the photographs and the latter are to accompany the geological reports or the former are to be printed on the margins of the relevant geological maps &c, &c.[129]

Acknowledgements

I am most grateful to Bill Birch and Clive Willman for their comments and suggestions on the original draft of the translation and also to Mr Eric Wilkinson of Bendigo for information on some of the localities and features mentioned in the text. Bill Birch and David Holloway kindly assisted in providing illustrations.

Conflict of interest: The author declares no conflict of interest.

Endnotes

1 There were very few such publications prior to 1858 and these were published in England, for example: G. H. Wathen, 1853. On the gold fields of Victoria or Port Phillip. *Quarterly Journal of the Geological Society of London* 9 (1): 74–79. H. Rosales, 1855. On the gold-fields of Ballarat, Eureka and Creswick Creek, Victoria. *Quarterly Journal of the Geological Society of London* 11 (1): 395–399. The more comprehensive accounts are A. R. C. Selwyn, 1861. Geology of the Colony of Victoria in *Catalogue of the Victorian Exhibition 1861, with Prefatory Essays, indicating the Progress, Resources, and Physical Characteristics of the Colony* (Melbourne) 2nd edition pp. 147–162 and A. R. C. Selwyn & G. H. F. Ulrich, 1866. *Notes on the Physical Geography, Geology and Mineralogy of Victoria* (Melbourne). *Intercolonial Exhibition Essays 1866–67* No 3 (This work was published separately but also included in various editions of the Official Record of the Exhibition). G. H. F. Ulrich, 1857. Minerals of Tarrangower. Quartz reefs. *Facts and Figures* 1(7): 50–51 is one of the few technical papers published in Melbourne.

2 See T. A. Darragh, 2001. Ferdinand Hochstetter's notes of a visit to Australia and a tour of the Victorian goldfields in 1859. *Historical Records of Australian Science* 13 (4): 383–437.

3 It was not listed in R. Etheridge & R. L. Jack, 1881. *Catalogue of works, papers, reports and maps, on the geology, palaeontology, mineralogy, mining and metallurgy etc. of the Australian Continent and Tasmania* (London), so was unknown to Robert Etheridge, who was one of Ulrich's colleagues on the Geological Survey of Victoria. It was listed in C. Anderson, 1916. Bibliography of Australian Mineralogy. *New South Wales. Department of Mines. Mineral Resources* 22, p. 54; however, it is clear Anderson never saw the publication as he recorded no mineral occurrences from it. Some information from Ulrich's paper provided by this writer was used by Bill Birch in his paper on native zinc (note 30).

4 For further details of Ulrich's education and career see W. D. Birch & T. A. Darragh, 2015. George Henry Frederick Ulrich (1830–1900): pioneer mineralogist and geologist in Victoria. *Proceedings of the Royal Society of Victoria* 127: 17–38.

5 The date of the latest information in the paper that has been ascertained is mention of John Dembinski's letter of 6 November 1857 on the origin of gold in reefs.

6 Presumably Geological Survey of Victoria was meant. Ulrich was appointed to the Survey as field geologist in September 1857.

7 Probably Phillips, J. A., 1852. *Gold-Mining and Assaying: a scientific guide for Australian emigrants.* London. This book has chapters on some New South Wales goldfields as well as on Ballarat and Mount Alexander. Westgarth, W., 1857 *Victoria and the Australian Goldmines in 1857*. London. This work arrived in Victoria on October 1857 and was advertised for sale in Melbourne that month. See for example *Age* 16 October 1857, p. 4; *Argus* 21 October 1857, p. 3. Eades. It is not clear who this author could be, so perhaps a spelling or compositor's error for Earp, G. B. 1852. *The Gold Colonies of Australia*. London, or Earp, G. B., 1853. *What we did in Australia.* London. G. H. Wathen, whose book Ulrich cites in the next sentence, had a chapter on the geology and another on the discovery of gold in Victoria.

8 Tarrengower later known as Maldon. Ulrich spelt the name Tarrangower. The official spelling on the Register of Geographic Names is followed.

9 Gold returns for 1857 were published in January 1858. See *Argus* 16 January 1858, p. 5.

10 Blanche Barkly Nugget found on 27 August 1857 by Robert and James Ambrose and Samuel and Charles Napier. *Argus* 14 November 1857, p. 4. Its recorded weight was 1743 oz. *Age* 14 November 1857, p. 5; 24 November 1857, p. 6. According to Samuel Napier's account the weight was 146 lb 4 oz 3 dwt. *Bendigo Independent* 9 May 1903, p. 3. Ulrich's figure of 140 pounds is 2042 troy ounces.

11 When self-government was introduced in 1856, parliament consisted of a lower house, The Legislative Assembly, and an upper house, the Legislative Council. The latter was established in 1851 when Victoria separated from New South Wales.

12 This refers to the Eureka Rebellion in December 1854, which implies Ulrich wrote this account in late 1856 or early 1857, which is not the case.

13 This refers to McDonald's paddock at Clunes, which was rushed in 1855. Gold was discovered there in 1851, but later the land was sold. The reefs were worked by the Port Phillip Gold Mining Company.

14 The bill was to be introduced in October 1858, but was never passed into law. A law on mining on private property was not passed by both houses of Parliament until 1884.

15 Four km E of Harcourt.

16 Amphitheatre is about 10 km SSW of Avoca. Glen Patrick is 13 km SW of Avoca.

17 Daisy Hill is 7 km S of Maryborough.

18 Probably Pearl Croydon Dyke.

19 What is now regarded as Ordovician. Ulrich used the term older or Lower Silurian for rocks that are now called Ordovician. The name Ordovician was introduced in 1879 to replace Lower Silurian.

20 It is not clear where Ulrich got his information on basalt in the Gulf of Carpentaria region (possibly from Leichhardt's account or Gregory's expedition); however, it is not correct.

21 Alfred Richard Cecil Selwyn (1824–1902) worked in Victoria from 1852 until 1868.

22 The trap penetrating the granite in fact refers to lamprophyre dykes of late Jurassic age that occur at Bendigo and penetrate the Harcourt Granodiorite at Harcourt and not basalt. See C. Willman & H. E. Wilkinson, 1992. Bendigo Goldfield. *Geological Survey of Victoria Report* 93, p. 20.

23 Native iron has not been recorded in the basalt and olivine is an essential constituent of the basalts.

24 Taken from Selwyn's report to Parliament Paper no 1854/A21, p. 8 but not a literal translation.

25 Hor 11–12 refers to the direction of strike using the hours of a clock face with 12 pointing north.

26 Jim Crow, a hill near Franklinford. Possibly means the volcano Mount Franklin as Jim Crow is not volcanic, according to R. P. Whitworth, 1865. *Bailliere's Victorian Gazetteer and Road Guide*. Melbourne, p. 197. The name Jim Crow for the nearby creek is soon to be changed to Larni Barramal Yaluk. Larn-Ne Barramul was the Aboriginal name for Mount Franklin.

27 All these latter group of volcanic hills are in the Sunbury–Gisborne area, visible from the road to Bendigo.

28 Lake Purdiguluc, the largest of the Warrion Hills lakes.

29 W. Westgarth, 1846 *Tasmanian Journal of Natural Science* 2: 402, but not a literal translation.

30 L. Becker, 1857. Native zinc embedded in basalt. *Transactions of the Philosophical Institute of Victoria* 1: 157–158. Ulrich modestly failed to mention that he provided a report of his blowpipe analysis of the zinc that occupied about half the paper. See W. D. Birch, 2001. Native zinc from Brunswick, Victoria, Australia: The case for and against a type locality. *Australian Journal of Mineralogy* 7(1): 27–34.

31 *Herald* 23 July 1857, p. 6; *Age* 3 August 1857, p. 5.

32 Scolecite has not been recorded in the Victorian basalts. He probably meant natrolite.

33 This substance cannot be identified at present.

34 For an account of Melbourne zeolites including historical information see D. G. Vince, 1989 Melbourne in W. D. Birch (ed.) *Zeolites of Victoria. Mineralogical Society of Victoria Special Publication* 2: 1–30.

35 It is not clear where Ulrich obtained this material.

36 No known basalt has been found with texture.

37 Parliamentary Paper 1855–56 A108, pl 14. Not a literal translation.

38 What is now regarded as Ordovician. See note 19.

39 Parliamentary Paper 1854 A21, p. 10.

40 See note 25.

41 Edward Hitchcock, 1853. *Outline of the Geology of the Globe, and of the United States in particular: with two Geological Maps and Sketches of characteristic American Fossils*. Boston, Phillips, Sampson & Co., 1853. pp. 136, 6 plates of fossils, 2 maps.

42 The period of time preceding the appearance of life on earth.

43 William Branwhite Clarke (1798–1878); see ADB. Christopher D'Oyly Aplin (1819–1875) see J. T. Woods, 1964. C. D'Oyly H. Aplin, first Government Geologist for the Southern District of Queensland. *Memoirs of the Queensland Museum* 14(4): 107–114. Aplin discovered graptolites at Keilor in June 1856 when mapping Quarter Sheet 1NW.

44 This information had not been published at the time Ulrich wrote his paper.

45 Not *Lingula*, but a phyllocarid arthropod. For a correction to this identification see Ulrich's letter to Hochstetter below.

46 Elongate concretions that resemble a straight-coned elongate Palaeozoic cephalopod shell.

47 Unfortunately never published, if it was written.

48 Lilydale Limestone.

49 Johann Friedrich August Breithaupt (1791–1873). Professor at the Freiberg Mining Academy. It is not clear which of his works Ulrich was referring to, but probably *Die Paragenesis der Mineralien* 1849, Freiberg, where 'edle Quarz-Formazion' is dealt with on page 148.

50 The Mariners Reef at Maryborough was at that depth in October 1857.

51 C. J. Brown and Henry Brown discovered Brown's Reef in 1854. See *Argus* 16 July 1897, p. 7.

52 Parliamentary Paper 1854/A21, p. 9. Ulrich's translation is more an extensive synopsis or recapitulation than a literal translation.

53 Despite the evidence present here, the theory that the gold originated from the granite was current well into the second half of the 20th century.

54 Harcourt Granodiorite.

55 Blue Hills between Maldon and Shelbourne part of the Harcourt Batholith. See D. P. Cherry & H. E. Wilkinson, 1994. Bendigo and part of Mitiamo 1:100,000 map. *Geological Survey of Victoria Report* 99.

56 Kangaroo Reef about 0.5 km east of the Kangaroo Creek near Taradale is marked on Quarter Sheet 9SW with a note (4).

57 I have assumed that Ulrich would have used the Hannovarian Lachter (1.92 m) rather than the Prussian Lachter (2.092 m) as he was educated at Clausthal in Hannover.

58 Frenchmans Reef is situated on Kangaroo Creek about 1.3 km north of and on the strike of Kangaroo Reef, marked on Quarter Sheet 9SW with a note (3).

59 Ulrich is probably referring to *An Act for amending the Laws relative to the Gold Fields* 24 November 1857, which came into force in January 1858.

60 Due north of the town of Maldon close to the granite.

61 Mariners Reef, Maryborough, situated just south of the main town east of the Goldfields Reservoir.

62 In reporting on the Mariners Reef, this figure was stated by a report in the *Bendigo Advertiser* (26 October 1857, p. 2) taken from the Progress Report of the Mining Commission.

63 Heathcote.

64 A substance found in the flue of a smelting furnace, usually referring to zinc oxide rather than to a lead compound.

65 St Arnaud.

66 At Long Gully, about 3 km NW of the centre of Bendigo.

67 American Gully is on the Maiden Gully side of Windmill Hill. It drains westward, and is the opposing drainage to California Gully which starts on the California Gully side of Windmill Hill and drains eastwards.

68 *Argus* 6 November 1857, p. 6. Dembinski wrote several letters to newspapers on the subject from 1856 to 1857.

69 John Ravicz Dembinski (c1828–1858). *Age* 27 March 1858, pp. 4–5. Dembinski undertook a number of experiments on extraction of gold from quartz.

70 Charles Kinnear patented his Pulveriser and Amalgamator in Victoria in August 1854. See *Argus* 19 August 1854, p. 7. Description in *Leader* 14 September 1867, p. 30. Kinnear was born in London on 30 January 1800 and died at Ballarat on 19 March 1876 (*Ballarat Star* 20 March 1876, p. 2).

71 Johann Gottfried Christopher Ballerstedt (1795–1869). Obituary in *Bendigo Advertiser* 18 October 1869, p. 2.

72 £6750–£9000 Sterling.

73 A process whereby the gold is separated from the ore by fusion with lead.

74 I have not been able to trace this person.

75 *Argus* 10 October 1856, p. 5; 23 February 1857, p. 6.

76 *Argus* 30 March 1857, p. 7.

77 Carl Friedrich Plattner (1800–1858), professor at the Bergakademie, Freiberg.

78 David Wilkinson (1806–1877), civil engineer. Born at Welford, Northamptonshire, Wilkinson arrived in Melbourne with his wife and five children aboard *Marlborough* on 2 November 1852. He took out several patents in the 1850s and 1860s, including the April 1857 patent mentioned by Ulrich. Lived in Prahran; see his letter *Ballarat Star* 22 February 1858, p. 3. He was the father of Charles Smith Wilkinson, geologist, who later worked for the Geological Survey of Victoria, and became Government Geologist for New South Wales. David Wilkinson died on 20 June 1877, aged 71 at Burwood, Sydney, *Argus* 2 July 1877, p. 1.

79 This is a mixture of minerals, not a distinct mineral in its own right.

80 Specimen Hill, Chewton.

81 German Reef is on the east side of Maldon township.

82 On the east side of Maldon township, north of German Reef.

83 1/12 of an inch.

84 Coliban Reef at Malmsbury.

85 Siebenbürgen. The German name for Transylvania now in Romania, but at that time part of Hungary.

86 It is not clear why these sentences are in quotes. The idea that the auriferous reefs would become poor at shallow depth was originally promulgated by Roderick Murchison and the idea received strong support in Victoria from Frederick McCoy (see T. A. Darragh, 1987. The Geological Survey of Victoria under Alfred Selwyn, 1852–1868. *Historical Records of Australian Science* 7(10): 1–25.

87 Unfortunately Ulrich did not write a continuation.

88 Christian Gottlieb Ferdinand Hochstetter (1829–1884) visited Victoria in October and November 1859 on his way back to Europe from New Zealand. He left Melbourne aboard *Benares* on 18 November. T. A. Darragh, 2001. Ferdinand Hochstetter's Notes of a Visit to Australia and Tour of the Victorian Goldfields in 1859. *Historical Records of Australian Science* 13 (4): 383–437.

89 Strathlodden was an old pastoral station. Ulrich's camp was at Yapeen close to Mein's White House, Yapeen, which was within the old boundaries of Strathlodden. The map was published as Quarter Sheet 15NE Guildford.

90 *Phyllograptus*. Fossil localities Ba 8 and Ba 9 are marked close to Ulrich's camp.

91 I've not yet found where Selwyn published such a view.

92 White Hills Gravels of late Cretaceous-earliest Tertiary age. See D. P. Cherry & H. E. Wilkinson, 1994 note 55.

93 Calival Formation of Eocene to Oligocene age. See Cherry & Wilkinson, 1994, note 55.

94 Welsh Mountain, Fryers Creek is actually Welch Mount, at head of Poverty and Old Butchers Gullies, tributaries to the east of Fryers Creek near Irishtown.

95 1 Ell is about 60 cm.

96 The distance from Campbells Creek to Daisy Hill is about 42 km due west.

97 Richard Daintree mapped Quarter Sheets 11NE Mt Bullancrook [sic] (partly mapped and never published), 12SE Darley.

98 These sandstones proved to be Permian in age.

99 This must have been a personal communication as Daintree had not published anything up to that time.

100 Clarke arrived in Melbourne from Tasmania 18 April 1860. *Argus* 19 April 1860, p. 4.

101 W. B. Clarke, 1860. *Researches in the Southern Goldfields of New South Wales*. Sydney, p. 252 "it is surmised by a member of the Geological Survey of Victoria, that some of the gold-bearing quartz drifts above the Lower Silurian rocks at the White Hills, Bendigo, have been originally derived from the conglomerates of the Carboniferous formation."

102 Ovens diamonds. *Age* 8 May 1860, p. 5. Discovered by one O'Niel in the black sand of Sebastopol, Ovens diggings.

103 Ulrich's newspaper report re gemstones *Mount Alexander*

Mail 25 July 1860, p. 2 (short report made no mention of Ulrich); 27 July 1860, p. 4 (long report with note by Ulrich).

104 Found in one of the Richmond quarries by Charles Smith Wilkinson (1843–1891). He joined the Geological Survey as an assistant on 15 December 1859 and was appointed Daintree's assistant.

105 The mineral is phillipsite.

106 A specimen of native zinc from Deep Lead, Creswick Creek, was exhibited at the 27th August meeting of the Royal Society of Victoria and presented to the society. *Age* 28 August 1860, p. 5.

107 *Taenopteris daintreei* was published by McCoy in 1860 without formal diagnosis. It was formally described and illustrated in 1875.

108 Huelgoat, Finestère, France.

109 Victorian Exploring Expedition (Burke & Wills).

110 Quarter Sheet 15 SE Yandoit.

111 Pleonaste is a variety of spinel, so not corundum.

112 Tubba Rubba Creek, about 8.4 km east of Dromana on the Mornington Peninsula.

113 J. W. Salter, 1863. Note on the Skiddaw Slate Fossils. *Quarterly Journal of the Geological Society of London* 19 (1): 135–140, Figs 7–15.

114 Quarter Sheet 15 NE. The fossil locality is Ba 8. The syenite dyke is near the southern edge of the map. A sketch of the outcrop of the syenite is given in the right-hand margin of the map (note 20).

115 Marked in the northeast corner of Quarter Sheet 15 NE. Note 1.

116 Not basalt but lamprophyre.

117 Marked in the southwest corner of Quarter Sheet 15NE. It is 4 km north of Yandoit, just west of the Newstead-Daylesford Road.

118 Probably not haussmanite, but one of the black manganese oxides that are common in the weathered zones in gold country. They need to be X-rayed to identify the species. For the magnesite see QS 15NE note 34, rock specimen Ra 81.

119 Presumably Blacksmiths Gully reef marked on the western edge of QS 9NW Taradale.

120 G. H. F. Ulrich, 1864. Gold and Silver Bearing Reefs of St Arnaud. *Victoria. Votes and Proceedings of the Legislative Assembly* 1864, paper 44.

121 This process was introduced at Joachimsthal, Bohemia, in 1856 by Adolf von Patera (1819-1894).

122 George Foord, one of Melbourne's best known analytical chemists, was born in London on 5 June 1822 and died at Burwood, Victoria, on 15 May 1898. Foord and his wife arrived in Melbourne aboard *Marlborough* on 4 November 1852. He set up an assay office at 46 Collins St east in March 1853. *Argus* 11 March 1853, p. 12; 18 May 1898, p. 1.

123 1 Loth is 14.62 gram.

124 Raspberry Creek, a tributary of Gaffneys Creek. Mining took place about 9 km northwest of Woods Point.

125 Wandiligong goldfield on Morses Creek about 5 km south of Bright.Not sure about diamonds from there.

126 Enhydros or water stones. Discovered by E. J. Dunn at Pennyweight Flat.

127 Lal Lal is in fact about 19 km southeast of Ballarat. The Lal Lal coalfield was discovered by gold miners and worked from a shaft sunk by the Victoria Lignite Company from about 1863. *Mining and Geological Journal* 3 (4): 11; 4 (2): 52-55.

128 No photographs that can be attributed to Ulrich have been found.

129 The only instance of such a lithograph on a map was taken from one of Daintree's photographs and printed on the margin of Quarter Sheet 28SE Puebla.