Why is That Hole so Big? An Analysis of Expenditure Versus Gain in Alluvial Gold Mining

COSMOS CORONEOS

The type of method employed in working alluvial gold deposits is the result of a series of decisions about balancing capital expenditure against expected gains. Some of the factors influencing those decisions include the size of the lease, the nature of the terrain, the availability of water, and the costs of equipment and supplies. These factors are considered using the case study of the Lisle-Denison goldfield of north eastern Tasmania.

When walking across an alluvial goldfield one is confronted with an array of mounds, holes, channels and trenches varying in size and complexity. Explanations for why certain types of methods of mining were employed vary from constraints imposed by terrain to cultural preferences. While these interpretations are applicable, the bottom line when it comes to the scale of, and methods used in, alluvial gold mining, centres on the balance between expenditure versus gain.

This article examines a segment within the wider study of the archaeology of mining; the circumstances surrounding expenditure versus gain in alluvial gold mining. Such a study is of relevance when it is considered that the 'industry and social structure of a mining town was determined to a great extent by the nature of its ore deposits.'[1] This observation is more fully articulated by Lawrence:[2]

> The location of mineral deposits fixed the mines and hence the settlement in space. The distribution of the mineral through the soil determined how it could be worked and for how long. This in turn structured the placement of the workings and the kind of workings necessary. It determined if the gold could be worked by small groups of individuals or by large groups of capitalists. It determined if the industrial plant were to be shovels and cradles, sluice boxes and a giant nozzle ... The kind of mine determined the kind of settlement: would it be a few scattered temporary tents, or a city of timber and stone? Gold was the basis of work and work was the foundation of community. To understand community at Dolly's Creek it is necessary to begin with the work of mining the gold. The work, its nature and location framed the settlement and the community that grew in it. [This] shaped the activity on the field and determined the kind of physical remains that were left.

The study of the remains of alluvial mining and the principles which dictated the methods used quite often supplement and confirm what is already known about a goldfield through historical sources and/or the archaeological investigation of the habitation components of the goldfield. However it is not always this straightforward. With short-lived alluvial goldfields the associated settlements were composed of equally ephemeral structures which makes their identification and interpretation within an often confused cultural landscape, difficult. Invariably such fields would not have attracted great interest from contemporary commentators, namely journalists and government geologists, and consequently historical documentation would be scant. By understanding the relationship between the effort expended in mining and the estimated returns the archaeologist can make some sense of the remains observed on the goldfields where the more conventional indicators are absent or limited. Through such means the relative richness of a field and the type of miner involved can be estimated.

More importantly, the application of the understanding of why certain forms of mining took place at certain times and locations would assist in the reconstruction of the evolution of a goldfield, through the relative and absolute chronology of the various forms of mining used and their spatial distribution over a goldfield landscape. As will be shown in this article there is a progression and correlation between the methods employed, the total area of a goldfield actually mined and the size of the mining population. To illustrate this point the Lisle goldfield, in Tasmania, will be presented as an example. The Lisle goldfield example will demonstrate that as the mining population of the field decreased, larger ground moving methods of mining were employed and the size of the field expanded.

The Lisle goldfield will be referred to throughout the article, as the field displays some of the problems that may make the interpretation of goldfields difficult. Namely, the townsite and the satellite habitation areas of the nineteenth century have been obliterated by later mining leaving only the alluvial mining remains. Furthermore the Lisle goldfield is a useful baseline study for the principles presented in this article as no quartz or hard rock mining ever took place there, leaving the alluvial mining remains uncontaminated by other forms of mining. Lastly, the Lisle goldfield has been extensively surveyed and the archaeological landscape is relatively well understood.[3]

The Lisle goldfield is one of seven goldfields situated amongst the foothills of Tasmania's mountainous north east region, approximately 50 kilometres from Launceston (Figs 1 and 2). Discovered in 1879, the population of the field peaked in that year at 2 300. It is estimated that Lisle in its first year produced 42 000 ounces (11 907 kg) of gold making it Tasmania's largest ever alluvial goldfield. The evolution of the Lisle goldfield after the initial gold rush was unlike most other Australian goldfields. The primary gold deposits that shed the alluvial gold were not, and still have not been, located; hence the transition of the goldfield occupation into a stable and permanent settlement never took place. The population declined markedly in the two years after the discovery of Lisle with 350 inhabitants, 185 of which were male, remaining on the field in 1881. By the 1890s the mining population of the goldfield oscillated between 20 and 70 males.

Alluvial mining continued throughout the nineteenth century with ground sluicing techniques being mostly employed for gold recovery.[4] The inhabitants supplemented their gold earnings with agriculture and timber getting. A change to the pattern of mining took place in 1901 when a dredge was put to work on the flooded ground adjacent to Lisle Creek. This enterprise produced unsatisfactory results and the operation was closed down two years later. More far reaching in terms of the mining development of the goldfield was the introduction of hydraulic sluicing during World War I. The infrastructure, in the form of an extensive system of water races, was put in place by a handful of small companies. The

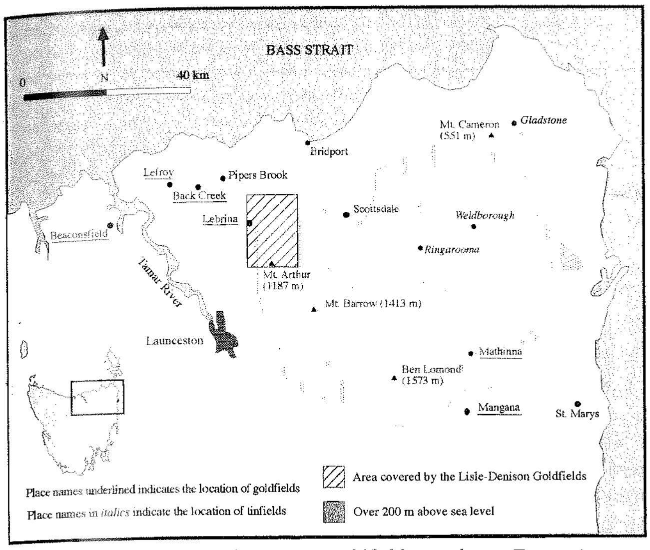

Fig. 1: Location of the Lisle-Denison goldfields, north east Tasmania.

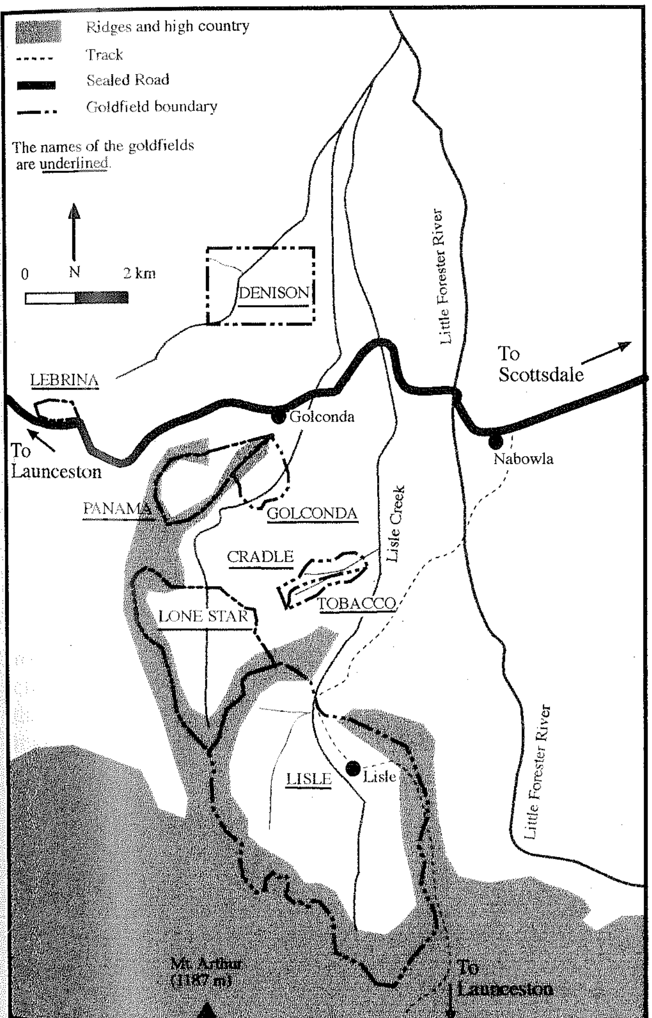

Fig. 2: Lisle-Denison goldfields, area map.

gold output of the Lisle goldfield was greatly increased by the application of hydraulic sluicing but the companies soon folded as their earnings could not pay off the initial outlay in capital involved in the setting up of their operations. Individual miners bought up the leases, the rights to the water races and the plants left behind by the companies and hydraulic sluicing continued between the Wars.

After World War II the pattern of mining was altered again with the pervasive use of carbon fuel based engines in a wide variety of applications. Pumps recirculated the water used in hydraulic sluicing which did away with the reliance on water races. Motor vehicle access meant that Launceston was less than two hours away and therefore not all the miners lived on the field. In 1948 there were only 24 residents in Lisle and the closing of the Post Office in 1950 signified the end of permanent settlement. In the 1970s the practise of hydraulic sluicing was stopped in recognition of the environmental damage that was being inflicted, in particular to the silting of Lisle Creek, which adversely effected dairy producers downstream. The form of mining that has replaced hydraulic sluicing is a radical departure to what had been practised previously. The points of extraction of gold bearing wash and the processing plant are now separated by kilometrės. Mechanised excavators range across the goldfield selecting choice patches of ground. Processing points are suitably located on level ground where the discharge from the treatment plants empty out into tailing ponds which cover extensive areas of ground.

THE CHOICE OF MINING METHODS

The decisions about what mining methods to employ on any patch of ground is based on a balance between expenditure and gain. That is, the 'objectives of goldmining ventures were to maximise the throughput of goldbearing material, whilst attaining the greatest efficiency in gold saving for the minimum cost in terms of time, labour and expense'.[5] Expenditure versus gain is a governing principle not only in mining but in any enterprise. What follows is a discussion of the variables involved.

It is often said that certain forms of alluvial mining are dictated by the terrain, but terrain is just one mitigating factor bearing on cost, the primary consideration for the choice of alluvial mining method employed. In engineering terms it is possible to undertake large scale sluicing in the arid regions around Kalgoorlie. Possible but not feasible: the costs involved in bringing in water makes such a venture financially prohibitive. What is always taken into consideration is whether the method employed will give a profit given the amount of gold on a claim.

What constituted a profit depended very much on the type of miner and operation involved. Generally there were two types of alluvial gold miner, one of which was the stereotypical itinerant or ephemeral digger who prospected alone and/or rushed from one new goldfield to another. Indicative of such a character was the hope of a rich strike which meant that he invested little in equipment and lived day by day on a subsistence level earning enough gold to make "tucker" until the time he dug up his fortune. What it cost to feed and clothe a miner has varied over the last 150 years as well as from goldfield to goldfield. At Lisle in the first few months of the rush the miners were said to be earning £3/10/0 to £4 which was considered to be good money.[6] As a general rule of thumb for the purposes of this article the weekly cost of living for a miner was half an ounce of gold.[7] The other type of miner was engaged in long term or sustained alluvial operations such as ground or hydraulic sluicing. These forms of mining and those who worked the claims relied on a sustained and small profit margin over long period of time, perhaps a few years, as opposed to the fluctuating fortunes of the itinerant digger. Those engaged in these operations were either a syndicate of miners sharing expenses, work and profits or more commonly wage miners. The wages for miners again varied from period to period, goldfield to goldfield. A South Australian miner's weekly wages in 1876 were £2/2/0.[8] For hired men on the Victorian goldfields in 1869 the daily wage was 8 shillings (s) or £2/16/0 for a seven day week.[9] At Charters Towers and Ravenswood the weekly wage for a miner was £3.[10] In ground and hydraulic sluicing as well as dredging and other large scale forms of mining, wages formed a fixed but only partial expense; the costs involved in buying the equipment needed and preparing the ground for mining also had to be included in any profit calculations. These considerations will be discussed below.

Before a particular method of mining could be applied it was first important to determine whether the ground chosen would be payable. This was done by estimating the amount of gold per cubic metre of earth. It is important to emphasise that the value of gold per cubic metre is not expressed by the amount of gold in the richest layer or wash but by the amount of sterile dirt that has also to be worked and/or moved in the process. For example, if on a claim the wash contained one ounce per cubic metre and was covered by a cubic metre of sterile gravel then the value per cubic metre would be 0.5 of an ounce or ten pennyweight (dwt). If the wash was under nine metres of sterile earth the value per cubic metre would be 0.1 of an ounce or two dwt.

Generally the greater the value of gold per cubic metre the less the ground that has be moved for profit. Lower value per cubic metre claims could only be made to pay if many more times the ground is extracted and processed in a short period of time. This principle is known as the economics of scale. Table 1 illustrates the return on ground with differing values of gold per cubic metre when compared to the amounts of ground that could be processed over a week. What can be seen immediately from this table is that with high value ground such as one oz per cubic metre even small volumes of ground moved, two cu/m (less than the amount an individual can shovel and pan in a week) can provide a profit. It also shows that the greater the amount of ground moved in a given time the greater the return, as well as increasing the viability of mining low value ground.[11] The pattern shown in Table 1 is reflected on most alluvial goldfields. The initial stages of a rush saw small ground moving methods employed on the higher value gold deposits. As these became depleted and/or lessened greater ground moving methods took their place increasing in scale as the value of the ground decreased.

Table 2 and Figure 3 show the various rates at which ground can be processed in a week by certain mining methods. The figures given for the rates of ground that could be mined with a given method are estimates as the rates may vary due to other factors. These factors will be discussed below and include the amount of water available, the fall of the ground and the composition of the ground itself. It is not possible to say exactly what quantity of ground can be mined as no two claims ever work under exactly similar conditions. However, as Table 2 shows, there is a correlation between technology and the amount of ground that can be moved. Generally modern methods with the application of mechanisation are more effective than older methods. This increased capacity to process lower value ground explains why older workings are successively re-worked using more sophisticated methods.

Table 1. The return on ground of differing value according to the amount of ground worked.

cu/m ground moved	1 oz per cu/m	0.5 oz (10 dwt) per cu/m	0.1 oz (2 dwt) per cu/m	0.01 oz (4 grains [gr]) per cu/m
2	2 oz	1 oz	0.2 oz	0.02 oz
10	10 oz	5 oz	1 oz	0.1 oz
100	100 oz	50 oz	10 oz	1 oz
1 000	1 000 oz	500 oz	100 oz	10 oz
5 000	5 000 oz	2 500 oz	500 oz	50 oz

Table 2. Quantity of ground processed in a week using different methods.

mining method	cu/m per 7 days (84 hours)	number of miners
shovel and panning†	3.5	1
shovel and cradle††	7–21	1
sluice box with 5 horsepower pump†	25	1
sluice box††	28	1
cradle††	21–63	2
1 x 4 m sluice box†	119	?
sluice box†††	168	4
ground sluicing†††	525–1 050	3
sluice box with races (ground sluicing)†	1 800	?
hydraulic sluicing with elevator†	1 800	?
hydraulic sluicing with elevator††††	2 771	?
mechanical elevator and trommel†	3 125	?
hydraulic sluicing†††	630–4 200	3
small hydraulic suction-cutter and bucket wheel dredges†††††	5 200	?
1.2 cu/m hydraulic excavator†	5 600	?
1 cu/m front end loader†	8 400	?
small bucket dredge†††††	208 333	?
large bucket dredge†††††	2 500 000	?

† Blowers 1992
†† Lock 1889
††† Smyth 1869
†††† Montgomery 1891
††††† MacDonald 1983

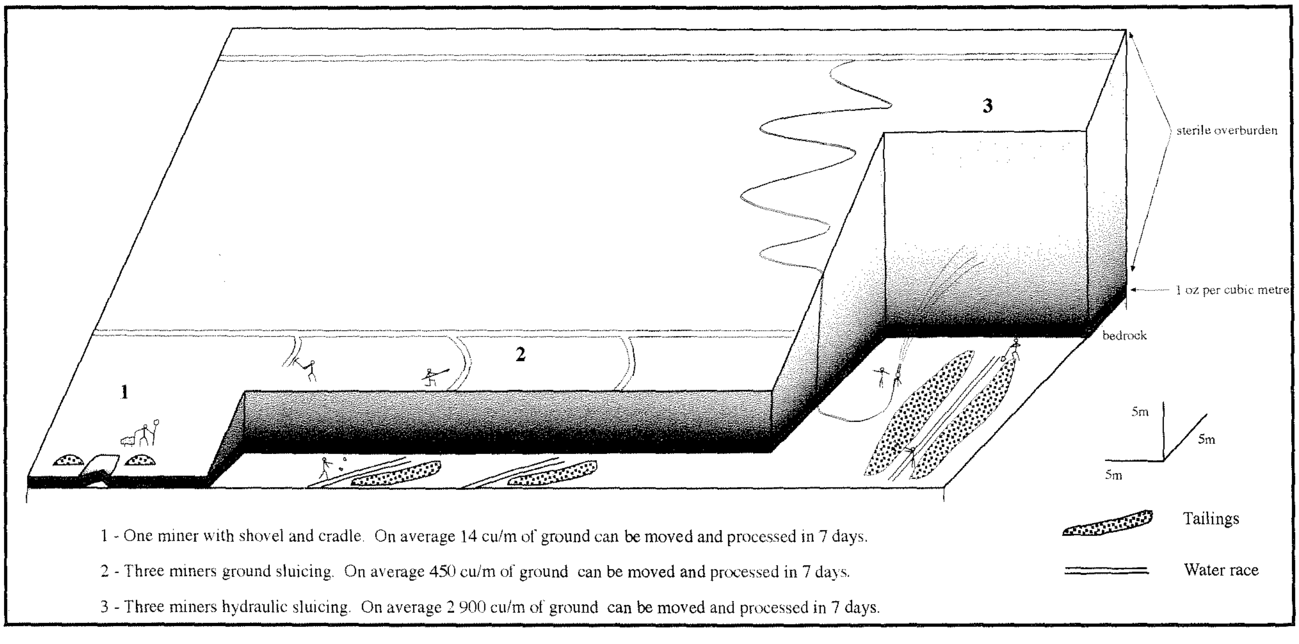

Fig. 3: Scale representation of different rates of mining.

FACTORS INFLUENCING COST-EFFECTIVENESS

The cost-effectiveness of moving greater amounts of ground in a shorter period of time can also be expressed in the minimum amount of gold per cubic metre that needed to be recovered in order to cover expenses. The figures below are provided by Smyth and indicate the price of gold and the expenses of running a sluicing claim in Victoria in the 1860s.[12]

Wages for 3 men at 8 s	£1/4/0
Wear and tear	£0/6/0
total:	£1/10/0

Based on these figures it is possible to extrapolate the returns per cubic metre that would be required in order to cover the daily expenses of operating the same claim with differing rates of extraction. These figures are shown in Table 3.

Table 3. Quantity of gold recovered required to cover expenses.

cubic metres worked per day	gold recovered per cu/m needed to cover expenses
6	5 s or 60 d (1 dwt, 7 gr)
24	15 d (7 gr)
100	3.6 d (1.6 gr)
500	0.72 d (0.32 gr)

It would seem that the larger scale alluvial mining operations would be the optimum way to recover gold. This is essentially correct: the larger the scale of operations, the greater the costs involved. Table 3 does not take into account the cost of digging the races which would feed the water required to move such amounts of ground, the charges in most cases on the use of water or the cost of purchasing the equipment to be able to move such amounts of ground (see below). Such costs would raise the minimum amount of gold to be recovered considerably. However, there are also other reasons that make it impossible to always employ such large ground moving methods. These include the following:

- the size of the lease
- the nature of the terrain
- the availability of water
- the increased costs of equipment and supplies

The availability of ground for large earth moving mining methods very much depended on the density and number of claims on a particular goldfield. In the initial stages of any rush the goldfield was inundated with hopeful prospectors. As a result the amount of ground per miner available was small, approximately eight by eight metres. At the height of the Victorian gold rush, some claims were as small as three m^2.[13] In such small claims "pot hole" mining or creek diversions were the only methods that could be used and as the initial rush of any gold field centred around the shallower and richer deposits this method was profitable. This is because on an eight by eight metre claim adjacent to a creek with perhaps two metre depth of ground to bedrock (128 cubic metres), a miner with pick and shovel could process the whole claim in 37 days. If the claim was subjected to ground sluicing then the total volume could be moved in 3.7 days for the same return of gold. However, to prepare the claim for ground sluicing would require the digging of water races which may take months to complete depending on the number of miners involved. At times miners with adjoining claims worked together for the purposes of ground sluicing, as they did at Lisle in the first six months of the rush.[14] Generally very small deposits or small claims are only profitable if done by hand.

For those engaging in ground and hydraulic sluicing and other large earth moving methods the size and of course value of the ground were the dominant factors in determining how much capital could be invested safely. The level of capital costs had to be balanced by a proportionate level of production. Appropriate and consistent revenues were required to flow for a number of years to provide for the return of all capital plus a fair margin of profit.[15] Nevertheless, once the initial investment had been made, even extensive deposits of very low ground could be mined profitably. The cost of obtaining land for the right to mine was generally negligible in relation to other expenses associated with mining on a ground sluicing or greater scale. Laws and rates varied from colony to colony but generally a Miners Right cost sixpence (d) to £4 rental per acre per year. A gold lease was 24 acres with five s rent for an acre for the first year and £1 per acre for each succeeding year.[16]

The second factor determining whether large scale sluicing would be cost effective concerns the nature of the ground and the terrain. If the overburden to be cleared away contains large rocks and boulders the amount of ground that can be moved per hour decreases, as does profit, because of the dead time absorbed in clearing the boulders. Furthermore, if the wash itself contained much clay then extra time was required to breakdown the clay in order to remove the gold. Another consideration associated with the nature of the terrain is the degree of ground slope or fall on the claim. If the fall was not sufficient to carry away the tailings then there would be the need for hydraulic elevators (later diesel pumps) or even bucket dredges, which raise the cost of operations considerably.

The third factor is the availablity of water, because in the nineteenth century the main means by which large amounts of ground could be mined was through the use of water. Smyth notes: 'The greater the amount of water used the greater the proportionate amount of dirt that can be washed, and the greater the proportionate profits. It is far more profitable to have a large sluice than a little one'.[17] On a crowded goldfield where claims were small and the gold deposits were concentrated, a great deal of water per claim was not required because of the mining methods used, including pot hole mining, small scale sluice boxes, and creek diversions. These workings were situated on or near water courses where either the wash dirt was carried to the water or the water course itself was diverted short distances. However, when working low grade deposits by sluicing, the water that would have supplied numerous small claims was not sufficient.

It would be a mistake to assume that the water could be used for free once the demands on water available on a goldfield lessened with the decrease in the number of miners and claims. Water had to be paid for in one way or another either if it was obtained from a Government reservoir or a through a government charge on the carrying capacity of the races feeding a claim. In the example given by Smyth in Victoria the cost of obtaining water from a government reservoir was 0.33 pence per thousand gallons (4 550 L).[18] The claim he uses as an example consumes 360 000 gallons per day to remove 150 cubic metres of ground which equates to 2 400 gallons (10 920 L or 11 cubic metres of water) per cubic metre or 500 gallons (2.275 cubic metres of water) per minute. Table 4 shows the minimum yield required for the same piece of ground mined at different rates when the cost of water is added to Table 3, and it is evident that even with the costs of water, large scale sluicing is more profitable than small scale sluicing.

These calculations do not include the cost of constructing the races. It takes 750 work days on average to dig one kilometre of race 0.91 by 0.61 metres capable of carrying 15 cubic metres of water per minute and another 150 work days per year to keep it open.[19] This work is considered to be 'dead time' as food and/or wages would have to be paid for no profit. In Victoria in 1869 there were approximately 3 680 kilometres of races which cost £321 903.[20] This equates to

cubic metres worked per day	volume of water required	adjusted daily expenses	gold recovered per cu/m needed to cover expenses
24	57 600 gallons	£1/11/7	£0/1/3.79 (6.3 gr)
100	240 000 gallons	£1/16/7	£0/0/4.39 (1.8 gr)
500	1 200 000 gallons	£3/3/0	£0/0/1.51 (0.6 gr)

Table 4. Quantity of gold recovered required to cover expenses when the cost of water is considered.

£87/10/0, or 20 to 25 ounces of gold per kilometre. If this extra expense is added to the calculations in Table 4 an extra 17.7 d (seven grains) per day would have to be won, per kilometre of race, to pay off the initial costs within six months.

It should be noted that the larger the sluicing operations the greater the length and number of races required. Sluicing was almost exclusively employed on ground such as slopes or banks, which was above adjacent water courses. To be effective water had to be bought in above the workings so as to flow over them in the case of ground sluicing or so as to provide the pressure for hydraulic sluicing. This involved the construction of races usually upstream of the workings. The length of the races depended greatly on the lay of the terrain and the method of mining involved. The gentler the slope that the claim was situated on the longer the races would have to be. Generally races associated with ground sluicing were not as long as for hydraulic sluicing as the water only had to come a few metres above the workings. In the case of hydraulic sluicing where the water had to be bought in at least 20 metres above the workings further problems of obtaining water were presented. Not only did the race have to be considerably longer but the higher the elevation of the race, the less water would be obtained when it intersected the upper reaches of a water course.

In the Lisle Valley, a locality with an abundance of rain throughout the year, there was not sufficient water available to allow for hydraulic sluicing at the elevations required. In 1922 the New Bonanza Co. cut a 20 kilometre water race from the Little Forester River east of Lisle to provide the required water for large scale hydraulic sluicing.[21] Races dug for ground or low pressure sluicing were considerably shorter but still involved considerable time, as shown in the first year of the Lisle rush when one party spent nine months cutting a 4.5 kilometre race for low pressure sluicing.[22] Some idea of the proportionate costs involved in establishing a claim is provided by a recent example from New Guinea. There, when setting up a five year hydraulic sluicing claim with an hydraulic elevator, the digging of the race was five times more expensive than the cost of the sluicing equipment or the equivalent to five months worth of labour with 20 men employed, and repair and maintenance on the claim.[23]

As to how much water was required to move a cubic metre of gravel, no absolute comparisons can be made because of factors such as the differing conditions, amount of water pressure, and quantity of boulders in the ground. The amount of water can vary between 54 to 168 cubic metres of water per cubic metre of gravel.[24] Even at the lowest rate, it was cheaper in the long term to use water than to pay wages for the equivalent amount of ground moving power in human labour.

The final factor in determining the cost effectiveness of large scale sluicing is the relative cost of equipment and supplies. Distance and accessibility to a gold field can inflate prices for the transport of equipment and the wages of those employed, thereby making some claims unprofitable. At Lisle in the first few years the cost of portage was considered exorbitant at £12 per ton in winter. On the Palmer River goldfields the costs were as high as £30 to £40 per ton.[25]

ALLUVIAL MINING AT LISLE

The above discussion examined some of the principles of alluvial gold mining involved in determining expenditure versus profit. Mining is an industry which works on a small and steady profit margin over long periods of operation. However, mining is also a high-risk business where much effort in terms of labour and money could be thrown away on a gamble or poor prospecting. It is not possible to say that substantial surviving archaeological remains of mining meant a successful enterprise. Quite often the reverse is true. There is ample evidence on the Lisle goldfield as well as other goldfields of the years of labour by individuals who found little but always hoped for that lucky strike. The nature of the ground and the availability of water are physical and tangible elements that can assist in interpreting the archaeological record; the availability of capital and the irrational dreams of individuals are invisible, intangible, elements in the archaeological record.

In the above discussion mining methods were discussed in an order of progression from basic forms to larger, more complex forms. This pattern can also be observed in the evolution of the Lisle goldfield and is a sequence not uncommon on alluvial goldfields. In this section it will be shown that there is a correlation between the style of mining employed, changes in the mining population, and to some extent changes in technology (Table 5). As well as the progression in the complexity of mining techniques there was also a progression in the continued expansion of the area covered by mining operations which originated at the centre of the initial rush.

During the initial stages of the Lisle rush when the mining population was at its peak of 2 000 people, alluvial mining centred in or near Lisle Creek. At this location the deposits of gold were the most concentrated and the overburden thin. The style of mining was dictated by the nature of the deposit in conjunction with the density of miners. Because of the richness of the ground, the limited size of the claims and the intense competition for water, pot hole mining and creek diversions were the most prevalent style of mining. Where individual miners combined, small scale ground sluicing also took place. The township of Lisle in the first year expanded linearly along the east bank of Lisle Creek for a distance of up to three kilometres.

Table 5. Progression of mining at Lisle.

type of mining	maximum height above Lisle Creek	maximum distance from Lisle Creek	date	estimated number of miners	estimated size of field (in m²)	m² per miner
creek diversions and pot hole mining	0–3 m	0–50 m	1879	2000	380 000	190
ground sluicing	0–30 m	0–300 m	1880–1913	600–20	1 220 000	2 030–61 000
dredging	<0 m	0–100 m	1901–1903	5	404 700	80 940
hydraulic sluicing	0–60 m	0–1 400 m	1914–1950	20	1 620 000	81 000
hydraulic sluicing with diesel pump	0–90 m	1 700 m	1950–1970	5	1 630 000	326 000
mechanisation	>0–100 m	0–1 700 m	1970–1995	10	>1 630 000	n/a

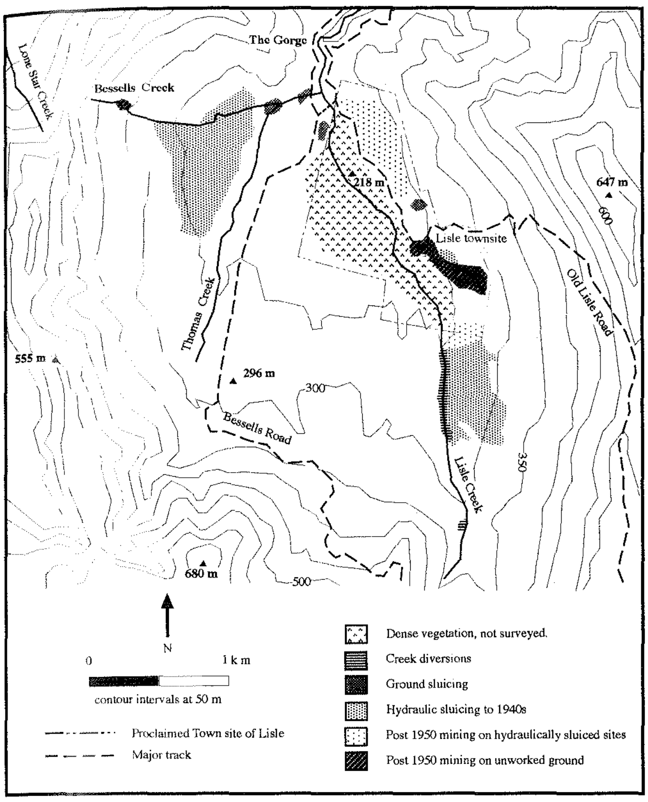

Fig. 4. Distribution of alluvial mining site types at Lisle.

As the rich, easily obtainable deposits became depleted, many miners began to leave the field. This freed up ground for larger scale mining, principly ground sluicing. The decreasing number of miners also meant the demand on available water decreased and in the low-value ground that was left on the terraces at the base of the slopes of the Lisle Valley it was more advantageous to pay for water, in the form of digging races, than to hire labour. The ground that had been left between the pits and shafts was also worked. This practise continued for the rest of the century and into the present century. In the flat, marshy terrain on the lower part of Lisle Creek, where ground sluicing could not operate effectively, a dredge went into operation.

Little is known about the development of the Lisle township during the latter period. The cycle of destruction of the town continued as the population dwindled. It seems that the core functions were centralised around the junction of the Old Lisle Road and the Esplanade while individuals and families became dispersed across the valley. This is because the extent of mining had reached the western slopes of the valley and most of the inhabitants were also engaged in agriculture.

The onset of World War I coincided with the introduction of high-powered hydraulic sluicing to the gold field. The late application of this method of mining during this time may have not been coincidental. The Lisle Hydraulic Gold Mine and Lisle Gold Mining Co. obtained the water supply for these operations from within the Lisle valley. The war perhaps saw many of the remaining miners leaving the field and the demand on the valley's water supply being reduced in consequence. With water rights divided amongst fewer miners, the two companies would have been able to secure the water they required. With hydraulic sluicing, mining operations moved further up the slopes of the Lisle valley where the depth of the wash made ground sluicing an uneconomical proposition. Hydraulic sluicing also took place on the valley floor where hydraulic elevators lifted the wash onto sluice boxes supported by trestles.

Hydraulic sluicing continued during the Depression years when the races that were dug with company money were utilised by small groups of miners with few capital resources. Diesel pumps eventually did away with the need for water races and allowed for the re-circulation of the scant available water. This allowed for the mining of ground further up the slopes of the Lisle Valley where sufficient pressure for hydraulic sluicing from water races was not obtainable. The practise would have continued up to the present were it not for changes in mining legislation. Mechanisation has since taken the place of hydraulic sluicing, changing the style of mining that had gone on before. The place of extraction and the place of processing could now be kilometres apart. However the practise of old ground being re-worked by more efficient methods still continues. Each time the value of gold per cubic metre is less and less but it is able to generate profit because of the larger amounts of ground that can be processed.

The permanent inhabitants of the Lisle Valley during these years disappeared, leaving the town site to be totally destroyed by mining and agriculture to lapse. Habitation in the valley continued but in a different form. The miners, up to a dozen at any time, lived alone for short periods on the scattered claims around the valley. The availability of motor transport meant that they could return to their homes and family on a weekly or even nightly basis. This same pattern applied to the forestry workers who began planting and tending the pine plantations in the valley during this time. The huts and camps constructed in the last 30 years reflect this temporary, transhumant lifestyle.

In summary, the pattern of mining originated in and on the banks of the gold bearing creeks of the Lisle valley. A cycle was created whereby the lessening value of gold deposits resulted in a decrease in the mining population and an increase in the scale of the ground processing methods applied. Mining operations started again on Lisle Creek and expanded further away from the banks of the creek each time. This cycle was repeated twice with the application of ground sluicing and later hydraulic sluicing. Changes in technology are represented by the floating dredge and mechanisation but the pattern remains the same. The dredge re-worked the ground on Lisle Creek while backhoe pits have been observed adjacent to Lisle Creek and on the slopes above the areas which have been hydraulically sluiced. The expansion of the workings and the introduction of motor transport in turn lead to the dissolution of the Lisle township and the disappearance of permanent habitation in the valley.

CONCLUSION

This article has presented some of the principles and circumstances surrounding expenditure versus gain in alluvial gold mining. The examination of the spatial distribution and evolution of the mining remains on the Lisle goldfield has been discussed as an example of one way of interpreting an alluvial goldfield through the understanding of why particular mining techniques were applied at particular times and in particular locations. There are no claims concerning comprehensiveness of what has been presented nor is it claimed that this method of interpreting alluvial mining sites and landscapes is the premier means of analysing such remains. However, it is hoped that the information presented will be of use in the study of other alluvial goldfields and provide another avenue of attack for bemused archaeologists attempting to understand what they see before them.

NOTES

1 Bell 1982:15.

2 Lawrence 1995:72.

3 For a comprehensive account of the setting, geology, history and archaeology of the Lisle goldfield, see Coroneos 1993.

4 The alluvial mining terms and site types referred to in this article are largely consistent with those of Neville Ritchie (1981). The site type 'Creek Diversion' is defined in Coroneos (1993:103; part 2).

5 Ritchie 1981:66.

6 *The Launceston Examiner* 6 February 1879.

7 The price that gold was bought for varied between goldfields. In the nineteenth century and the first quarter of the twentieth century the price varied between £3/10/0 to £4/11 (Bannear, 1993:21 and Bell, 1991:167). During the Lisle rush gold was being bought for £3 15s per ounce in Launceston and as a consequence many of the miners took their gold to Victoria where £4 per ounce of gold was being offered (*The Launceston Examiner* 18 February 1879).

8 Boothby 1876:81.

9 Smyth 1869:132.

10 Bell 1982:41. In the nineteenth century, a miner's weekly wage was approximately 0.6 of the price of an ounce of gold. For today, given that the average weekly net wage is around $500 and the price of gold, at the time of writing, is around $385; a weekly wage is 1.3 times that of an ounce.

11 In small scale alluvial mining today a claim with over 1 gram (13 grains) can be profitably mined by any method while anything less than 0.2 gram (3 grains) is unprofitable (Blowers 1992:127).

12 Smyth 1869:132.

13 Clacy 1963.

14 *The Launceston Examiner* 5 November 1880.

15 Macdonald 1983:308.

16 Bernewtiz 1943:42.

17 Smyth 1869:142.

18 Smyth 1869:132.

19 Blowers 1992:86.

20 Smyth 1869:128.

21 *Report of the Secretary of Mines*, 1922. Mines Department, Hobart.

22 *The Launceston Examiner* 5 November 1880.

23 Blowers 1992:109.

24 Wilson 1907:157.

25 Bell 1982:39.

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