Tailings and Mine Waste: Commentary

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I must congratulate both Craig Readhead on his excellent paper and Kym Livesley on his first class commentary. As a result of the quality and extent of both papers, I am left with a very modest task. I will be primarily concerned with gold tailings in Victoria.

Perhaps I should commence by outlining how gold tailings are generally created historically and how they might be treated to recover any residual gold remaining.

CREATION AND TREATMENT OF TAILINGS

Physically, tailings fall into four general categories, namely soft rock tailings (such as fine coal refuse), hard rock tailings (such as sands from lead zinc gold processes), fine tailings (having little or no sand including bauxite red muds and slimes from tar sands) and coarse tailings (which have a sizeable course sand fraction such as uranium tailings). However, as tailings share the same broad physical characteristics, disposal problems are usually similar. They do differ with various chemical characteristics and environmental considerations.

The recovery of gold from the initial ore body is primarily undertaken by gravity separation. Thus overburden or obvious waste (or perhaps low-grade mineralised rock for treatment when the gold price increases)

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is removed and the ore is first broken up. Historically this was done with a stamp battery which resulted in fine but relatively coarse material. Later it was undertaken by the use of a ball mill, a rod mill or a tromell (basically rotating drums with for example steel balls inside to break up the material). The gold is then separated from the other material by gravity. The residue after the removal by gravity separation of the loose gold was described as "tailings". Today those "tailings" would certainly be treated further and when ultimately discharged would more likely be considered waste.[1]

Last century those tailings would often not have been then chemically treated, but merely placed in dumps. However cyanide processes were used (such as the passing of an auriferous solution of potassium cyanide over zinc shavings through a number of tanks) and the gold was precipitated.[2] Primitive and dangerous to the miner. The first cyanide plant was set up at Charters Towers in 1892. By 1897 there were 70 cyanide plants in the field treating 25,000 tonnes of tailings a month.[3] This century and particularly from the 1980s with the development of carbon-in-pulp ("CIP") procedures, those tailings dumps have become a valuable asset with economically recoverable gold therein. Some CIP plants have been economically viable with recoverable grades as low as 0.3 of a gram per tonne.[4] The price of gold obviously plays a vital role.

The use of chemicals to treat tailings has progressively become more and more sophisticated. One of the advantages of treating tailings is that the gold-bearing material is generally consistent and it is possible to design the treatment plant with a reasonably predictable ore flow.

The most commonly used chemical is cyanide. This is used in either a carbon-in-pulp (CIP), resin-in-pulp ("RIP"), carbon-in-leach ("CIL") or by heap leaching (where the material is placed on a pad for example of concrete and the cyanide is sprayed on and allowed to percolate through the material. It is then drained off. Whilst this method has advantages in respect of low-grade material the percentage recovered is lower than with CIP or CIL processes).

Other chemicals such as thiourea or chloride compounds can be used but are expensive and potentially very dangerous to health.

"Roasting" of the material prior to cyanidation is undertaken with some complex ores.

The development of the CIP technology has been particularly important in both the retreating of tailings and as part of the normal mining process. Prior to CIP the standard process involved precipitation

1. Contrast the definition of "Tailings" in s 4(1) of the MRDA which refers to "waste" with Burt CJ in the *Mullavey* case ([1989] WAR 233) who described tailings as "the residue of earlier mining operations, being minerals above the natural surface of the land".
2. Stone and Mackinnon, *Life on the Australian Goldfields* (Methuen, 1976), p 24.
3. *North Australian Research Bulletin*, No 8, September 1982, p 11. This new cyanide process replaced a chlorination process used at Charters Towers which had proved uneconomic.
4. For example Grants Patch Mining Ltd treating the tailings from the Gwalia Mine which ranged from 0.3 to 0.8 of a gram with a 0.3 cut off.

of the dissolved gold from a filtered and clarified pregnant solution by a reducing agent such as zinc dust or activated carbon. The CIP variation avoids the expensive and difficult filtration and clarification step. The remarkable expansion of gold production throughout Australia in the 1980s owes much to the increased recovery achieved by the CIP process.[5] It is also why the residue of modern mining operations may not be "tailings" in the historical sense but waste material.[6]

Such chemical treatment is today a normal part of a mining operation so that any tailings (or waste) now being produced will contain potentially hazardous chemicals which where possible are removed prior to discharge. Any tailings dam into which the tailings are deposited must be appropriately designed and constructed to ensure that any remaining chemicals do not affect any waterways or groundwater. Specific obligations are imposed on the miner to ensure that the tailings are dealt with in an appropriate and safe manner.

There is often economic advantage in attempting to recover cyanide and other additives from the tailings before they are discharged. The siting and design of the tailings dam is today of paramount importance.

> "More recently however environmental considerations have gained increasing importance and perhaps nowhere else in mining operation are these environmental issues of more significance than in tailings disposal. Environmental factors are often of equal or greater importance than economic issues in tailings disposal planning at least in the eyes of the regulatory agencies with overall authority for approval of a mining operation and citizens groups having considerable influence in the political process."[7]

5. S B O'Malley, BMetE (Melb), Hon M AusIMM, *Technology in Australia 1788-1988*, Sir Lindsay Clark Memorial Volume (Australian Academy of Technological Services and Engineering, Melbourne, 1988), p 740.
   The figures on the growth production are as follows:
   1930— 10 tonnes
   1940— 50 tonnes
   1980— 15 tonnes
   1986— 75 tonnes
   1990—220 tonnes
   1992—200 tonnes (estimated)
   Contrast this with last century:
   1856—100 tonnes
   and 1903—120 tonnes
6. See above, n 1.
7. Stephen G Vick, *Planning Design and Analysis of Tailings Dams* (University of Oklahoma Press, 1983), p 129.
   > "In the view of conservationists, there is something special about dams, something—as conservation problems go—that is disproportionately and metaphysically sinister. The outermost circle of the Devil's world seems to be a moat filled mainly with DDT. Next to it is a moat of burning gasoline. Within that is a ring of pinheads each covered with a million people—and so on past phalanxed bulldozers and bicuspid chain saws into the absolute centre of hell on earth, where stands a dam. The implications of the dam exceed its true level in the scale of environmental catastrophes. Conservationists who can hold themselves in reasonable check before new oil spills and fresh megalopolises mysteriously go insane at even the thought of a dam." John McPhee, *Encounters with the Archdruid*.

The mine manager will wish to ensure that the tailings dam will allow the liquor to gradually separate from the solids so that the water can be decanted and returned to the plant for further use. Ultimately the area used to impound the water may be dewatered, so as to allow rehabilitation. It is in the mine manager's interest to ensure that decanting of the water, the ultimate dewatering of the impoundment area and the rehabilitation is undertaken economically and efficiently.

There are a number of ways to remove or destroy the cyanide in the tailings. For example, biological destruction.[8] There are many other methods which can be used prior to pumping into a tailings dam where natural degradation may be allowed to complete the task. These methods include acidification, alkaline chlorination, ion exchange, air purging, ozonation, electrolytic oxidation, chemical oxidation, natural degradation, evaporation, biodegradation, oxidation with hydrogen peroxide, absorption on ferrous sulphide, oxidation with sulphur dioxide-air, adsorption on activated charcoal, electrodialysis, high-pressure oxidation, ultraviolet photolysis, etc.[9]

Apart from considering whether or not the tailings have potential for further treatment, tailings can be used for such other purposes as agriculture ballast road material, raw material for bricks or lightweight aggregate.

As one would expect, other methods of treating tailings after the gravity separation stage continue to evolve. One emerging technology is that of bioprocessing for the treatment of refractory (sulfide) ores. Bioprocessing or bioleaching is being used as an alternative to roasting or pressure leaching of the refractory ores. Bioprocessing is the use of naturally occurring strains of bacteria which break down (oxidise) those refractory ores. It is also successful in the extraction of other metals such as copper, manganese and uranium. Whilst there are presently only three gold recovery plants in operation throughout the world using bioleaching (one of which is Ashton Minings Harbour Lights operation in Western Australia) work has now commenced on the Ashanti Gold Mine in Ghana (West Africa) which when completed will lift recovery from 650,000 ounces to 1,000,000 ounces a year.[10]

Other technology still in the laboratory and not yet tested in the field claims that even after normal CIP processing there is still substantial gold remaining which may be recoverable. As I am a director of one of the technology companies making such a claim (Action Gold Development Ltd) I will not develop this aspect further.

VICTORIA

In commenting on certain aspects of the situation in Victoria, I must express the same disappointment and frustration as others have

8. G M Ritcey, *Tailings Management (Problems and Solutions in the Mining Industry)* (Elsevier Science Publishers BV, 1989), p 541. Homestake Mining Company pioneered this method in 1984.
9. Ritcey, op cit, p 611.
10. *"Civil Engineers" Australia*, 19 February 1993, p 16.

expressed as to the considerably reduced mining activity in Victoria over the last decade or so.

Delegates will no doubt recall David Bradley's paper in 1991, reviewing the *Mineral Resources Development Act* 1990 ("MRDA").[11] In his commentary on that paper, Michael Hunt was pessimistic as to the probable failure of the MRDA to stimulate mining in Victoria.[12] The problem in Victoria was and still is "culture" or attitude of the community to mining and the success of those opposed to mining in creating an atmosphere of reflex opposition to mining. This acts as a considerable disincentive to those making decisions as to where mining exploration and development funds are to be expended. Those in the community opposed to mining are often residents who have moved into an area which historically had been very actively mined and has now become a charming rural retreat. Those residents are happy to take the benefits of the environment created by the early miners with interesting cottages and villages but wish to actively discourage any disturbance of that tranquillity with further mining activities. For example the area around Blackwood and Barry's Reef (perhaps 50 kilometres from Melbourne) is now well afforested with no sign of the "bare earth" decimation by mining activities last century where there may have been 10,000 to 20,000 miners with all trees being burnt for firewood.[13] The site of the old Barry's Reef township cannot even be located. But the area is still today a potential underground gold resource. Those who have holiday cottages or have retired to live there are not surprisingly in opposition to mining. There is also understandably pressure to preserve some of the old tailings dumps for historical reasons particularly in a tourist precinct which relies on what has been preserved from the 1850s and 1860s. As I will mention later there is still considerable opportunity to frustrate mining by use of the planning procedures. Similar attitudes apply where tailings treatment projects are proposed.

It is the intention of the present government to review and amend the MRDA and hopefully that will overcome some of the problems which other commentators have noted and some of which I mention later.

Victoria has a large and important resource in the various historical tailings dumps presently not utilised.

Whilst accurate figures are not available, it is probable that there is in excess of 75 million tonnes of mineralised tailings in Victoria which contain some gold and given improvement in technology or an increase in the gold price could become economically viable (all other planning and environmental matters having been eliminated). Potentially there could be perhaps gold to the value of $600-$1,000 million (at Australian $500 per ounce) as a resource situated on the surface and in many cases, not much use to farmers and causing environmental concern. As new technology is developed the value may become much greater.

Notwithstanding the importance of this resource there are presently only four current tailings treatment licences which were granted prior to

11. David Bradley [1991] *AMPLA Yearbook* 375.
12. Michael Hunt [1991] *AMPLA Yearbook* 419.
13. Stone and Mackinnon, op cit, p 168.

the proclamation of the MRDA in November 1991. There may be mining licences issued since November 1991 for the purpose of treating tailings but they would number only a few. Previously there had been many hundred Tailings Treatment Licences (314 were granted over a 20 year period).[14]

SEBASTION SANDS DUMP

Perhaps it would be interesting to look at a specific example of a proposal to treat an existing tailings dump. The example I have in mind is the "Sebastion Sands" dump north of Bendigo. These sands accumulated from the "Frederick the Great" mine which was mined in 1864 producing 73,375 ounces from 165,443 tons of quartz in eight years. The mine was in production for 42 years producing a total of 175,000 ounces of gold (over 5 tonnes) and was for a time the richest mine in the Bendigo region.

For the period between 1902 and 1911 the sands were partly cyanided. The sands were treated once more between 1933 and 1937. (The brick-lined vats are still present on the southern slimes heap and will remain as a historic relic.) The mine itself was a sulphide deposit which resulted in much of the conventionally assayed gold not being recovered initially and thus enabling subsequent cyanide operations to be successful as oxidation of the ore over the years released much of the gold for extraction.

There is currently approximately 500,000 tonnes of sands and slimes on the surface which have a conventional assay of less than 1 gram per tonne on average. Other assaying methodology suggests there is possibly in excess of 9 grams per tonne. Whether that is recoverable or not has not yet been resolved. New technology will be required.

The Sebastion dump is well served by bitumen roads and is close to a railway line. It is also within one kilometre of the Sebastion township. A Tailings Treatment Licence has been issued. The Shire of Marong has also issued a planning permit. Some of the terms of the planning permit are as follows:

(i) detailed site plan showing location of plant set-backs, building structures, construction materials, all approved by the Planning Authority;

(ii) bank guarantee for $20,000 in case of damage to Shire property and in respect of rehabilitation works (notwithstanding that the applicant has already lodged a bond with the Department of Energy and Minerals);

(iii) external cladding of any proposed building, or roof in non-reflective colour bond material or painted in muted tonings to blend with the environment;

(iv) a bund wall shall be constructed around the plant area to partly screen the development;

14. Department of Energy and Minerals.

(v) plant area and all dams shall be fenced for public safety, at least 2.4 metres high chain mesh;

(vi) existing trees to be retained and further trees and shrubs to be planted at specific locations before works commence to achieve a screen;

(vii) noise not to exceed permissible noise levels specified by the Environment Protection Authority. Other noise reduction provisions;

(viii) dust suppression as specified by the Department and during dry periods extensive wetting of tailings will be required. Dust from access roads to be kept to a minimum;

(ix) minimisation of any nuisance by admission of noise vibration, smell, dust, waste, water etc in accordance with procedures for suppression to the satisfaction of the Planning Authority;

(x) all sludge and sediment to be retained on site. Dams to be clay-lined;

(xi) no obstruction of the flow of water in the natural drainage line;

(xii) appropriate rehabilitation of the land. Rehabilitation of the tailings dams to the satisfaction of the Planning Authority;

(xiii) specific directions as to which access roads to be used.

It is probable that the costs of undertaking the project would be between $3 million and $4 million. It is estimated that break-even costs would be approximately $15 per tonne, that is roughly 1 gram recovered with gold at $450 per ounce.

At the present state of technology this dump would appear to be unprofitable unless gold increases in price substantially. However with improved recovery methods increasing the grade recovered, the dump, although reasonably small, becomes profitable.

One of the major problems to be considered will be the disposal of tailings. Adjoining land may be required for the tailings dam.

NATURE OF TAILINGS

Both Craig and Kym have discussed the nature of tailings and concluded that they are chattels. Whether or not the tailings remain chattels or as a result of an abandonment or intermixture, they again form part of the realty is, notwithstanding the MRDA, still important in Victoria.

The MRDA defines tailings as follows:

> " 'Tailings' means any wastes, mineral or stone that is produced in the course of doing work under a licence and includes any mineral or stone that is discarded from plant or machinery used for extracting minerals": s 4(1).
>
> " 'Licence' means an Exploration Licence or a Mining Licence under Part two."

In the MRDA the legislature has clearly accepted that tailings are chattels and do not form part of the land in the absence of the clear intent of the legislation. Thus the MRDA specifically provides in s 10 that tailings are to be treated as part of the land:

> "**10.** Tailings are to be treated as part of the land on which they are situated and minerals in them are owned by the Crown unless the property in them passes under Section 11 or unless a minerals exemption is current in respect of them."

Section 11 provides that the minerals only pass from the Crown to a holder of an exploration licence, mining licence, miner's right or tourist fossicking authority when the minerals are recovered in accordance with the terms of such licence etc.

It should be noted that s 10 may only apply to "Tailings" created pursuant to a mining licence issued under the MRDA. Tailings in existence prior to 6 November 1991 must still therefore be considered chattels.

A further problem is the definition of "Mining":

> " 'Mining' means extracting minerals *from land* for the purpose of producing them commercially and includes processing and treating ore" (emphasis added).

Section 14(1) permits the holders of a mining licence to undertake "mining" on "land". I think we must agree that tailings are not land but chattels unless they become part of the realty by abandonment or intermixture.[15] Thus there may now be no authority to mine or treat tailings already in existence at the time of proclaiming the MRDA—which of course is the majority of tailings in Victoria.

Any tailings produced after November 1991 will by definition become "land" for the purpose of mining.

The ownership of tailings on Crown land has presumably passed to the Crown pursuant to s 59 of the *Mines Act* 1958 notwithstanding its repeal on 6 November 1991. Thus a mining licence over Crown land on which the tailings are situate may not need to specify whether the gold is being obtained from "Tailings" or below the surface. But strictly if the pre-1991 tailings are treated it may not be the extraction of minerals "from land".

However, pre-1991 tailings on private land could still be the subject of arguments as to ownership or whether there is authority to undertake "mining" in respect thereof. The result may be that without the landowner's consent tailings on private land cannot be treated. Even then whilst the mining is "on" land treatment of pre-1991 tailings may not be "from" land.

The opportunity for those opposed to mining to seek to restrain mining activities as being without lawful authority would be irresistible.

15. *Mullavey's* case; *Mills v Stokman* (1967) 116 CLR 61.

MINING LICENCE

The MRDA now provides that a mining licence will authorise the relevant "mining" activity which had previously been undertaken pursuant to a tailings treatment licence or a tailings removal licence.

Under the *Mines Act* 1958 (as amended) any tailings situated within an exploration licence were excluded from that exploration licence. Under the MRDA tailings are included within an exploration licence.

In contrast to the Western Australian situation it would appear that the Minister has accepted advice that strata titles can be issued in Victoria.[16] Thus a mining licence could issue for mining beneath the surface and a separate mining licence for mining tailings (as defined) situated on the land.

On the arguments advanced above a strata title (without an amendment to the MRDA) would not be available in respect of pre-1991 tailings.

COMPENSATION

Section 10 of the MRDA is not concerned as to ownership of the tailings but with ownership of the minerals which remains with the Crown (which as Craig points out in respect of gold already was with the Crown at common law).

Thus whilst the legislature may have now clarified the position arising in the future in respect of "Tailings" as between the Crown and an applicant for a mining licence and who owns the minerals and how they may be recovered a dispute could occur between a vendor and a purchaser where the contract is silent as to ownership of the pre-1991 tailings on the land sold. The comments of Brinsden J in *Mullavey's* case could become relevant in the event of such a dispute, namely that the tailings may become part of the realty if they have no longer retained the separateness as to be identifiable as such but had become mingled with realty.[17]

The question of ownership of the pre-1991 tailings situated on private land may be of importance for the purposes of compensation to the landowner in respect of mining activities. It would appear that the owner of the tailings (if separate from the landowner) would not be compensated as the MRDA only provides for compensation to the owner or occupier of land. But the owner of such tailings would certainly argue that there is no power to mine such tailings.

16. MRDA, ss 15(9) and 16(4) and reg 220 of the *Titles Regulations*.
17. See, above, p 292.

ENVIRONMENTAL AND PLANNING OBLIGATIONS

Planning

To undertake mining operations it is necessary in most areas to obtain a town planning permit. This will of course depend upon the specific planning scheme but most local schemes provide for the need for planning approval. As the retreatment of tailings by its very nature can create noise, dust, extra traffic and may be considered unsightly and a potential threat to groundwater, streams, etc the probability of a planning objection is high. In some areas the local municipal council is weighted towards those who regard mining as a threat to the amenity of the area. Even if there are no objections the planning authority is likely to insist upon reasonably stringent conditions for the issue of the permit.

Whilst the conditions imposed may not in themselves be objectionable, there is always the possibility of dispute once mining operations have commenced as to what are reasonable requirements.

If there are objections, an appeal is necessitated to the Administrative Appeals Tribunal which will add considerably to the expense (particularly if expert reports are required) and a delay of perhaps six months.

Exploration licences are specifically exempted by s 43(3) of the MRDA (subject to the consent of the Chief Administrator under the MRDA) from the *Planning and Environment Act* 1987 and any planning scheme in respect of undertaking the following works:

(a) geological surveying; and

(b) geochemical surveying; and

(c) geophysical surveying; and

(d) drilling of a hole not more than 250 millimetres in diameter; and

(e) digging of a trench not wider than 150 millimetres and not deeper than one metre.

(As Michael Hunt noted—one hole and one trench?)

The Chief Administrator must be satisfied that there will be minimal disturbance of the land and minimal disturbance to or removal of vegetation.

Whilst this has the considerable advantage of allowing the investigation of existing tailings dumps pursuant to an exploration licence (which was not available under the previous Act) it does not necessarily guarantee the obtaining of a planning permit for the actual tailings treatment proposal.

A work plan must be lodged and approved by the Chief Administrator both in respect of a mining licence and an exploration licence.

Prior to the commencement of work in accordance with the above work plan, the applicant must have entered into a rehabilitation bond in accordance with s 80 of the MRDA. Pursuant to the rehabilitation bond the licensee must rehabilitate the land in accordance with a rehabilitation

plan approved by the Chief Administrator and to the joint satisfaction of the Minister under the MRDA and the Director-General as defined in the *Conservation Forest and Lands Act* 1987.

The amount of the bond (cash or bank guarantee) varies but is unlikely to be less than $20,000 and more probably $50,000.

Environmental

Pursuant to the *Environment Protection (Schedule Premises and Exemptions) Regulations* 1984 extractive industries including mining are exempt from the need for works approval or licences under the *Environment Protection Act* 1970 ("EPA").

The Minister administering the MRDA effectively must ensure that the works programme is satisfactory on environmental grounds. However, that does not diminish the potential responsibility and liability pursuant to the EPA. The treatment of tailings which generally involves cyanide or even in some cases the mere treatment of tailings without the addition of cyanide to that already present would fall within the definition of "pollution and waste" under the EPA and thus potentially breach s 39 (waters), s 41(1) (the atmosphere) and s 45(1) (land).

Particular concern relates to "aggravated pollution" (s 59E).[18] This is the most serious pollution offence under the Act. A miner who intentionally, recklessly or negligently pollutes the environment or intentionally, recklessly or negligently causes or permits an environmental hazard which results in:

(a) serious damage to the environment; or

(b) a serious threat to public health; or

(c) a substantial risk of serious damage to the environment; or

(d) a substantial risk of serious threat to public health

is guilty of an indictable offence.

An environmental hazard is defined as meaning:

> "a state of danger to human beings or to the environment whether imminent or otherwise resulting from the location, storage or handling of any substance having toxic, corrosive, flammable, explosive, infectious or otherwise dangerous characteristics": s 4(1).

The maximum penalties for a breach of this section is a fine of $1,000,000 for a corporation, or of $250,000 or seven years' imprisonment or both in the case of an individual.

The width of the above definition in a State as densely populated (compared to other States) as Victoria creates a real concern for a miner proposing to chemically treat tailings. The breach of a tailings dam or the escape of tailings water could very easily pollute the groundwater and affect stock and people for some distance.

18. See Jillian Segal's comprehensive article, [1991] *AMPLA Yearbook* 236.

Courts have not found it necessary in cases where there is pollution to water, soil or the atmosphere to consider it necessary whether the defendant intended to pollute or whether pollution resulted from negligence of some sort. In *Allen v United Carpet Mills Pty Ltd* [1989] VR 323 it was held by the Victorian Supreme Court that the defence of honest and reasonable mistake was not available where pollution of the environment was concerned. All that was needed to be shown was that there was pollution resulting from a discharge from the defendant's premises which were used for a commercial or business undertaking.

Directors of mining companies should particularly note s 66B(1) of the Act states:

> "If a corporation contravenes, whether by act or omission, any provision of this Act or a notice or a licence or permit under this Act, each person who is a director or is concerned in the management of the corporation is also guilty of the offence which relates to the contravention and liable to the penalty for that offence."

It should be noted that directors and managers can be prosecuted independently of the company.

CONCLUSION

A miner wishing to undertake the treatment of tailings in Victoria still has some very real procedural problems to deal with and certainly has important planning and environmental requirements and obligations to satisfy.

The value of the potential total resource in tailings throughout Australia is too large to ignore. New technology will be developed to recover economically gold from low-grade dumps. The value of this resource must be balanced with the legitimate concerns of the community as to environmental and historical matters.

However, with positive government support (and an amended Act) and the incentive of a rise in gold price, one must optimistically believe that all problems will be surmounted.