

## **Placer Gold Mining in Mongolia – the New Zealand Way**

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### **ABSTRACT**

This paper describes the successful introduction into Mongolia of the New Zealand method of placer gold mining by Cold Gold Mongolia Ltd. (CGM), using a mobile screening plant and New Zealand-designed hydro-active riffled sluices. In 1999, CGM imported into Mongolia a 60m<sup>3</sup>/hour screening plant from New Zealand together with a complete set of mining equipment. The New Zealand plant operated successfully in the 1999 mining season, producing 37 kilos of gold in a 4-month scavenging operation from abandoned workings on the Toson Terrace in the Zaamar Goldfield. The site had been previously mined by a Mongolian company from 1993-96 using traditional Russian mining and washing methods. At the start of the 2000 season, CGM shifted operations to northern Mongolia and opened the Yalbag Mine. Difficulties included patches of frozen ground (permafrost) and inaccuracies in the usually reliable soviet exploration drilling records. The Yalbag Mine has operated successfully for 2 years, producing 113 kilos of gold. The introduction of New Zealand mining methods and New Zealand technology permitted high percentage gold recovery, 24-hours a day gold washing, same-day rehabilitation of mined-out areas, reduction of truck movements and efficient use of manpower. The paper draws attention to 2 features that merit attention by the Mongolian mining industry: a) the high percentage of gold recovery and b) the minimisation of environmental impacts and achievement of cost-effective environmental rehabilitation.



**Fig.1:** Gold concentrate in a gold pan, taken from the New Zealand hydro-active riffles in the 2001 mining season at CGM's Yalbag Mine in northern Mongolia.

## Introduction

Cold Gold Mongolia (CGM) is a 100% Kiwi-owned company that was formed for the express purpose of establishing a placer gold mining operation in Mongolia. The attraction was, and continues to be, the large amount of placer gold reserves and the favourable legislation for placer gold mining operations. The managers of CGM sought to introduce into Mongolia the type of gold washing equipment perfected in New Zealand that appeared to be ideally suited to the long and narrow placers prevalent in Mongolia. CGM began activity in 1999, importing into Mongolia a 60m<sup>3</sup>/hour screening plant fitted with a New Zealand-designed hydro-active riffle system. Also imported was all the necessary support equipment needed to mine the New Zealand way.

The New Zealand method of placer gold mining has a recent history of innovation and success. In the 1980s the high world price of gold stimulated a lot of interest in reworking the rich goldfields in the South Island of New Zealand, and at that time it was relatively easy to obtain mining permits. By the mid-1980s there was more than 200 screens in operation, all equipped with wide sluices instead of the traditional narrow sluices. This innovation alone was enough to significantly improve gold recoveries, but a new problem was observed. Because the slurry velocity on the wider sluices was a lot lower, of necessity to catch more gold, the bed of the riffles tended to pack tight with sediment. This was particularly noticeable when the wash water was very dirty. When tight packing occurred, the gold was prevented from getting to the base of the riffles and so the gold tended to be washed off over the top, resulting in significant losses of gold. At the time, the only way to stop this was to scratch the sand in the sluice every 1 to 2 hours in order to maintain the sand in a loose condition. The breakthrough arose in 1988-89 when New Zealanders invented the hydraulic riffles, and within a year virtually all screens operating in New Zealand were fitted with them. The hydraulic riffles kept the sediment loose, and so eliminated the necessity to stop in order to scratch the sediment every few hours. This allowed the New Zealand miners to get the full benefit of the wide riffles without the disadvantage of frequent stoppages to scratch the sediment.

In its current configuration, CGM's 60m<sup>3</sup>/hour Screening Plant has the following technical characteristics. The plant consists of a 4-metre long Trommel, 1.5 metres in diameter, which is skid-mounted and fitted with hydraulically-operated levelling legs, plus a 10-metre pivoting Tailings Conveyor. Gold is recovered from 8m<sup>2</sup> of riffle table area, 6m<sup>2</sup> of which consists of hydro-active riffles, and the remaining 2m<sup>2</sup> is expanded mesh over 'nomad' matting.

Hydro-active riffles are a simple non-mechanical method of significantly improving gold recovery. Hydro-active riffles use low-pressure water under the riffles to maintain a fluid bed. For hydro-active riffles to work effectively they must process gravels with a diameter of less than 15mm and low velocity feed rate.

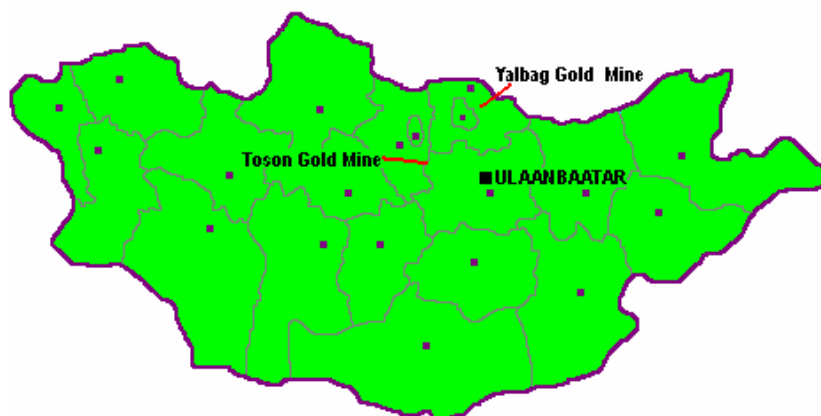
When tested by the Government's Central Geological Laboratory of the Minerals Authority of Mongolia (MRAM) in 1999, the New Zealand-designed hydro-active riffle system of CGM had a recovery rate of 96%, the second highest in Mongolia for the year. First place for 1999 went to Zaamar Goldfields Ltd. (100% subsidiary of Canadian company Java Gold Corporation (JVAG on CDN) who attained 97% using Knelson<sup>TM</sup> centrifugal concentrators.

The excellent recovery of CGM's 60m<sup>3</sup>/hour screening plant is mainly due to 3 factors:

- a) first screening the gravels down to less than 12mm so that only the gold-bearing gravels go through the gold recovery system;
- b) allowing lower water velocity to be used on the sluices due to the smaller gravel size;
- c) widening the sluices so the gravels can be spread out and run at a slower speed over the NZ hydro-active riffles.

## Mining Activity 1999 – Toson Terrace

The New Zealand equipment was to be immediately put to work at the start of the 1999 season mining an alluvial gold deposit in the Harganat valley in Eroo Soum in Selenge, but unfortunately due to contractual problems with the Mongolian company that owned the mining license the planned mining operation never started production.



*Fig.2: Location of Toson Gold Mine and Yalbag Gold Mine.*

### Toson Terrace - Background

After some frantic searching as the 1999 mining season was already underway, CGM managed to find another area to mine, in the Zaamar Goldfield on the Toson Terrace at Mining License A-184. This is approximately 200km WNW of Ulaanbaatar, accessed by bitumen roads for 110km and the last 90km by hard pack all-weather dirt road.

The Toson Terrace has an interesting history of attempts to recover gold. The mining concession had been originally held by Gazar Toson Ltd., at that time a daughter company of Gazar Holdings Ltd., who began the Toson Mine in 1993, and produced 460 kilos of gold in the 1993-1996 interval using conventional sluices. In 1996, the Canadian/Indonesian-controlled Golden Tiger Corporation (GTC) initiated a bulk testing programme on the Toson Terrace, and the results have been recently published (Beaudoin 2000). This used a Pilot Plant with a 4m long trommel (incl. 1m scrubber) that screened off oversize at >5mm, and pumped slurry of c.40% solids to a 75cm Knelson™ concentrator at a maximum feed capacity of 20m<sup>3</sup>/hour of solids. The results indicated a gold grade of 320 mg/m<sup>3</sup> ('in situ') for a 3m thick Low Grade Zone, and 415 mg/m<sup>3</sup> ('in situ') for a 4m thick High Grade Zone. The top 30cm of the underlying bedrock material yielded a gold grade of 317 mg/m<sup>3</sup> ('in situ'). In addition, 200m<sup>3</sup> of sluice tailings of Mongol Gazar Ltd. were processed by the Pilot Plant and 29.02 grams of gold recovered, indicating a grade of 145mg/m<sup>3</sup> (loose material). These tailings were from the High Grade Zone, thus the 1993-96 sluice mining operations had achieved only 51% gold recovery (Beaudoin 2000).

Encouraged by these pilot results, the Canadian public company Java Gold Corporation (JVAG on CDN) attempted large-scale placer mining in 1997 using several Knelson™ centrifugal concentrators. Production forecasts of 10-12,000 ounces were announced for the 1997 season, but only 14.37 kilos were produced. This chronic failure on the Toson Terrace has been analysed by Grayson (2000) who presented the following reasons – a) bad management, b) old second-hand equipment with frequent stoppages and shortage of spares in-country, c) delays due to attempting “modifications” to the processing plant at the same time as production, d) failure to commission the IHC Jig recovery system. Java Gold never recovered from the disaster and, drained of cash, the company had almost no working capital to resume mining at Toson in the 1998 season. Mining was seriously delayed and only 18.9 kilos produced in 1998. Cash-starved, Java Gold sold most of its interest in the Toson Terrace in 1999 to Monpolymet Ltd. who resumed mining with traditional sluices.

### Toson Terrace - CGM

The 'start' position for Cold Gold Mongolia (CGM) introducing the New Zealand style of mining on the Toson Terrace was the lull in 1999 after Java Gold Corporation had ceased large-scale placer mining using Knelsons, as described by Grayson (2000).

CGM began with initial testing on the Toson Terrace with a smaller test screen also fitted with New Zealand hydro-active riffles. The processing capacity of the test screen was 10m<sup>3</sup> of gravel an hour. 10-metre samples were taken from the extensive former Mongolian mining site of Mongol Gazar Ltd. Samples were taken from the pit edges, from coarse and fine tailings, from abandoned Russian-style sluice boxes and some unmined ground adjacent to the open cut pit. The best results were from the edges of the pit and also some areas of bedrock that had not been cleaned properly inside the pit. Grades here were often in excess of 1g/m<sup>3</sup>.



*Fig.3: CGM pilot testing the margins of the flooded abandoned areas of the Toson Mine that had been previously worked by Gazar Holdings Ltd. from 1993-96.*

Of particular interest were the results of the tests on the tailings of the abandoned Russian-style sluice boxes, and both coarse and fine tailings returned the same result of between 200-300mg/m<sup>3</sup>. A large amount of the gold from the coarse tailings was in large pieces between 1-4 grams. The soviet drill results for this area before mining indicated an average grade of around 1g/m<sup>3</sup>. At face value, this equated to an overall recovery rate for the Russian sluice boxes used in 1993-96 of 70-80%. Interestingly, the results published by Gary Beaudoin (2000) of a field test conducted in 1997 nearby sluice tailings of Mongol Gazar Ltd. from the High Grade Zone, using a Pilot Plant with a Knelson<sup>TM</sup> centrifugal concentrator, indicated that 1993-96 sluice mining operations had achieved only 51% gold recovery. In the 1997 test, 200m<sup>3</sup> of tailings yielded 29.02 grams of gold, indicating a grade of 145mg/m<sup>3</sup> (loose material LCM).

CGM estimated that there had been 10,000 ounces of gold recovered from this area already, so a conservative estimate was that there would still be between 2,000 and 3,000 ounces of gold in the tailings from the 1993-96 mining.



**Fig.4:** CGM's successful scavenging operation in the abandoned part of the Toson Mine.

CGM ran a scavenging operation for the remainder of the 1999 season. First the CGM crew cleaned up any bedrock that previous testing showed contained more than 500 mg/m<sup>3</sup>. The gravel was transported to the screening plant by truck. Obviously this is not the most efficient way of mining but because of the limited amount of pay gravels in any one location it was not economic to set the screen up on site.

Once the CGM team had cleaned the bedrock, the overburden was removed from any pay zones in the pit walls by using an excavator to throw it on to the previously cleaned bedrock, then again the pay zone were trucked to the screen. By using this system CGM successfully recovered 37 kg of gold for the 4 months worked in the 1999 season. This was all taken from an area that in theory had been mined out by Russian-style sluices in 1993-96.

Overall the CGM screen worked very well in the Toson Terrace placer. However in places the pay gravel has a false clay bottom with very low gold grades resting upon it. This proved to be difficult to wash, and gold recovery from this clay-rich material was lower than it could have been as the CGM screen was not designed to process clay-rich material. In order to wash such material, the screen would require a scrubber section and an extra length to allow the wash water to disintegrate the clay. Nevertheless CRM are sure that, even in these difficult clayey-rich materials the CGM screen achieved a significantly higher gold recovery than would be possible with a Russian-style water cannon and sluice operation.



**Fig.5:** Clean-up of gold concentrate at CGM's scavenging operation at the Toson Mine.

## Mining Operations in 2000 & 2001 – Yalbag Mine

For the 2000 season, Cold Gold Mongolia (CGM) shifted its mining activities to the Yalbag valley, a small left bank tributary of the Eroo River in northern Mongolia. CGM's Yalbag Mine is located in the administrative district of Eroo Soum in Selenge Aimag. CGM negotiated a full contract mining agreement with the license holders, Cascadia of Canada, to mine Mining License No.A-1401 that they held.

Many companies have tried to mine in the Yalbag valley, but most have not enjoyed financial success and almost all have used the Russian bulldozer-and-sluice method. In addition to the financial considerations of mining, the bulldozer-and-sluice method always leaves an environmental mess once mining is complete.

The Yalbag area is known as a difficult area to work because it has a high rainfall over summer and in most areas the gravels are frozen all-year-round (permafrost). The ground that CGM worked had only intermittent permafrost so that was not such a problem, however, the rain was. CGM's stripping operation involved trucking the 4 metres of overburden around to the refill area, the top 2 metres of which was a rich black loam when dry but was a slippery black mud when wet, not ideal to operate trucks on!

Once mining began CGM also found that the results of the old exploration drilling were not accurate. This was unexpected as Soviet-drilling programmes usually produced results with a tolerably high standard of accuracy. Initially CGM was recovering around half of what the drill logs indicated, about 400mg/m<sup>3</sup>. What was worse was that the best grades of gold proved to be on the opposite side of the valley to where the best drill results were. Unfortunately this was where CGM had stockpiled its overburden for the initial mining cut.

CGM could not expand the pit until it had moved past the stacked overburden. Because CGM were digging 5 metres below water level, a pump had to be kept running constantly to keep down the level of ground water. As the water table was gradually lowered the amount of water being pumped out reduced significantly.

The initial pit was established by stockpiling the overburden on adjacent ground (see above) and the first 15,000m<sup>3</sup> of pay gravel were trucked 1.5km to the nearest area of unreclaimed mined ground where the washing plant was set up. CGM then had a hole 100m long, 40m wide at the bottom and 60m wide at the top. This hole was to serve a dual purpose, the first 60-metre length of the hole from the bottom was to be the settling and recycling pond. The remaining 40-metre length was used as the initial tailings dump.

CGM then moved the screen into the hole and started processing the pay layer on-site. This is the New Zealand way, ensuring that the gravel is only handled once, being dug out with an excavator and loaded directly into the screen for processing after which it drops straight back into the hole. Once all the gravel accessible to the excavator has been processed, then the screen is moved along the cut. The timing of moves varies considerably with gravel depth, but for example with the 2-metre pay layer at Yalbag the screen needed to be moved approximately every 18 hours.



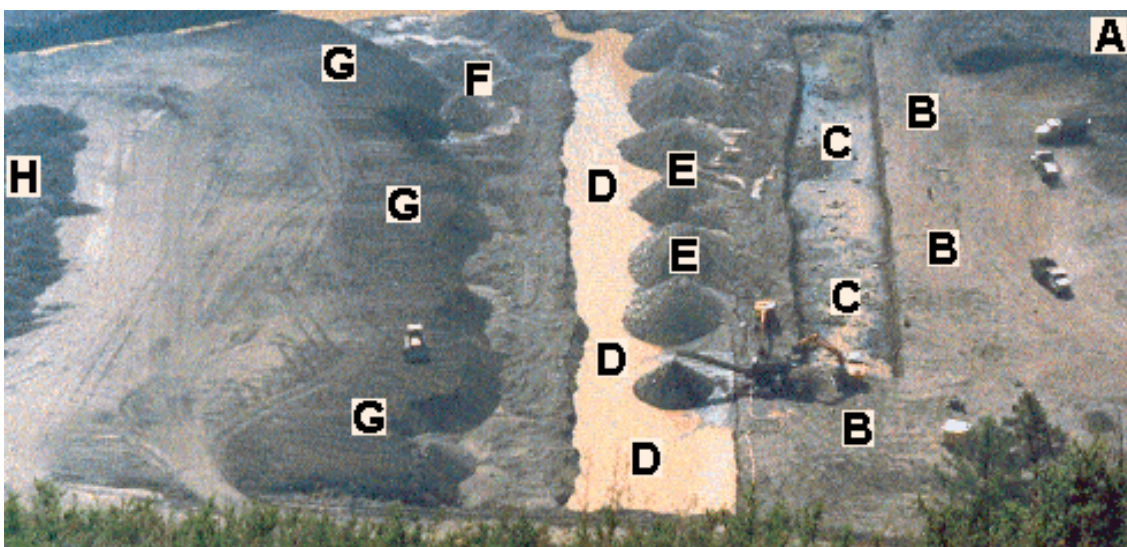
**Fig.6:** Panoramic view of CGM's Yalbag Mine in the 2001 mining season. The view is taken looking northwards across the valley, with the Yalbag River flowing left to right, discernable at the edge of the conifer forest.

Competitions in 2001 amongst CGM's mining staff showed that it was possible to move the screen in as little as 19 minutes, with a team of only two staff. The timing was started from when the last bucket had been loaded into the hopper to when the first bucket of gravel was loaded after the move. However, this is NOT the usual practice, and under normal circumstances the 2-person team can move the screen in 30 minutes.

The overburden was progressively removed from the advancing mining operations (see A), trucked behind the tailings' dump zone and dumped on the tailings (see G). The topsoil was separated and formed the final layer to facilitate regrowth of vegetation (see H). Reclamation is an integral part of CGM's mining operation, being progressive and is inexpensive as the dirt is handled only once. CGM's overburden and reclamation cost are one and the same.



**Fig.7:** Panoramic view of CGM's Yalbag Mine showing method of mining:  
 A=scrub clearance then topsoil and overburden removed by excavator onto trucks; B=top of placer (pay gravel) cleared of scrub, topsoil and overburden; C=see next illustration; D=flooded excavation of mined-out block, with discharged tailings; E=cones of oversize conveyed into flooded mined-out block; F=cones of oversize burying previous mine-out block; G=trucked overburden being bulldozed over old oversize mounds; H= trucked topsoil being bulldozed over trucked overburden.



**Fig.8:** Panoramic view of CGM's Yalbag Mine showing method of mining. Labelling as in Fig.7. C=block of placer recently mined-out.

### Gold Recovery compared with Soviet Drilling

CGM found as they moved up the Yalbag valley that the gold grade improved, also the payable zone became much wider than the drilling results indicated. Gold recovery at Yalbag is very high, as the average gold size is over 500 microns. Despite this, other mining companies mining in this area only usually recover around 70% of estimated reserves. On the 3 blocks CGM has worked, gold was produced to 130% of the estimated reserves based on soviet drilling exploration. This showed that the soviet drilling had seriously underestimated the gold content.



*Fig.9: View of CGM's Yalbag Mine, showing a Hitachi excavator removing overburden (centre left) to expose the top of the placer, and a second Hitachi excavator (centre right) mining the placer and feeding it directly into CGM's 60m<sup>3</sup>/hour screen plant. Note the conical mounds of oversize dumped by conveyor. The string of oversize mounds results from the periodic moving of the skid-mounted mobile 60m<sup>3</sup>/hour screen plant to keep up with the advancing mining cut.*

### Rate of Mining & Processing

In full operation, CGM's Yalbag Mine processed over 1,000m<sup>3</sup> of pay gravel a day, and removed 2,000m<sup>3</sup> of overburden during the day shift.

### Mining & Washing Season

The harsh Mongolian winter is a severe constraint on all-year-round mining and gold washing. Normal placer operations are therefore restricted to a tight weather window, apart from dredge operations and other winterised plants. For 2001, CGM's Yalbag Mine had a target of 165 mining days for the season, mining 24 hours a day, giving a theoretical maximum of 3,960 mining hours available.

In 2001, CGM began mining on 30<sup>th</sup> April, on ground already stripped in 2000. However, this ground had frozen over in places during the harsh Mongolian winter, and the ice now made mining the placer very difficult. Digging frozen gravel with 20-ton excavators was a strain on the machines and CGM paid the price later in the season when the excavators suffered from cracked booms. Fortunately 15 days later most of the frozen placer of the stripped areas had thawed.

CGM operated 22.5 hours a day during 2001, stopping at 20:00 hours each day to lift the Nomad matting at the head of the tables was more than half of the gold (65%) of the total that was recovered. At the same time, the opportunity was taken to refuel and grease the

excavators. A 2-shift system was used, mining stopping at 8:00 in the morning for 15 minutes for the change of shift, giving a second opportunity to grease the excavators again. A further 45 minutes of stoppages occurred every 24 hours to permit the skid-mounted screens to be moved in order to keep in close proximity to the face being excavated. Every 2 weeks, the hydro-active riffles were lifted in order to extract the remaining 35% of the total that was recovered, a process that takes about 3 hours. Any maintenance that is needed is also done at this time. During the season, the screen mesh was changed once, as this has to be done every 100,000m<sup>2</sup>, an essential operation that takes a full day.

Thus, of the theoretical 3,700 screening hours available at the Yalbag Mine in 2001, in practice 3,350 screening hours was actually achieved. CGM finished on 15<sup>th</sup> October 2001, significantly earlier than necessary but based on awareness of the relatively harsh autumn the previous year, the expiry of water permits and icing-up of equipment.

The mining and washing hours achieved in 2001 were remarkably high compared with normal Mongolian operations but typical for New Zealand mining and washing operations.

### **Mining Plant**

CGM's Yalbag Mine utilised two 20-ton excavators, one for overburden removal and one for screen loading. These were caterpillar-tracked excavators, model EX200-3, built by Hitachi in 1996, fitted with 125Kw Isuzu turbocharged motors. When purchased in Hong Kong, both excavators had 1,000 hours on the clock, and at the end of the 2001 season one of the excavators now has 9,000 hours on the clock, the other has 8,000. Both excavators were still performing well at the end of the 2001 season. CGM considers that scheduled maintenance is the key to low operating costs and high machine availability, and Hitachi are one of the most reliable manufacturers in the world for excavators. The limited number of spares required were sourced from New Zealand in 7-10 days. In the 3 years that CRM has operated the 2 excavators in Mongolia, no malfunction has occurred that prevented the mine from operating. In the first year of operation, one excavator had a total computer failure and the machine became very slow but could still be used until a new computer arrived.

CGM's Yalbag Mine utilised 6 trucks in total. 3 trucks were used for stripping (at 90% availability – CGM use between 5-6 Russian Kraz 7m<sup>3</sup> trucks). Under the northern Mongolian conditions, the trucks performed adequately. Downtime for maintenance was however huge, with only a 50-60% availability. The advantage of using Russian trucks was that spares are readily available in Mongolia and very cheap.

Water supply for the screen was provided by a 125Kw turbocharged Isuzu motor coupled to an Ajax 5x6 pump, satisfying the screen's requirement for 2,200 litres of wash water for every cubic metre of washed gravel.

Drainage was achieved satisfactorily using an Isuzu-powered 100Kw motor coupled to an Ajax 5x6 pump with a reduced impellor. The pump was also capable of supplying water to the screen but had to be at nearly full speed (2,200 rpm) in order to do so. CRM try to avoid operating any machines for too long at maximum speed as this reduces the service life.

Both pumps are fitted with 6 metres of plastic suction hose, the '100Kw' set-up has a 150mm diameter hose and the 125Kw hose has a 200mm diameter hose. Both hoses are fitted with a suction intake strainer. Connecting the pump and the screen is a 150mm diameter layflat hose fitted with camlock quick couplings, the layflat hose being cut into 20-metre lengths for ease of handling when moving the screen.

### Washing Plant

To wash the gold, CGM's Yalbag Mine used a New Zealand-built 60m<sup>3</sup>/hour screening plant fitted with a New Zealand-designed hydro-active riffle system, as described above. The system is skid-mounted and fully mobile, hence dispensing with trucking of pay gravel. The screening plant was moved approximately every 18 hours, each move taking about 30 minutes.

The hydro-active riffles performed well, and required only minimal maintenance during the season. Care had to be taken to ensure that at all times a fluidised bed was maintained, in order to maximise gold recovery.



*Fig.10: Mining operations at CGM's Yalbag Mine in the 2001 season. Direct mining of virgin placer is underway by a Hitachi excavator, swinging to load the pay gravel directly into the hopper of the skid-mounted New Zealand screening plant. No trucking is required.*

### Gold Recovery

Gold recovery was estimated to have been consistently maintained at well above 90% at the Yalbag Mine for both the 2000 and 2001 mining seasons. Independent testing in the 2000 season by the Government's Central Geological Laboratory showed that the New Zealand-designed hydro-active riffle system of CGM had a gold recovery rate of 95%.

Regarding coarse gold, the screening plant used at the Yalbag Mine is designed to screen-off material greater than 12mm in diameter and therefore any nuggets larger than this would be automatically lost. Interestingly, at one stage in the season, when the mesh of the screen required replacing due to wear, a 21-gram nugget of gold was recovered in the sluices, having got through an enlarged hole in the mesh.

Appealing though gold nuggets are, CGM estimated that less than 0.5% of the gold at Yalbag would be in the form of nuggets, and the priority was to maximise the recovery of the fine gold, with at least 10% being less than 500 microns in size.



*Fig.11: View inside the screen plant, rotating from left to right, showing the jetting of the tumbling pay gravel from 2 spray bars.*

### **Gold Characteristics**

The New Zealand hydro-active riffles produced gold with the following characteristics. The average size of the gold recovered was 2mm, maximum size 21 grams, minimum size was absolute gold dust that floated on water. Many of the nuggets were heavily water-worn and some had quartz attached. The fineness of the gold was determined as having 92-93% purity.

### **Other Minerals**

With the gold, the main heavy minerals were black sands consisting mainly of ilmenite, magnetite, ironstone and garnets. Except for native gold, no other valuable minerals such as native platinum Pt were present, and no potentially problematic cinnabar HgS or native mercury Hg was present.

### **Upgrading & Preparation of Saleable Concentrates**

After every 2 weeks' of operation, the riffles became full of a very heavy concentrate, consisting of 90% black sands and ironstone. It was a very slow process each time to carefully wash the 20 or so 12-litre buckets of heavy concentrate using a 'wash-up sluice' in order to produce a super-concentrate filling a gold pan.

The next stage was to sieve the super-concentrate to produce a coarse fraction and a finer fraction. The coarse fraction was panned to separate the gold. The finer fraction was re-washed over a wide sheet of aluminium using a very slow water flow in order to fully remove the black sands.

### **Gold Output & Sales**

Output at CGM's Yalbag Mine was 33 kilos of gold in 2000 and a further 81 kilos in 2001. Companies are free to sell or export gold, but CGM followed the majority who choose to sell concentrates and dore to the Mongol Bank (central bank) in Ulaanbaatar as the price offered is conveniently close to the world price. Sales Tax of 10% is payable plus 2.5% state royalties.

### **Mine Operating Costs**

Mining costs at CGM's Yalbag Mine using the New Zealand system were low because pay gravels were handled only once. CGM calculated that the cost to excavate the pay gravel and process to recover the gold was only 0.6 USD per cubic metre. The additional cost of removing the overburden, which at the same time was dumped on the tailings for reclamation, was estimated to be only 0.7 USD per cubic metre. This included the cost of using a bulldozer to do the final levelling and maintain a tidy dump head.

### **Energy Requirements**

During full-scale operation, the total energy requirement of CGM's Yalbag Mine was 1,200 litres of diesel per day, including fuel for trucks. Diesel fuel was delivered by local contractors using a 6,500-litre Russian road tanker from Ulaanbaatar city, some 240 kilometres distant from the mine. The cost of diesel fuel was 0.4 USD per litre, delivered. At the mine, diesel was stored in a 24,000-litre fuel tank. The mine was equipped with a Lister 3-cylinder 16 Kw diesel generator, purchased second-hand nearly new in 1998 in excellent condition.

### **Output and Manning Levels**

The mine staff required to operate CGM's Yalbag Mine was significantly less than a comparably sized sluice box and water gun operation. CGM's Yalbag Mine operated 24 hours day. On the 12-hour day shift, the mine required 8 people for stripping and mining, whereas on the 12-hour night shift only 2 people were required to keep the screen operating.

### **Rehabilitation of Mined-out Areas**

CGM's Yalbag Mine is almost unique in Mongolia in implementing effective phased rehabilitation. Rehabilitation is continuous with the mining. The New Zealand method of mobile mining dispenses with the creation of a large string of open excavations along the placer, and the accumulation of a mountain of oversize by a static wash plant next to a large unmanageable tailings lagoon. This scenario is almost inescapable with the traditional Mongolian/Russian method of mining with a static wash plant, and rehabilitation to something approaching the original landform is rendered virtually impossible.

CGM's Yalbag Mine effectively minimised the risk of dirty water escaping into the river system by adopting a method of mining almost unique in Mongolia. By virtue of the screening plant being mobile, there is no opportunity for the accumulation of enough tailings to overwhelm the tailings pond and so trigger the release of dirty water into the nearest stream. Instead typically no more than 18-hours of tailings accumulate before the screening plant is shifted forward to a new location, and the tailings covered in spoil. Similarly the tailings pond also advances with the mining and is thus effectively 'as new' every day.

Environmentally damaging truck movements are minimised to the essential trucking of overburden and topsoil relatively short distances. The mine utilises the New Zealand mobile method of mining whereby the skid-mounted screening plant is shifted regularly to the pay gravel. Thus the pay gravel is handled only once, by excavators, so dispensing with long-distance trucking of the pay-gravel to a static washing plant.

## Discussion

### Environmental Issues

The environmental consequence of the tradition of having a static washing plant is that a large single mass of tailings inevitably results, often overloading the tailings pond leading to occasional eruptions – or even continuous escapes - of dirty water into the local river system. Such river pollution has been documented in the Yalbag valley by Melchert, Peter & Budiin Mendsaikhan (1999) and Melchert (1999), and in the Zaamar Goldfield by Dallas (1999) and Farrington (2000).

Much of the Yalbag valley is scarred by the legacy of recent placer gold mining using the Russian sluice methods, with little visible attempts at mine rehabilitation. In contrast, CGM's Yalbag Mine undertakes phased rehabilitation to approximately the original landform. From an environmental standpoint the New Zealand system offers major advantages over the traditional Russian sluice mining:

- a) Environmental impacts by trucks are minimised (no trucks used for moving placer);
- b) Environmental impacts on rivers and streams are minimised as the method of working ensures that dirty water is contained and tailings buried promptly;
- c) Environmental impacts on landforms are minimised, as the mined-out areas are backfilled continuously, and no mounds of oversize or chains of excavations are left;
- d) Environmental impacts from potential re-mining of tailings is avoided, as the mining system ensures that over 90% of the gold is removed, rather than the 40 to 70% normally achieved by traditional Russian sluices;
- e) The black topsoil, approximately 300mm thick and rich in plant matter is excavated and swiftly redeposited in a single trucking movement, minimising loss of topsoil and avoiding needless damage to topsoil from prolonged storage;
- f) The black topsoil is spread on top of the trucked overburden, which itself rests on top of the oversize and tailings infilling the mined-out areas. Thus the resulting soil profile is reasonably natural in character, maximising the permanence and speed of recolonisation by local flora and fauna.

### Economic Issues

The New Zealand system offers major economic advantages over traditional Russian sluice mining. In particular:

- a) recovery of well over 90% of the gold is achieved as a matter of routine;
- b) fewer trucks needed, as the pay gravel is loaded directly into the screening plant;
- c) fuel costs are minimised;
- d) labour requirements are reduced to a cost-effective minimum;
- e) rehabilitation is part of the daily mining routine and therefore is not an end-of-season financial burden, and does not become a liability issue at the end of mining.

## Conclusions

The performance of a 60m<sup>3</sup>/hour screening plant fitted with a New Zealand-designed hydro-active riffle system has achieved excellent results in Mongolia over 3 consecutive seasons - 1999, 2000 and 2001. The New Zealand system proved highly successful in a 4-month test period in 1999 on the Toson Terrace in the Zaamar Goldfield, proving efficient and profitable in scavenging in supposedly mined-out in 1993-96 by Russian style monitors and sluices. In 2000 and 2001 the New Zealand system proved to be highly effective at CGM's Yalbag Mine in northern Mongolia. CGM's Yalbag Mine not only looks like any alluvial mine in New Zealand, it has the same low operating costs, good gold recovery rates, progressive reclamation done to a high standard and a clean water discharge achieved. Normally in New Zealand this has to be achieved with an average gold content usually well under 200mg/m<sup>3</sup>. Due to the low average grade of New Zealand, miners in New Zealand have been forced to become efficient and inventive to survive.

The grades in Mongolia are much higher therefore the incentive for improving efficiency has been far lower for Mongolian miners. However, as the rich deposits in Mongolia are depleted the need for efficiency gains will become increasingly important.

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