Review of the Gold Dredges in Mongolia, with comments on mitigation of environmental impacts

Gerrit Bazuin (1), **Robin Grayson MSc** (2) **Frank McBride** (3) **& Iain Barclay** (4)
(1) General Director of Ochir Leasing Co. Ltd. ochirlg@magicnet.mn
(2) General Director of Eco-Minex International Co. Ltd. emiweb@magicnet.mn
(3) General Director of MACSS Co. Ltd. ganafrank@netscape.net
(4) Marketing Director of Eco-Minex International Co. Ltd. emiweb@magicnet.mn

ABSTRACT

Gold dredges are novel in Mongolia, part of the ongoing placer gold boom. Four large dredges are operating, plus one ready to assemble and one more planned. Designs are based on dredges of 50 years ago that used mercury to enhance gold recovery, a technique discontinued technique. The designs cause the coarse tailings to be discharged on top of the fine tailings giving an unnatural restored profile. Retroengineering is affordable to create a more natural profile. The dredges use the 'spud' system for steerage rather than 'cable-and-winch' system; thus the discharged tailings tend to accumulate in mounds. Conversion to 'cable-and-winch' would be difficult and not affordable. An alternative would be the addition of a swinging stacker to spread the discharged tailings more evenly. Three of the 4 dredges use sluices of improved type, one uses conventional jigs, and recovery of fine gold would be much higher with 'sawtooth' jigs. The 4 dredges might boost production by 1 ton of gold a year between them if sawtooth jigs were installed. This would give a fast payback, but local interest rates on loans are a prohibitive 4-7% per month, so special financial incentives are needed, such as a tax holiday. The dredges are assisted by land-based draglines to strip off the overburden creating severe environmental impacts, notably steep-sided high mounds of overburden. A switch to cutter-suction dredges to pump the overburden away as slurry would produce more acceptable landforms, but financial incentives are required. A constraint on restoration is the 'swell factor' that increases the volume of excavated material by 30-50%, so restoration to the original landform is not possible, as complete recompaction is not achievable. Rehabilitation is possible, with scope for 'wildlife gain' due to the potential to create a wetland mosaic.

Fig.1: *Mongolrosvestmet gold dredge in Zaamar Goldfield in 1998. The bucket-line is out of the water.*

Introduction

A 'gold rush' is underway in Mongolia based on the rich and numerous placer (alluvial) gold deposits. The rapid expansion of placer gold mining has occurred since the Government launched the 'Gold Project' which opened up to local and foreign investors the extraordinarily large geological database produced by the command economy and formerly kept secret by the State.

Mongolia is a semi-arid country except near the northern border with Russia, and thus most of the placers are amenable to dry-mining and indeed the shortage of surface water and limited supplies of ground water are a major hurdle of expansion of placer mining into the rich placer gold deposits in many arid regions such as the Gobi.

Nevertheless, many placers in Mongolia are beneath the water table, and are more amenable to low-cost dredge operations rather than the uncertainties and expense of pumping the groundwater to permit dry mining. Mongolia has some exceptionally large placers that are largely below the water table, and the only realistic option is dredge mining.

Fig.2: *front view of Mongolrosvestmet gold dredge in Zaamar Goldfield in 1998.*

This paper reviews the current gold dredge mining in Mongolia and examines the potential for mitigation of environmental impacts by upgrading the existing dredges and adoption of 'western' standards for all new dredge projects. The paper also examines to what extent such retroengineering of old dredges to increased specifications can be self-financing and what the source of such financing might be.

  contact: emiweb@magicnet.mn

Geological and Hydrological Factors

The main geological factors affecting dredge operations is the presence of placers in river valley systems. In general, upper terraces are self-draining and amenable to 'dry' mining. However the river floodplains – and often the lowermost terraces – are charged with water, and 'wet' mining using a dredge is generally the only feasible option.

In Mongolia the harsh winter climate renders impracticable 'dry' mining for more than an average of 155 days a year, as the gold recovery requires water, not ice. 'Wet' mining has a particular advantage in that the dredges are able to operate for considerably more than 155 days a year, due to the 'dredge ponds' freezing over but still holding large volumes of unfrozen water below for most of the winter, and because the process plant of a dredge tends to be largely 'walled in'. However the dredge needs to be steerable and effective as an ice-breaker even when the dredge pond is frozen sufficiently for a truck to drive across.

A dredge is the ultimate in 'mobile mining' with the gold recovery plant usually on-board the dredge and thus the mobile floating dredge conveys the recovery plant to the placer, dispensing with the need for a fleet of trucks.

Fig.3: *side view of Mongolrosvestmet gold dredge showing walled-in flanks to protect from cold.*

In spite of these inherent advantages, dredges face some special operational problems. In particular, a second dredge or a dragline may be needed to strip off the overburden prior to the gold dredge being able to operate. Even then, a gold dredge is fairly indiscriminate, and thus if a barren zone separates a pay-layer the entire thickness is dredged and processed, with consequent dilution of the original grade. Incorporation of some overburden is also usual, and for operational reasons a dredge may need to 'dredge through' a low-grade area whereas a dry mine can more easily mine around it. A further operational problem is that often in Mongolia, as elsewhere, the richest placer tends to rest upon the underlying bedrock or inside the first 50cm or so of its weathered surface. A dredge needs to recover this material. A special difficulty can occur if the oversize is too large compared with the size of the dredge buckets, and thus big boulders and big pieces of broken rock will be left behind or dropped from the bucket, thus a carpet of boulders and broken rock may accumulate on the bottom of the dredge pond, complicating further excavation.

contact: emiweb@magicnet.mn

Mongolrostsvestmet Dredge in Zaamar Goldfield

The Mongolrostvestmet dredge is active in the Zaamar Goldfield in Tov Aimag. The dredge is mining placer gold from the floodplain and lowermost terraces of the Tuul River in the Baikal catchment. The owner and operator of the gold dredge is Mongolrostvestmet Corporation which was established in 1973, and is one of the world's largest producers of fluorspar (CaF_2). It has diversified into coal mining, gold mining and exploration and mining of other metals such as molybdenum, silver and tungsten.

Fig.4: *rear view of Mongolrosvestmet gold dredge showing disposal of coarse and fine tailings.*

The dredge is a Russian-made **bucket-line dredge** manufactured in Irkutsk, and it became operational in the mid-1990's after a 10-month construction and assembly period. The dredge has a displacement of 1,500 tons, and a maximum reach (depth) of 12m although the average operating depth is about 7m. The dredge has 77 250-litre buckets on a chain, and a dredging design capacity of 1.2 million m^3 a year. The rated capacity is $350m^3$/hour, with 1,800kW of on-board power and a nominal power load of 700-800kW. Power is supplied by the electric grid. Including dredge crew, dragline, goldroom, and workshops, about 500 people are employees including 50 Russians. Prior to dredging, overburden is stripped off by a Russian-made dragline with a $11m^3$ bucket and a long boom. Mining operations include the dredge, 2 water monitors and one scrubber. Gold recovery is by traditional Russian sluice boxes designed for continuous operation.

The entire operation averages 12 kilos of gold per day, and the original in-situ reserves were about 20 tons in a placer deposit with an average grade of about $0.87g/m^3$ with sporadic nugget anomalies between 20 and 30 g/m^3. However the placer includes significant fine gold.

  contact: emiweb@magicnet.mn

Bayangol Dredge & Dragline in Zaamar Goldfield

The 'Bayangol' is Mongolia's newest gold dredge was launched in August 2000. It was ultimately financed with private foreign capital. The Bayangol dredge is active in the Zaamar Goldfield in Tov Aimag. The dredge is mining placer gold from the floodplain and lower terrace of the Bayangol valley, a side-valley of the Tuul River in the Baikal catchment. The deposit is 6.6km long and varied from 80 to 800m wide, averaging 253m.

The Bayangol dredge was formerly known as the "Hailaast dredge" after the original owners of the project, the 90% State-owned Hailaast Shareholding Company. The company signed a contract with the dredge manufacturer IZTM in Irkutsk, Russia on 14th March 1997 (amended 15th May 1998), but by 1st October 1998 the project had run into problems. Originally 7m US$ finance had been obtained from the Sumito Corporation of Japan though the Central Bank of Mongolia (Mongol Bank) with the support of the Government of Mongolia, at an interest rate of 7-8% per year – very favourable terms in Mongolia where loans from local commercial banks are typically 4-8% PER MONTH. After 2m US$ had been paid as an advance, the financing ceased for various reasons. Thus Hailaast Shareholding Company did not actually complete and launch the dredge, but had partly assembled the dredge on-site. The partly assembled dredge together with the Mining License were then privatised.

Today, the owners and operators of the gold dredge are Golden East Co.Ltd., a USA-registered private company with Russian owners and Russian crew.

Fig.5: *Gold dredge 'Bayangol' in Zaamar Goldfield in August 2000 (Photo: Golden East Co. Ltd.).*

The Bayangol dredge is a Russian-made **bucket-line dredge**, manufactured by ITZM in Irkutsk, model "Draga D 250 M" and it became operational in August 2000 after a prolonged construction and assembly period. The dredge is 5-storeys high, 44m long and 18m wide, with a draught of 3.2m, and a maximum reach (depth) of 8m. The dredge has 73 buckets on a chain, scooping 250m^3/hour. The dredge has a design capacity of excavating 800,000 to 1 million m^3 of material a year. The Bayangol dredge is claimed to be able to pay for itself in 6 months. Of great significance, the dredge is designed to operate at air temperatures as low as -25ɵC. The dredge is intended to operate 24-hours a day with a crew of 7 per shift.

The deposit holds 6.5 tons of placer gold, recoverable in 8 years, and the proposed dredge area covers 1,400 hectares of the Tuul River floodplain. All production is expected to be sold to the Mongol Bank (= Mongolia's central bank).

Prior to dredging, overburden is stripped off by 2 Russian-made draglines (ESH-6/45) with a 11m^3 bucket, and a 70m long boom, capable of removing 1.8-2 million m^3 of overburden a year.

  contact: emiweb@magicnet.mn

Mongolrostvestmet Dredges in Yeroo Goldfield

Two more dredges owned by Mongolrosvestmet Corporation are active in the Yeroo Goldfield in Selenge Aimag. The dredges are mining placer gold from the floodplain of the Yaroo River in the Lake Baikal catchment.

The 2 Yaroo dredges are Russian-made **bucket-line dredges**, manufactured in Irkutsk. Both the dredges were bought second-hand and one appears to be about 25 years old and the other about 15 years old. The dredges became operational in the 1990's. Currently one dredge has mined out its reserves and is expected to be relocated to another mining site soon, whereas the second dredge still has 2 years of reserves to mine.

One dredge has a displacement of 1,470 tons and is designed to process 350m^3/hour, at a rate of up to 40 buckets per minute, using buckets of 250 litres capacity (approximately 0.35m^3). The pontoon height is 3.5m and the dredge is capable of excavating 12m deep. Power is supplied by an onboard electric motor of 1,600 KWt, with average working of 833KWt. Gold recovery is by Russian-made sluices.

The second dredge has a displacement of 1,510 tons and differs in having more powerful electrics (1,70KWt, averaging 1,100KWt), and is equipped with Russian-made simple jigs. The performance of the jigs is expected to be better than a sluice system.

Fig.6: *Rear view of Mongolrosvestmet gold dredge in the Yeroo Goldfield in 1998, showing covered boom enclosing conveyor with oversize, and launder chute discharging fines from the sluices. (Photo: Mongolrosvestmet JSC)*

English-made Dredge in Berleg Goldfield

An English-made bucket-dredge is located in Mining License A-104 in the Berleg Goldfield in Selenge Aimag. The dredge is on-site but has yet to be assembled. It is intended to mine placer gold from the floodplain and lower terraces of the Yeroo River. The owners of the gold dredge appears to be a local company, Tsamb Khokh Tenger Ltd.

Fig.7: *Buckets of English dredge in Berleg Goldfield, awaiting assembly. (Photographer: Iain Barclay, September 2000)*

The English dredge is in many ways remarkable. It is a British-made **bucket-line dredge**, manufactured in 1894, more than a 100 years ago – according to local staff. The manufacturer's plate is visible: **"Ransomes Sims & Jefferies – Engineers – Ipswich – England"**(Fig.6.).

Fig.8: *Cast iron nameplate of the English manufacture of the dredge. Photo: August 2000.*

The antiquity of the dredge is also indicated by its riveted construction. The dredge was apparently purchased second-hand in Russia where presumably it had been active for many decades as a gold dredge or less likely as a normal civil engineering dredge.

Fig.9: *Riveted construction of the English dredge in the Berleg Goldfield. Note severe corrosion pitting.*

The English dredge arrived on-site in 1997 and will require extensive refurbishment. According to one bucket-dredge expert, this is probably unrealistic and would probably prove too be more expensive than purchasing a new dredge.

Fig.10: *Winches and pulleys of the English dredge in Berleg Goldfield, awaiting assembly.*

A special feature of the English dredge is the presence of large structural timbers as part of the strengthening of the sub-deck structure.

Fig.11: *Timbers in sub-deck structure of English dredge.*
(Photographer: Iain Barclay, August 2000)

The exact dimensions of the English dredge are not unclear, but it is designed to use buckets each of $4m^3$ capacity on a chain.

Number of Gold Dredges

Currently there are 4 gold dredges operational in Mongolia – all built in Russia, with a 5^{th} English-built dredge on-site awaiting to be re-assembled. The main areas using gold dredges are the Zaamar Goldfield in the steppe zone west of Ulaanbaatar, and the Yeroo Goldfield in the forest-steppe transition north of Ulaanbaatar.

In the short-term, our research indicates that the number of gold dredges is set to increase. One new large gold dredge is planned for Zaamar, and the introduction over a period of maybe as many as a dozen small dredges in northern Mongolia is predicted, due to the current placer mines having largely exhausted those parts of placer deposits amenable to dry mining. They are now struggling to recover gold from beneath the water table by pumping out pit-by-pit. It is anticipated that by the end of 2001, many such mines will become unworkable unless they introduce small dredges.

Special Environmental Impacts of the Gold Dredges

The severe environmental impacts of placer gold mining is described by Farrington (2000, this volume) for the Zaamar Goldfield in Mongolia. Impacts of equal severity are apparent in other, less-famous, goldfields in Mongolia.

The following discussion focuses on technical design aspects of the existing dredges and their consequent environmental impacts.

a) Overall Design of Gold Dredges

The gold dredges in operation in Mongolia are a natural progression of well-proven traditional designs, but it is clear that the designs, although antiquated, are highly profitable in placer gold mining in the local situation. The use of 'spuds' for steerage rather than 'cable-and-winch' is of special significance. Furthermore the design of the on-board mineral separation plant is not very different from that commonplace world-wide 50 years or more ago, when mercury (Hg) was acceptable to assist in maximising high % recovery of fine gold. There is however no evidence for mercury having been, or being, used in the Mongolian gold dredges, but it is important for independent verification to take place.

b) Gold Recovery by Gold Dredges

The gold dredges use rotating sluice boxes ideal for continuous operation. However, although there have been some advances in design in recent decades, "a sluice box is still a sluice box" and are not much improved on those of centuries ago, such as those depicted by Agricola (1556). The high % losses of gold by sluice boxes is a well-documented phenomenon, as noted to researchers such as Reaburn (1925), and more recently Wang & Poling (1983) who produced the reference chart below:

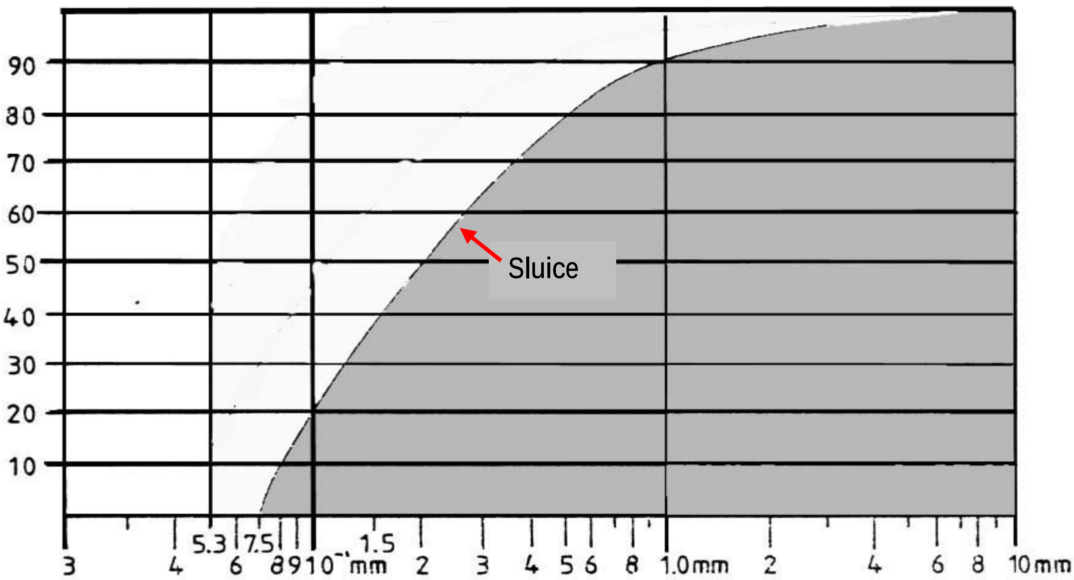

Fig 12: % recovery of gold particles by a riffled sluice (adapted from Wang & Poling 1983).

A major improvement on a sluice box would be a conventional jig, which uses a harmonic wave movement with the UP-stroke a mirror image of the DOWN-stroke. This improvement has been documented 15 years ago by Wang and Poling (1985) who produced the following comparison chart:

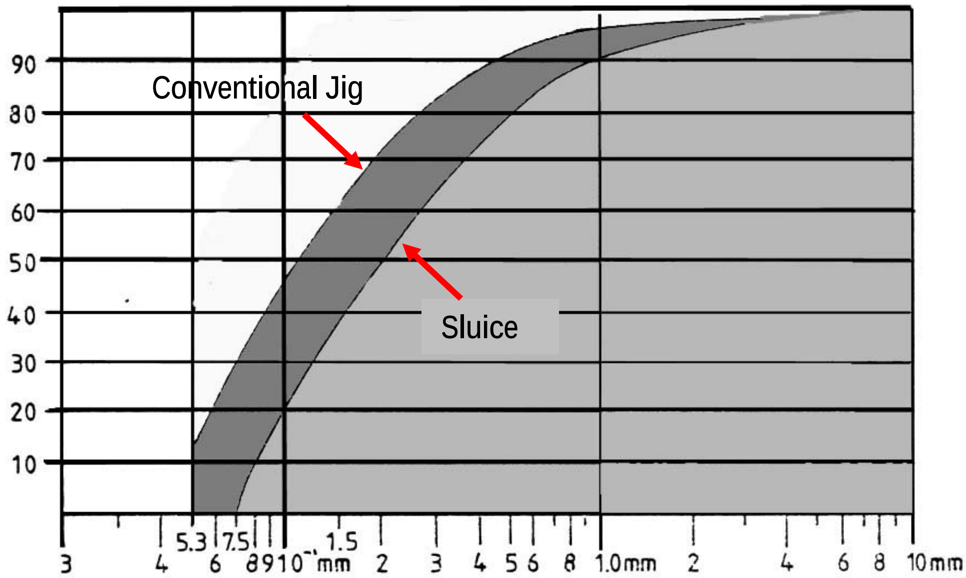

Fig 13: *% recovery of different size gold particles by a conventional jig compared with a riffled sluice (adapted from Wang & Poling 1983).*

The chart shows that while there is not much difference between sluice boxes and conventional jigs for gold particles of 1mm or larger, the difference becomes dramatic for smaller-sized gold. For example, a conventional jig recovers 125% more gold with a grain size of 10^{-1} mm. The implication is that the gold dredges in use at present in Mongolia are losing a lot of gold, especially fine gold, because they are using sluice boxes.

A significant improvement on a conventional jig is the "saw-tooth jig" which has a fast UP-stroke and a relatively slow DOWN-stroke. The saw-tooth jig was introduced by IHC Holland to Malaysian and Indonesian jumbo dredges in the late 1950s and a much-improved recovery of tin ore (cassiterite SnO_2) was demonstrated by Nio (1978) over that of conventional jigs. The results of Nio (1978) for cassiterite are superimposed on the graph below:

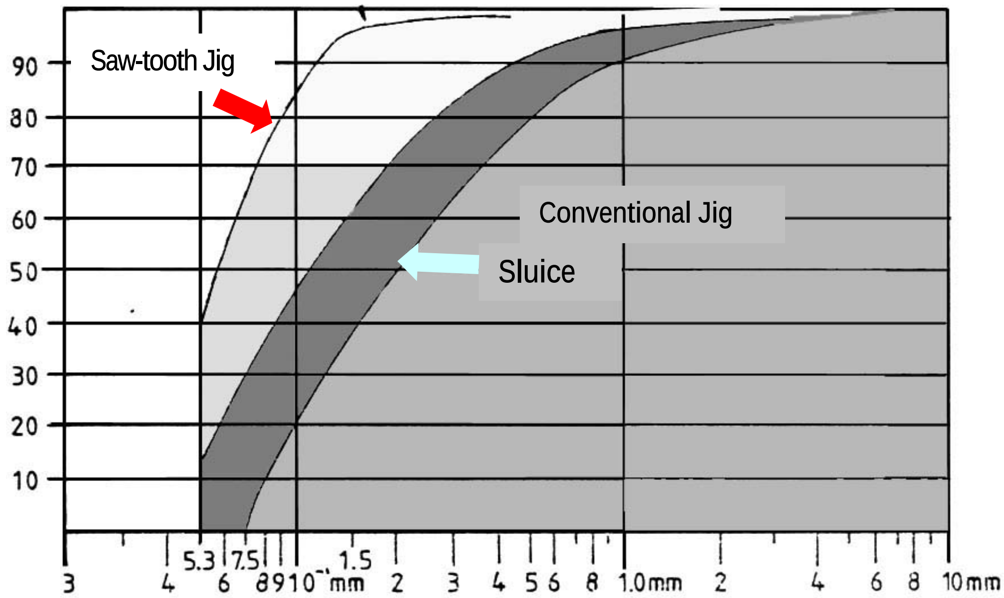

Fig.14: *Comparison of % performance of saw-tooth jig with conventional jigs and sluices. Adapted from Nio (1978) and Wang & Polling (1983).*

Caution is needed in interpreting Fig.9 as the test was for cassiterite not gold, but the superior performance of saw-tooth jigs over conventional jigs and riffled sluices is clear.

The performance of the mineral processing plants on board Russian gold dredges has been a matter of debate. The most recent study is by Sheveleva et al. (2000) of Irgiredmet JSC of Irkutsk. They draw attention to the actual gold content of placers in Russia, particularly those containing fine gold, being "highly different from the content indicated in exploration and production documents. Placers containing middle-sized gold, that are traditionally under development, generally contain a lot of fine gold (up to 50%)." Sheveleva et al. (2000) report results of control sampling of Russian placer deposits which are under development by Primorzoloto, Zabaikalzoloto, Yakutzoloto, Yeniseizoloto, Amurzoloto and Uralzoloto companies and state: "the actual excess of the fine gold amount over the gold amount indicated in the balanced reserves is 150 to 300%. This is due to losses of this particle size gold when sampling exploratory workings by traditional panning method." Igriredmet JSC carried out research on the Dzhalina river placer in the Amur region of Russia. This demonstrated that the Russian '250-I dredge' was recovering only 22.5% of the gold, and that the exploratory panning had recovered a very similar figure – 23%. The bulk f the deposit proved to be fine gold (Sheveleva et al. 2000).

While the gold dredges in Mongolia are capable of high % recovery of coarse gold, they are not designed to recover more than 40-50% of the fine gold. It is difficult to envisage how the dredges at Zaamar can be recovering more than 70-80% of the gold content overall, even though the gold dredges are highly profitable. The provisional conclusion is that the 4 active gold dredges (2 at Zaamar and 2 at Berleg) are estimated to be losing, between them, about 1 ton of gold per year, with a value of 9million US$ a year, equivalent to about 10 US$ per household in Mongolia. Retrofitting of saw-tooth jigs would self-finance within a season, and operating costs would remain unchanged. Thus the profitability of the gold dredges, especially in Zaamar, would increase substantially, and the Mongolian Government would benefit considerably from the additional royalties and other taxes.

An interrelated issue is that the "lost" gold might in a few cases be sufficient to render commercially viable the re-dredging of the same deposits using high % gold recovery systems.

Given the substantial environmental impact of the dredges, it would seem reasonable to require the high environmental price to be offset somewhat by recovering the maximum % of gold content, and thus increase the overall economic return.

Furthermore, if the gold dredges were retrofitted with high % gold recovery systems then part of the increased operational profitability could be devoted to rehabilitation of the areas already devastated by dredges and draglines, and for the first time embark upon phased restoration.

However an important deterrent to retrofitting the dredges is the very high cost of capital in Mongolia, with local commercial banks offering loans at 4 to 7% PER MONTH. Under these circumstances, it would be better to agree for a tax holiday conditional upon retrofitting the dredges to the satisfaction of the Minerals Resources Authority and the Ministry of Nature & Environment.

c) Environmental Impact of Tailings Discharge System

All the gold dredges working in Mongolia use an old method of discharging the tailings, the same basic concept of half a century or more ago. The 'fines' (soil, clay, silt and sand) are discharged to the bottom of the dredge pond, and the coarser fraction (stones, boulders and rocks) is dumped on top. This is the opposite sequence to natural sediments, and can render problematic the rehabilitation of the new land surface due to the lack of fines. This old-fashioned method was for decades traditional in dredge placer mining in Central Sumatra in Indonesia, where the new land surface can be seen to be still largely barren some 70-80 years later. Of course by dumping the coarse material on top it was a reasonable way of burying the mercury lost from gold recovery in the sluices. As modern gold dredges should not use mercury, the necessity of depositing the tailings in this environmentally-inappropriate manner should no longer apply, certainly not in Mongolia.

Gold dredges that incorporate design improvements of the last 30 years usually deal with tailings in the following manner. A Stacker Belt is a boom protruding from the rear of a dredge with a conveyor carrying the coarse material to the water's edge, and a pipeline strapped to the boom carries the fines in a slurry to a boom-extension where a hydrocyclone system releases the fines on top of the coarse, and recirculates recovered water back to the dredge pond. This arrangement is now regarded as conventional but is not used in Mongolia.

Retrofitting the existing gold dredges in Mongolia with tailings chutes of the above configuration is affordable, given the high profitability of the dredges, and would not increase operating costs significantly.

Fig.15: *Rear view of Mongolrosvestmet dredge in Zaamar goldfield, showing boom containing conveyor for disposal of oversize, the boom enclosed as protection against severe cold. To the right, near to the waterline, is a chute dumping fines from the sluices. A second similar sluice is just visible to the left.*

Fig.16: *Close-up of Mongolrosvestmet gold dredge showing one of the two chutes depositing fines and water that has passed through the sluices into the dredge pond.*

Fig.17: *Mongolrosvestmet gold dredge, mining from right to left, after the dragline stripped-off the overburden. In this example, the overburden extends below the water table, and thus the drag-line has created a muddy pond ahead (left) of the advancing dredge. The new island at the rear of the dredge is due to the 'swell factor' causing the volume of tailings to exceed the volume of the in-situ placer. (photographer: Robin Grayson, 1997).*

Fig.18: *End result of the passage of the Monrosvestmet dredge at Zaamar, with creation of a series of arcuate mounds with large stones (oversize) on top of the fines. This artificial landscape was formerly the floodplain of the Tuul River. (photographer: John Farrington, August 2000).*

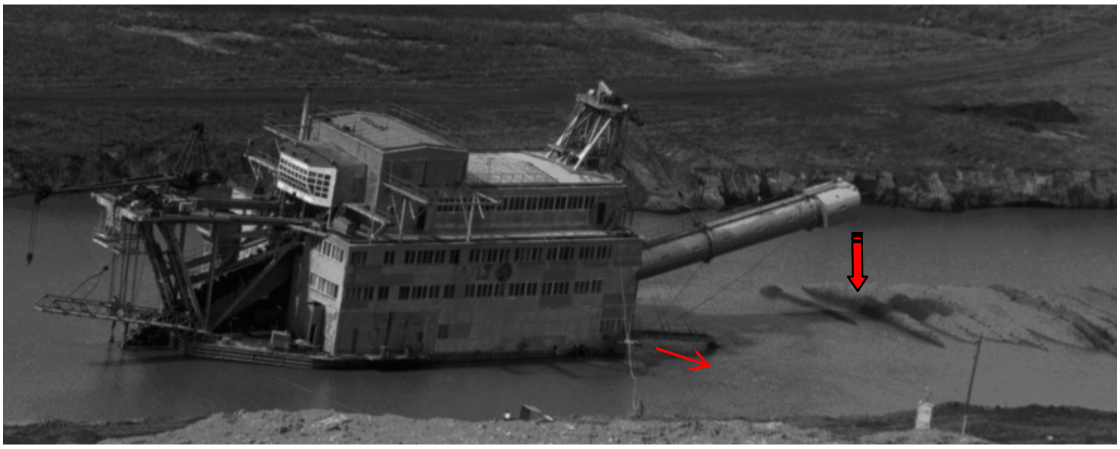

Fig.19: *Closer view of Monrosvestmet dredge at Zaamar, mining from right to left. The fine-grained tailings are discharged by a pair of chutes, one of which is visible (thin red arrow), and the large tailings (oversize) are discharged by a conveyor on a boom (large red arrow). This causes the fines to be buried beneath a thick layer of large stones. (photographer: K.Dendinas, 1997).*

d) Environmental Impact of Spud System

The gold dredges in Mongolia, at least those in the Zaamar Goldfield, each use 2 ‘spuds’ to position and move the dredge. A ‘spud’ in layman’s terms is a long metal pole at the rear of the dredge that is dropped vertically to embed firmly in the floor of the dredge pond, and thus serve as a rigid anchor. The spuds keep the dredge in position. One spud is used for manoeuvring the dredge by swinging left and right upon the spud, and the second spud is auxiliary. Unfortunately the ‘Spud System’ means that the gold dredge is rather limited in its means of progression, more-or-less confined to a 30^o arc movement at the cutting end, the arc being twice the length of the dredge. Thus a 50m long dredge will mine its way forward in a 100m arc.

An inescapable result of this method of dredging is that the rear end of the gold dredge, where tailings are discharged, is pinned to the floor of the dredge pond by the spud. Thus the large volume of tailings generated by a 100m cutting swing are all destined to be expelled from the dredge’s rear end in a relatively small area dictated by the spud. A large and difficult-to-restore arcuate mound results. Only when the 100m cut is complete the spud lifted, the dredge moved forward and the spud once more dropped.

A technical disadvantage of the spud system is that the dredge has to remine part of its own tailings on the return swing, sometimes up to 20% when dredging at the maximum depth.

Large modern gold dredges manoeuvre without recourse to spuds, and instead use cables from shore to shore and electrically powered winches to achieve and maintain the desired position. Cutting in an arc is dispensed with, and the tailings are dispersed in a much more acceptable landform, albeit with a tendency to be in long but gentle ridges.

The cable-and-winch system is more efficient than the spud system, allowing a much longer sidewards cut (creating broader dredge ponds) and fuller use of each bucket “square-on” (reducing differential wear on the buckets). Furthermore the spud system can stress the bucket line to such a degree that there is a risk of the bucket line jumping out of the guide tumbler with consequent damage and long delays. Thus the cable-and-winch system is now standard in most dredge situations.

Unfortunately, conversion of a gold dredge from a spud system to cable-and-winch is often technically difficult, requiring substantial reconstruction, and it seems unlikely that such modification can be done at reasonable cost for the active gold dredges in Mongolia. However the Ministry of Nature & Environment (MNE) and the Minerals Resources Authority of Mongolia (MRAM) should insist that all new dredges be built with the cable-and-winch system.

e) Environmental Impact of Drag-lines associated with Dredges

The environmental impact of a gold dredge is substantial, but the impact of a drag-line stripping off the overburden can be higher. This is because the function of the drag-line is to shift the overburden SIDEWARDS out of the way of the advancing dredge, and thus the drag-line causes a permanent and substantial impact on the landscape because it builds a linear ridge of spoil mounds parallel to the dredge pond. Observation shows that the drag-line does not return after the dredging to attempt to restore the landform by dragging the spoil mound back on top of the tailings after the dredge has passed. Apart from the very high cost of doing so, access by a drag-line to the bank of the old dredge pond is fraught with operational problems and is not always possible.

To mitigate the very large environmental impact of drag-lines, one promising option is to dispense with the use of drag-lines altogether and instead consider using a cutter-suction dredge to remove the overburden ahead of the advancing gold dredge. The capital and operating cost of a cutter-suction dredge is comparable to that of a drag-line. Instead of tall overburden mounds being heaped and abandoned, the cutter-suction dredge coverts the overburden to slurry which is pumped onshore to the desired place and thus low mounds can be produced, more visually acceptable and more amenable to revegetating quickly and permanently.

While “putting back” the land surface to its original contours after dredging is desirable it is not in practice achievable, even if the mine operator is willing and substantial funds are available. This is due to the “swell factor” – the increased volume of material once disturbed by excavating it, due to decompaction and, if wetted, absorption of water accompanied by expansion of some minerals, notably clays. Unlike other forms of open-pit mining such as coal mining or sand & gravel mining, the volume of gold removed from the site is extremely small – negligible in fact. Thus the “swell factor” is the determining factor in landform restoration. The ‘swell factor’ at the Toson Terrace in the Zaamar Goldfield has been carefully researched by Gary Beaudoin (2000, this volume) and estimated to be 44.63%, 59.49% and 52.75% for the 3 resource blocks tested. A range from 35% to 70% is apparent in Mongolia.

Thus, whether or not mining is by dredge or open-pit, a significant increase in volume of disturbed materials results. If the mine site is narrow or badly organised, then the end result is a “muck-bound” site, i.e. the greatly increased volume of material impedes further mining and prevents restoration to the original landform.

A further consideration is the “recompaction factor” for spoil mounds and backfilled dredge ponds and dry pits. Recompaction is due to the pressure exerted by overlying dumped material and is generally time-dependent and further subsidence of the surface should occur with time. Differential compaction frequently results in a rolling landform, especially if dewatering of muds has occurred or if the backfilled material is of varying composition. Where the rolling new landform is close to the water-table it is prone to create pools with hydroseres – gradations from open water through marginal marsh/fen to grassland or scrub.

Potential for ‘Wildlife Gain’ from Gold Dredges

The potential for ‘wildlife gain’ in the placer goldfields of Mongolia is considerable but has not yet been investigated. Whilst losses of landforms, landscape history, soil profiles, grazing and archaeological remains cannot be mitigated for, at least not ‘on-site’, the placer goldfields do offer opportunities for some ‘wildlife gain’ – notably in goldfields where a gold dredge is operating. A gold dredge offers some opportunity for creation of a wetland complex of habitats including open water and marshes, mimicking artificial ox-bow meander cut-offs (‘billibongs’) together with fens, reed beds and hydroseres from open water to scrub and forest. Careful dredging can create islands inaccessible to predators and livestock and thus havens for water-birds and plants.

Fig.20: *Major environmental disturbance caused by the combination of the Mongolrostvestmet gold dredge and associated drag-line. Dispensing with the drag-line and using a cutter-suction dredge would reduce the impact. Backfilling of the dredge ponds with the overburden mounds would be very expensive due to access by dragline now being blocked by dredge pools and unstable wet ground. The scope for creating a wetland mosaic with potential for significant wildlife gain is apparent.*

  contact: emiweb@magicnet.mn

To the south in the **Zaamar Goldfield**, where gold mining is already intense and expected to increase markedly in the short-term, an assessment of potential wildlife gain should be made, in which the present and planned dredges may have a central role. The semi-arid climate and overgrazing of the steppe grasslands and "grazing out' of fire-damaged forests preventing natural regeneration all indicate how sensitive the Zaamar region is to disturbance by mining. Thus every opportunity for refocusing the impacts of dredges, drag-lines and dry-pit mining to achieve wildlife gain should be sought. In particular, to create a habitat mosaic of islands, marshes and open water able to sustain hydroseres of vegetation with cover and sustenance for mammals, birds, reptiles, amphibians, fish and invertebrates. The urgent need for a baseline ecological survey on which such proposals can be based is apparent from the compilation and analysis of the impacts of mining at Zaamar by Dallas (1999) and Farrington (2000).

To the north in the **Yeroo Goldfield**, the situation is rather different being in the forest-steppe transition zone, and with marshes already widespread even in minor valleys. However, due to the wet conditions, many placers are below or at the water-table but too small or discontinuous to merit dredging. Instead the placer is mined in discrete blocks which are pumped out, mined and then allowed to flood, the mining activity being transferred to the next block. In this manner a string of marshes and pools are created which are fairly quickly recolonised and revegetated. In this area, the humidity and rainfall is significantly higher than at Zaamar and thus the spoil mounds in some places become naturally reforested, assisted by the 'swell factor' permitting the spoil to absorb rainwater and clay breaks in the spoil to create perched water tables accessible to the root systems of sapling trees.

Thus in broad terms, achieving wildlife gain in the gold mining areas in the forest-steppe transition is relatively easy to achieve with minimal effort or expense, but in the more steppe-dominated regions such as Zaamar, wildlife gain will be more difficult, and the role of the gold dredges may be critical to overall success or failure.

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