NZ Hydraulic Sluices and IHC Jigs in Placer Mining in the Bugant Goldfield of Mongolia

Gerrit Bazuin (1) **& Dr. Baatar Tumenbayar** (2)
(1) General Director of Ochir Leasing Co. Ltd., Ulaanbaatar, Mongolia
(2) Geological Director of Eco-Minex International Co. Ltd., Ulaanbaatar, Mongolia
(1) ochirlg@magicnet.mn; (2) tumenba@magicnet.mn

ABSTRACT

Two high % gold recovery systems were introduced to the Bugant Goldfield in north Mongolia: a 25m^3/hour New Zealand-built PAuSE Hydraulic Sluice, gravity-fed by slurry from a static screen (40-50mm holes) blasted by a Russian-style water cannon ('monitor'); and an IHC 2-Cell Sawtooth Trapezoidal Jig fed by slurry via a Warman pump from an IHC Conical Screen ('scrubber') with 35mm x 12mm slots. Difficulties were encountered: a) the high water table restricted operations, and a pontoon system is now being considered; b) the oversize was substantial with rounded slabs that damaged the screen, necessitating modifications; c) the high clay content affected washing and a clay washer is now being considered; d) the IHC Conical Screen operated at only 10-15m^3/hour, instead of 60-80m^3/hour, to minimise damage from large slabs, to allow clay to clear from the grizzly, and to break-up the clay; e) a change of mine ownership delayed mining until early July; f) mining ceased on 2nd October due to the hired trucks being taken to the 'Millennium Road Project'; g) frequent breakdowns of earth-moving equipment (trucks, bulldozers and excavators) occurred; h) the PAuSE NZ Hydraulic Riffled Sluice received enough pay-gravel to operate for only 720 hours (90 days x 8 hours) during the season, 24% of the target 3,100 hours; and i) the IHC jig stood idle for long periods due to a shortage of trucked feed. The advantage of using high % gold recovery systems was lost, even though they easily outperformed Russian sluices. The Russian-style method of mining by bulldozing destroyed 50% more trees than necessary, buried topsoil and sterilised gold reserves. Panning of 13 samples of overburden revealed good to rich grades (0.5-5.0 grams/m^3), indicating systematic underestimation of gold by earlier Soviet drilling.

Fig.1: *Gold recovered at Bugant Mine by the 25m^3/hour PAuSE Hydraulic Riffled Sluice from New Zealand, revealed by upgrading in a traditional Siberian wooden gold pan.*

Introduction

This paper describes mining in the Bugant Mine in north Mongolia using high % gold recovery systems in the 2001 season. The mine is in the valley of the Bugant River, a tributary of the Eroo River. The Bugant Mine is in the 504-hectare Mining License 744A, at longitude 107ɵ28’24”E and latitude 49ɵ24’59”N, 10 kilometres east of Bugant town which is the administrative centre of Eroo Soum in the region of Selenge Aimag. The mine is 420 km by road north of Ulaanbaatar, and 180 km NE of the Darkhan. The first 300 km from Ulaanbaatar is a good asphalt highway, then 100 km of good gravel road and a final 10-20 km of poor roads.

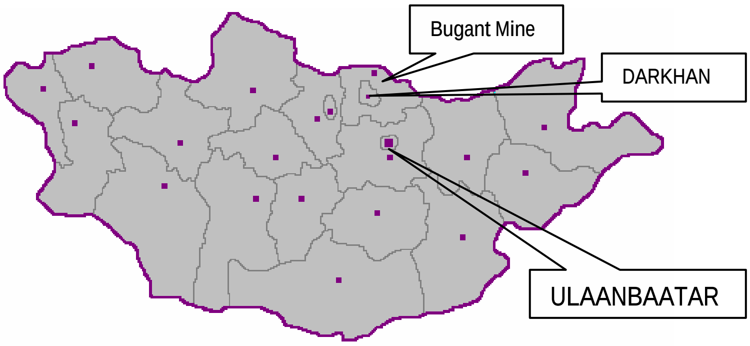

Fig.2: *Location of the Bugant Mine in relation to Darkhan City and Ulaanbaatar City.*

The Bugant River is about 800 metres above sea level at the Bugant Mine, and the nearby peaks attain 1,529 metres (‘Songino Uul’). The climate is sharply continental, averaging +25ɵC in summer and as low as -45ɵC in winter. Precipitation is enough to support a semi-continuous cover of Taiga forest dominated by mixed birch and conifers, with stands of willows by the main streams. The district is acutely prone to forest fire, and the mine site has endured several major fires judging from the charred trunks of old conifers and the forest’s age structure.

The geology of the district is dominated by its setting south of the Siberian Craton, in a deformed fold belt belonging to the Mongolian Geosyncline. The country rocks consist of Lower Palaeozoic and Devonian gneiss, schists, slates and psammites (metamorphosed sandstones), intruded by granites of Permian and Triassic age.

Two main valleys dominate the district, Bugant and Tolgoit, and many second-order valleys exist - Ikh Olont, Baga Olont, Mogoin Gol, Niilekh, Baga Sub, Nariin Gol, Dalt etc. Most have economic deposits of placer gold, and together constitute the Bugant Goldfield.

The Bugant Valley is 20 kilometres long and has 3 main geomorphological forms: a) ‘V’-shaped, in the higher mountainous areas, where the valley is typically 150 metres wide; b) ‘U’-shaped, in the 17-km long middle reach, where the valley is typically 400-800 metres wide; and c) ‘wide rectangular shaped’ in the lower reach. The Bugant Mine is in the middle reach.

Several gold-bearing terraces are present. The First Terrace is 2-3 metres above the normal level of the Bugant River, and the Second Terrace is 8-12 metres above the river level and has a width of 160-800 metres. The main mining operations are on the Second Terrace.

The Second Terrace shows some variation in the thickness and character of the sediments. Typically the sediments are 6.8 metres thick, resting on cleaved open-jointed weathered schistose slates, with 40 centimetres of medium-dark moderately organic rich sandy clayey forest topsoil, resting upon 3.8 metres of gravely sand, on 2.5 metres of clayey gravel. In general the placer (i.e. gold-bearing interval) consists of the top 30cm of the bedrock, the 2.5-metre thick clayey gravel and often part of the overlying gravely sand.

The placer has 55-70% by volume of rounded/subrounded clasts varying considerably in size: 47% are larger than 16mm, and cobbles in excess of 40cm diameter are not uncommon. The water-table of the placer is 1 to 2 metres below the surface of the Second Terrace.

  contact: emiweb@magicnet.mn

Previous Prospecting, Exploration and Mining

The Bugant area has been mined intermittently for placer gold since the early 1900's, originally by a group of Russian, Chinese and German mining companies, notably Mongolor.

Geological mapping at a scale of 1:50,000 was undertaken in 1968-70 by Yu.P. Tsipukov & P.I. Khubildikov, and general prospecting by N. Nyam and A.I. Stephanov in 1970-80. Detailed prospecting of the Bugant Valley was undertaken in 1981-82 by Kandinov and S. Bazarsad, and detailed exploration was undertaken in 1982-84 by L. Bazarsad and Ch. Erdenebileg. A general re-exploration and re-evaluation of the Bugant area was undertaken in 1989-92 by D. Gungaanyam and J. Otgon.

The 1982-84 soviet exploration in the Bugant Valley consisted of drilling a line of boreholes spaced 36 metres apart across the valley. The next line of boreholes was drilled 230 metres from the preceding line. Thus the length of each exploration block was 230 metres, enough to determine C_1/C_2 reserves but not adequate for proper mine planning. Each borehole was drilled with casing, and a sample retrieved every 20 cm to determine the sediment and the gold grade. Gold purity was found to be 89.9% in the Bugant Valley and 91% in side valleys.

Mining License 744A was named Dund Buganti ('Middle Bugant') and awarded on 9th September 1997 to Uurt Ltd., a Mongolian company whose General Director is Mr. S. Jadamba.

The Bugant Mine commenced in 1998, with Russian contractors under the supervision of Uurt Ltd. A mine camp was built and a well-engineered mine road was constructed alongside the northern edge of the placer where the Second Terrace meets the rocky hillside. Drainage channels were cut in a largely unsuccessful effort to dewater the placer. The Russian contractors used the traditional Russian mining method of bulldozing topsoil and overburden in a single cut to both sides of the valley, in order to clear the placer for mining. This destroyed 50% more forest floor than necessary, by burying trees and scrub with bulldozed material. No attempt was made to separate and conserve any topsoil. Flanking areas of placer with significant gold reserves have been sterilised by this simplistic dumping of overburden. No attempt was made to return the bulldozed overburden to the mined-out blocks, nor any attempt made at rehabilitation.

In 1998, the first season of mining operation, the Russian contractors produced 79.2 kilos of gold, using low % gold recovery Russian-style sluices, gravity-fed by slurry from static screens blasted by water cannons ('monitors').

In 1999, Uurt Ltd. attempted to operate the Bugant Mine itself, but experienced many difficulties due to lack of sufficient preparation time for mining after the departure of the Russian subcontractors. Clearance of vegetation began late, and further time was lost due to a lack of pumps necessitating the digging of deep drainage channels. Only 5 kilos were produced in 1999. Uurt Ltd. was using 2 small Mongolian-built Russian-style sluices fed by static screens blasted by water cannons. One sluice (built 1997) was capable of processing only $20m^3$/hour, and a second sluice (built 1999) was capable of processing only $35m^3$/hour. Earth moving equipment consisted of a Type 4341 Russian excavator ($1m^3$ bucket volume, built 1993); a Type 3322 Russian excavator ($0.7m^3$ bucket volume, built 1984); 2 Russian T-170 bulldozers (width 3.5m, built 1996 & 1998); a Russian T-130 bulldozer (width 3.5m, built 1986); and a Russian D-606 bulldozer (width 2.7m, built 1997). However the technical condition of the equipment was not good.

In February 2000 the virgin reserves of the Bugant Mine were estimated to be 120 kilos of gold (pure) in C_1 reserves, averaging 1.7 grams/m^3, and a further 89.6 kilos in C_2 reserves averaging 0.6 grams/m^3. Calculations were based on a cut-off grade of 0.2 grams/m^3, ignoring pay gravel <0.5m thick or <20 m wide.

In 2000, operations at the Bugant Mine was suspended and a buyer sought. The mine and license were acquired in early 2001 by BNP Progress Ltd., a Mongolian company whose General Director is Mr. Baatar Bat. Mining resumed rather late in the 2001 season in early July, delayed due to the change of ownership.

Methods

Desk Study & Preliminary Field Sampling

A desk study was made in February 2000 by Dr. Baatar Tumenbayar, Geological Director of Eco-Minex International Ltd., using extensive archival materials in Russian and Mongolian languages, followed by field sampling.

24 samples were bagged, washed, panned and tested for heavy mineral concentrates (black sands). The concentrates were identified using a Wessex Micro model WZ1 Binocular Microscope (x40) fitted with stereo-zoom and variable-control built-in halogen illumination (option of reflected and transmitted light) with 220v-240v, 50/60 Hz mains electrical supply. An eyepiece micrometer was inserted.

Gold particles were carefully separated and the size fractions were weighed with an electronic scale.

***Fig.3:** Wessex WZ1 Zoom Stereo Microscope in use in Mongolia by Robin Grayson, General Director of Eco-Minex International Ltd.*

Importing of PAuSE New Zealand Hydraulic Riffled Sluice

A Pause NZ Hydraulic Riffled Sluice was used at the Bugant Mine in the 2001 mining season. Ochir Leasing Co. Ltd. (UK-Mongolian joint venture) had purchased this equipment, built in New Zealand by PAuSE Ltd. under the direction of Jim Loveridge, and imported it into Mongolia in 1999. Such sluices are also called 'hydro-active'.

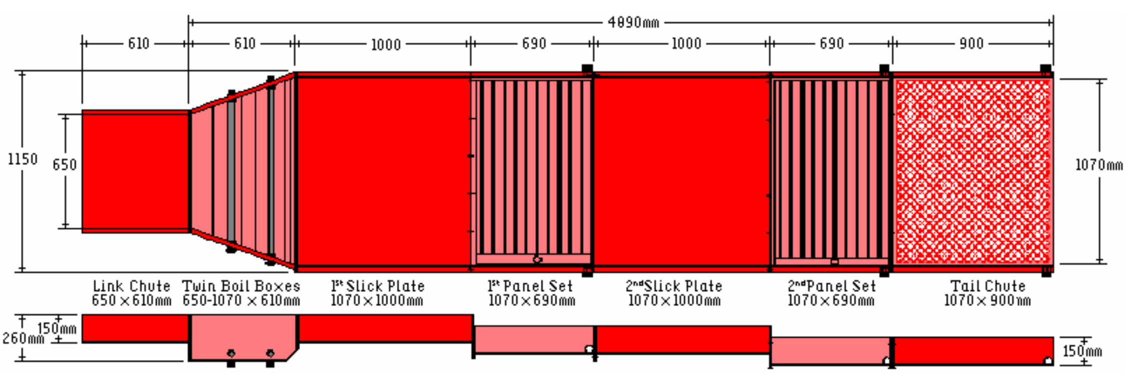

***Fig.4**: 25m^3/hour PAuSE NZ Hydraulic Riffled Sluice showing layout and dimensions.*

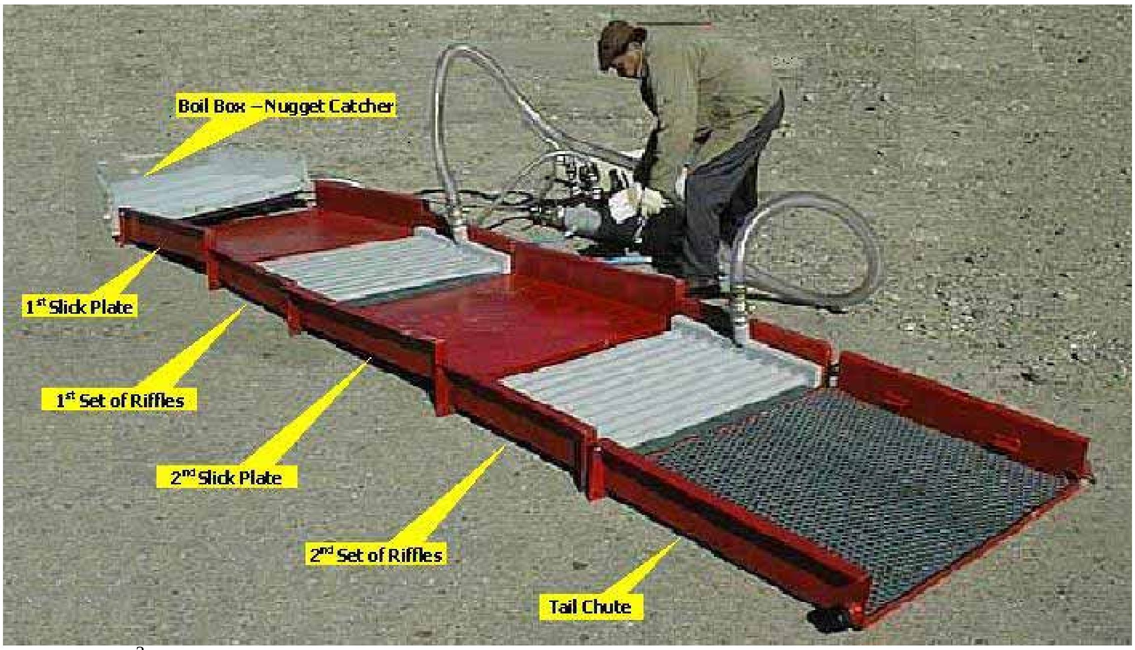

Fig.5: *25m^3/hour PAuSE NZ Hydraulic Riffled Sluice being inspected in Ulaanbaatar.*

New Zealand Hydraulic Riffled Sluices offer major advantages over normal sluices:

a) significantly higher % gold recovery, often as high as 95%;
b) good recovery of fine gold;
c) boil boxes serve as 'nugget catchers' to collect large gold;
d) slick plates create laminar flow and assist in stratification of the slurry;
e) hydraulic riffles do not pack hard, so more gold is caught;
f) simple "fingers test" confirms that fluidisation is working;
g) low-pressure hydraulic water is used, easy to operate and adjust;
h) tolerant of significant overfeeding and underfeeding fluctuations;
i) tolerant of wide variations in grade of feed slurry, and dilution of slurry;
j) faster cleaning is achieved, so more gold output hours a year;
k) usually only one stoppage for cleaning needed in a day;
l) significantly more gold output hours per day.

Fig.6: *NZ Hydraulic Riffled Sluices, mounted on a pontoon in New Zealand. (photo: courtesy of Jim Loveridge)*

Field Trials of PAuSE NZ Hydraulic Riffled Sluice in Sergelen Goldfield

In 2000 the 25m^3/hour PAuSE NZ Hydraulic Riffled Sluice underwent trials in the Sergelen Goldfield near Ulaanbaatar at the Delger-Ech Mine of Huder-Erdene Ltd., General Director Ms. Tungalag. The NZ Hydraulic Riffled Sluice was placed on the tailing's end of a Russian-style sluice, fed from a Russian-style trommel:

Fig. 7: *Russian-style trommel and Russian-style sluice at the Delger-Ech Mine in the Sergelen Goldfield near Ulaanbaatar. Note the very large amount of sticky pervasive clay.*

Fig.8: *25m^3/hour PAuSE NZ Hydraulic Riffled Sluice in action in the Sergelen Goldfield at the Delger-Ech Mine. Note the 'steps' and bowing of the sluice due to lack of a supporting frame.*

The NZ Hydraulic Riffled Sluice was effective in catching a significant amount of gold otherwise lost in the tailings by the Russian-style sluice in the Delger-Ech Mine. However the test was abandoned after a few weeks, due to: a) the massive clay content adversely affecting performance; b) inexperience of mine operatives in the novel equipment; c) malfunctioning due to the lack of a supporting frame beneath the sluice; d) lack of clean water essential for the boil boxes (200 litres/minute @ 15-35 kpa pressure) and for the 2 sets of hydraulic riffles (2 x 650 litres/minute @ 15-35 kpa pressure.

Valuable lessons were learned and put into effect at the Bugant Mine in the 2001 season.

Set-up of PAuSE New Zealand Hydraulic Riffled Sluice at Bugant Mine

At the Bugant Mine, it was decided to feed the 25m^3/hour PAuSE NZ Hydraulic Riffled Sluice directly by slurry from a static screen (40-50mm holes) blasted by a conventional Russian-style water cannon ('monitor'), dispensing altogether with a Russian sluice:

Fig.9: *25m^3/hour PAuSE NZ Hydraulic Riffled Sluice fed via a link chute from a Russian-style static screen blasted by water cannon (right). A = a cone of oversize from the tail-gate of the screening box. B = large oversize manhandled away by the water cannon operator.*

A tubular steel support was added to inhibit bowing of the NZ Hydraulic Riffled Sluice:

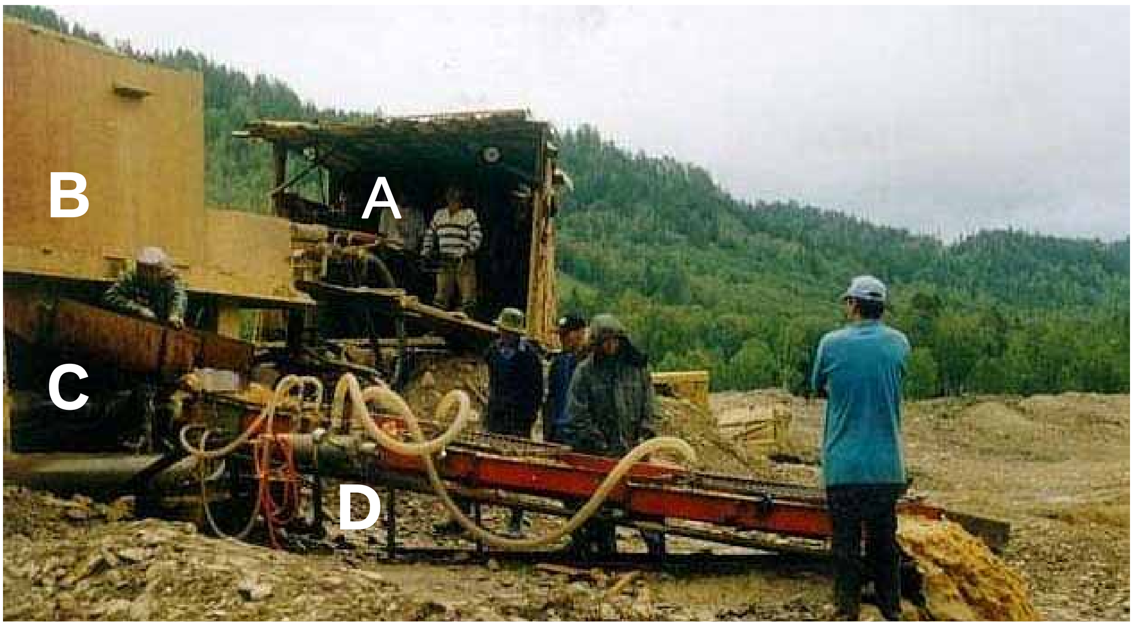

Fig.10: *A Russian water cannon 'monitor' (A) blasting pay-gravels above a static screen (B), feeding slurry via a link chute (C) to the 25m^3/hour PAuSE NZ Hydraulic Riffled Sluice (D).*

Set-up of IHC 2-Cell Sawtooth Trapezoidal Jig at Bugant Mine

Ochir Leasing Co. Ltd. rail-freighted from the Netherlands specialised components of trapezoidal sawtooth jigs from IHC Holland N.V. Assembly and part-construction took place in Barmash JSC in Ulaanbaatar under the direction of Gerrit Bazuin with considerable technical assistance from IHC Holland N.V. The first jigs were operational in August 1998.

For the 2001 mining season, Ochir placed at the Bugant Mine an IHC 2-Cell Sawtooth Trapezoidal Jig fed by slurry pumped by a Warman pump from an IHC Conical Screen ("scrubber") with 35mm x 12mm slots. The equipment was trucked from Ulaanbaatar and erected at the Bugant Mine at the start of July 2001, far later in the season than hoped for, but delayed due to the change of ownership of the mining license.

The reader is referred to the account by Bazuin, Delgertsoo & Grayson (2001) on the operation of IHC sawtooth trapezoidal jigs in Mongolia, and their inherent superiority over conventional jigs and sluices.

Fig.11: *Frank Mc Bride (right) with team at the Bugant Mine, having completed the electrical wiring of the IHC 2-Cell Jig (right) and the IHC Conical Screen (left). Note the Warman Pump (arrow) for pumping slurry by pipeline from the screen to the jig.*

Set-up of Mining Operations

As the new owners, BNP Progress Ltd. commenced mining operations at the start of July 2001. The existing mine camp was in good condition, but the company had problems to gather the necessary earth-moving equipment so late in the season. A local contractor was found to supply 3 second-hand Russian-built Kraz 5m^3 trucks plus drivers, and a second local contractor was found to supply 2 second-hand excavators (a Korean-built Hyundai caterpillar-tracked excavator and a Russian-built Kraz 6-wheeled excavator) together with drivers. A third local contractor supplied a Russian-built bulldozer to remove overburden but this broke down and was removed. BNP Progress Ltd. owned a smaller Russian-built bulldozer, suitable only for feeding the wash-plants and moving the tailings.

BNP Progress Ltd. selected the western downstream end of the placer reserves to commence mining eastwards, rather than expanding westwards from the eastern blocks that had been mined-out by Uurt Ltd. in 1999 and by Russian contractors in 1998.

Results

Minerals in the Black Sands

The main minerals observed in the concentrates included: native gold, magnetite Fe_3O_4, ilmenite $FeTiO_3$, martite (haematite pseudomorphs of magnetite), zircon $ZrSiO_4$, apatite, pyrite FeS_2, arsenopyrite FeAsS, cassiterite SnO_2 and fluorite CaF_2. Gold was the only mineral in commercial quantities. No potentially harmful mercury Hg or cinnabar HgS was seen, although technogenic mercury is prevalent in the district (Tumenbayar, Batbayar & Grayson 2000).

Gold Size

5,671 pieces of gold were recognised in the concentrates from the 24 samples, and had the following size/weight-frequency distribution characteristics:

Fraction	Weight	Gold Pieces	Average Weight	% Total Weight
> 3 mm	1.6130 grams	8	201.7 milligrams	28.4%
2 - 3 mm	0.8893 grams	22	40.4 milligrams	15.7%
1 - 2 mm	1.5942 grams	150	10.6 milligrams	28.1%
0.5 - 1 mm	0.7832 grams	359	2.18 milligrams	13.8%
0.25 - 0.5 mm	0.6157 grams	1,201	0.51 milligrams	10.9%
< 0.25 mm	0.1752 grams	3,178	0.06 milligrams	3.1%
	Total:	5,671	Total:	100%

All 7 samples taken of the placer confirmed good grades: 6 had very rich grades (2-10 grams/m^3), and 1 had a good grade (0.4 grams/m^3). This confirms the high grades reported earlier in systematic drilling detailed in Report 3733. All 13 samples taken of overburden had a remarkable gold grade (0.5-5.0 grams/m^3), indicating a systematic error in the Soviet drilling.

Fig.12: *Upgrading concentrates by panning, led by the Chief Panner Mrs. Jadamba (left). A security guard looks on. The water is warmed by wood-fired boilers for comfort and accuracy.*

Performance of PAuSE New Zealand Hydraulic Riffled Sluice

The performance of the 25m^3/hour PAuSE NZ Hydraulic Sluice was monitored daily by the mine operatives of BNP Progress Ltd. and by Gerrit Bazuin of Ochir Leasing.

No systematic measurements of % gold recovery were made. However a strong consensus swiftly emerged that the PAuSE NZ Hydraulic Riffled Sluice was recovering significantly more gold than expected with a traditional Russian sluice. In particular, the Chief Panner of BNP Progress Ltd., Mrs. Jadamba, stated that more gold was being recovered than earlier by a Russian sluice.

Fig.13: *25m^3/hour PAuSE NZ Hydraulic Riffled Sluice in action at the Bugant Mine. Note the high clay content of the slurry.*

The daily cycle began with cleaning the 2 hydraulic sluice sections by removing the NOMAD™ matting (backless type) for careful washing off of the concentrate, for taking to the panning area for upgrading. The plan had been to operate the PAuSE NZ Hydraulic Riffled Sluice for 20 hours a day, but as discussed later, this was rarely achieved due to problems in trucking enough placer, and thus the sluice averaged only about 8 hours a day. Daily production from the 25m^3/hour PAuSE NZ Hydraulic Riffled Sluice varied from 80 to 180 grams/day, largely dependent upon the volume of feed in the operating hours achieved.

From the outset, the addition of the tubular welded steel frame was successful in ensuring that the PAuSE NZ Hydraulic Riffled Sluice maintained the specified optimum angle of 8 degrees, confirmed frequently with a calibrated spirit level.

A particular problem was the presence of pebbles of up to 50-60mm diameter than were allowed through the static screen. These were mainly caught in the Boil Box of the sluice, preventing it functioning as a gold nugget catcher. On the other hand, it did restrain the larger pebbles from disrupting gold recovery further down the sluice. As well as the expected fine and coarse gold caught in the 2 hydraulic sluice sections in the Nomad™ matting, some gold nuggets were also recovered from these sections, one nugget as large as 15 grams.

A second problem was some uncertainty by the mine operatives, leading to the water pressure of the hydraulic sluices to be sometimes raised to 1-1.5 bar instead of the required 0.15-0.35 bar. This is expected to have caused a loss of fine gold on the days that it occurred.

Performance of IHC 2-Cell Jig & IHC Conical Screen

The volume of placer supplied to the IHC Conical Screen ('scrubber') feeding the IHC 2-Cell Jig was grossly inadequate. This was due to breakdowns of the contract-hired trucks and excavators. Priority was given to supplying the PAuSE NZ Hydraulic Riffled Sluice. Consequently the gold recovery achieved by the IHC 2-Cell Jig could not be assessed.

Fig.14: *Ex-Soviet military 6-wheeled excavator (right) with 600-litre bucket dumping gravel into water-jetted Grizzly of IHC Conical Screen, feeding slurry to an IHC 2-Cell Jig (left) at the Bugant Mine. Note the clayey tailings issuing from the jig and water+oversize from the screen.*

A problem arose with the IHC Conical Screen. This operated at only 10-15m^3/hour instead of 60-80m^3/hour to minimise damage, allow clay to fall through the Grizzly and to ensure enough residence time in the Scrubber for the clay to disaggregate into the slurry. The damage was inflicted by slabs of rock that got through the Grizzly sidewards and so entered the screen, bending many plates, and 'popping off' some. Emergency repairs were made by Ochir staff, requiring about 8 hours of downtime. Loose plates were straightened and re-inserted, and 12mm steel rods welded on to inhibit buckling. An issue was the slots in the screen plates being 35 x 12 mm - permitting feed to be larger than recommended for optimal jig performance.

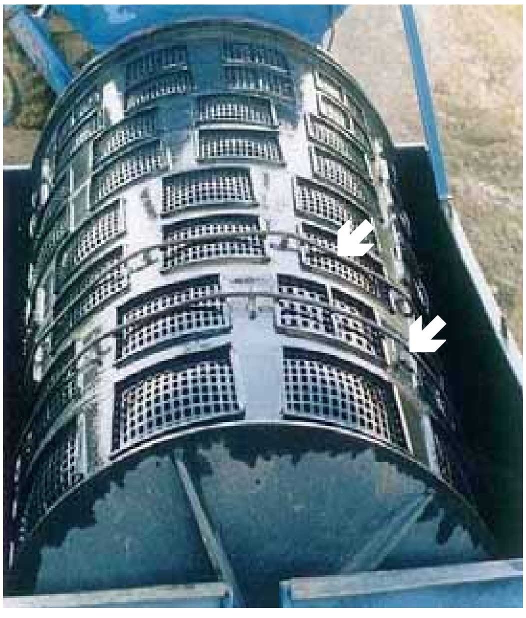

Fig.15: *IHC Conical Screen showing outward buckling of the screen plates due to battering by slabs of oversize that got past the Grizzly. Arrows show the welded-on metal rods to prevent further buckling of screen plates.*

Performance of Mining Operations

Contractors had already cleared trees and scrub from a few hundred metres of placer, in readiness for mining.

The mining method employed was that inherited from the 1998 season by the Russian contractors of Uurt Ltd. Bulldozers cleared the topsoil and subsoil together, with no attempt to separate and conserve the topsoil. The material was bulldozed to the lateral flanks of the placer (i.e. north and south), pushed into the fringes of the uncleared woodland. The irregular mounding of overburden/topsoil therefore buried some in-situ topsoil and is also expected to have sterilised some lateral pockets of placer by rendering it uneconomic for mining.

Mining of the placer then commenced. An excavator was used to excavate the placer and load it into a waiting truck. The choice of route of the truck to the washing plants was restricted by the linear mounds of bulldozed overburden/topsoil above the north and south edges of the pit walls. Haulage was therefore confined to trucking along the top of the yet-to-be-mined placer. A further obstacle to haulage was exerted by a 4m deep trench, incised into the placer to facilitate drainage from the active mining area westwards into the tailings ponds.

Advantage was taken of the overburden mounds in order to create the sites for the two washing plants. Oversize and tailings were directed into the mined-out areas. Clayey tailings water flowed by channels about 200 metres westwards (down-valley) to a large settling pond with an earth-built retaining dam. The dam was well-constructed and only clean water was discharged to the Bugant River.

Later BNP Progress Ltd. diverted an excavator and bulldozer to confirm reserves to the east, ahead of the advancing mining face. Near the end of the season, this led to high-grading of a block of richer placer. However the gains envisaged were offset by the longer trucking distance, the cost of driving a haul road through the forest, and the need to reinforce the soft ground of the haul road by tree-trunks.

Fig.16: *Korean Hyundai caterpillar-tracked excavator loading a Russian Kraz 5m^3 truck with placer at the Bugant Mine in 2001. The lack of clearance of trees and scrub was due to a decision to attempt high-grading at this location. The perpetuation of the Russian-style bulldozing of overburden into the forest destroyed 50% more trees than needs be, buried topsoil and sterilised some placer reserves. An influx of groundwater is invading the excavated area, counteracted by pumping.*

  contact: emiweb@magicnet.mn

Discussion

Due to change of mine ownership, operations commenced very late in the season, in early July, and ceased prematurely on 2nd October 2001 due to the hired trucks being taken away to work on the 'Millennium Road Project'. Only 90 days washing was achieved instead of the optimum 155 days. The main difficulty in meeting production targets was the frequent breakdown of earth-moving equipment (trucks, bulldozers and excavators) and so the gold washing plants were fed for about 8 hours a day, thus only about 720 hours (90 days x 8 hours) of washing was possible with the 25m^3/hour PAuSE hydraulic riffled sluice during the season, 24% of the optimum of 3,100 hours (155 days x 20 hours). The IHC jig was largely idle for most of the mining days due to a shortage of trucked material to process.

Many problems were encountered in mining and washing at the Bugant Mine, notably:

NATURAL PROBLEMS	Impact on Mining & Washing	Remedial Action Taken
1. Rock slabs abundant in placer	Damage to IHC Conical Screen	Urgent repairs & modifications
2. High natural water-table	Mining areas wet and muddy	Pumping & cutting of channels
3. Springs in the mined-out areas	Re-mining rendered difficult	Cutting of more channels
4. High clay content of placer	Special care needed in washing	Greater residence time for washing
5. High clay content of tailings	Special care needed in disposal	Substantial Settling Pond
6. Considerable risk of forest fires	Stringent fire precautions	No clearance in riskiest months
7. Pay-zone long and very narrow	Narrow mining face	No remedy applied

OPERATIONAL PROBLEMS	Impact on Mining & Washing	Remedial Action Taken
1. Change in ownership	Major delay in mining & washing	-
2. Earthmoving plant breakdowns	Major cut in mining & washing	-
3. Contractor takes away trucks	Termination of mining & washing	-
4. Mining starts in low-grade block	Cashflow damage	Attempt at high-grading
5. Washing plants not fully mobile	Expensive additional trucking	-
6. Russian-style bulldozing	Loss of topsoil; reserves sterilised	-

Halving the 185mm gaps between the Grizzly Bars protecting the IHC Conical Screen was desirable, but no suitable steel was available locally. This is now expected to be done in the winter months, together with steepening the angle of the Grizzly in order to throw-off the larger slabs of rock. It would be preferable to change the slots to closer to the recommended 25mm maximum feed, still capable of recovering all but the very largest gold nuggets.

The IHC Jig and IHC Conical Screen are both skid-mounted and mobile. Moving to 'catch-up' is achieved with a bulldozer to push them along a pre-prepared haul road to the new site at a speed of about 2 km/hour. Down-time is 12 to 24-hours due to the need to uncouple and reconnect the piping and electrical wiring, dewater and re-water the units and relocate the portable generator set. This is significantly slower than with a skid-mounted Screen with integral NZ Hydraulic Sluices, as demonstrated by Cold Gold Mongolia Ltd. very successfully in the Yalbag Mine, also in north Mongolia (Walker 2001). Due to the narrowness and thinness of the rich placer at the Bugant Mine, the need for mobility of the washing plants is paramount, or distances become very expensive for trucking, and more trucks are soon needed.

The Russian-style water cannon ('monitor') and screen used at the Bugant Mine are difficult to move. Even assuming some preparatory tasks are completed, it would still require 2 or 3 working days to relocate. Thus each move is equivalent to a loss of 2% of the available washing hours in a 155-day optimum mining season, negating the remarkable rapid mobility of the 25m^3/hour PAuSE NZ Hydraulic Sluice that can be moved in under an hour.

It is clear that the natural and operational problems, together with the limited mobility of the washing plants, render the Bugant Mine barely economic with present methods. A fundamental change of mining and washing is required for the 2002 season.

contact: emiweb@magicnet.mn

Mobile Pontoon-mounted Washplant

The authors suggest a different method of mining for the 2002 season, taking advantage of the high water table. Channels would be stopped up to allow the water table to create a 'start-pond' onto which a pontoon would be floated, bearing the IHC Conical Screen and IHC 2-Cell Jig. The floating washplant would be moored by winches close to the working face.

Onshore, an excavator would dig the placer and feed it directly into a Grizzly + Hopper feeding pay-gravel to a wheel-mounted conveyor with a ??-metre reach feeding the pontoon-based Grizzly+Hopper of the IHC Conical Screen. This Grizzly would be an additional line of defence for the screen. The slots in the screen would be reduced to give a better feed for the jig.

Disposal of oversize from the pontoon-based Grizzly+Hopper requires a second conveyor to dump it onto the bank at the rear of the pontoon. Disposal of tailings from the IHC jig requires a pipeline attached to the second conveyor, and an additional Warman Slurry Pump.

In the unlikely event that the water level being insufficient for the pontoon, then the existing pumps and pipelines would be used to extract "top-up" water from the river.

Stripping of the overburden could continue by bulldozing laterally, with the important proviso of first dozing the topsoil into discrete mounds for later re-spreading. The cost of 'double-dozing' of overburden back into the excavations after the passage of the pontoon might be prohibitive, and consideration should be given to dispensing with large bulldozers and instead use an excavator feeding topsoil and overburden into trucks or simple conveyors to transport it to backfill to the excavations after the passage of the pontoon.

A small dozer would still be essential for maintaining roads and levelling, but otherwise conveyors offer significant advantages over bulldozing or trucking of overburden and topsoil:

a) Cheaper to operate than trucks or dozers in terms of fuel, manning, maintenance and reliability - but need capital investment whereas trucks and dozers can be hired;
b) 50% reduction in tree and scrub removal, restricting it to that above the placer itself.
c) Topsoil would not be lost and be kept in good condition due to swift re-use;
d) Placer mining would not be compromised by truck and bulldozer movements;
e) Wet ground would not be a significant problem;

The proposed 'pontoon+conveyors' method of working is still under study and may require modifications. For instance, the high clay content may merit replacing the IHC Conical Screen with a purpose-built clay washer. Nevertheless, the additional capital cost of pontoon, manufactured locally, together with the conveyors, hoppers etc should soon be recovered by reduction of trucking, 20-hour operations and the solving of the water problem.

Abandonment versus Rehabilitation or Restoration

As noted, Russian-style mining by bulldozing maximises environmental damage by destroying 50% more of the tree cover than strictly necessary, loss of topsoil by churning with overburden and further loss of topsoil by burying beneath dozed material. This has become normal practice in Mongolia, with little rehabilitation attempted. Restoration to pre-existing contours is virtually impossible. Simple abandonment is intended by most miners.

Generally this is detrimental to the environment. However the Bugant Mine appears exceptional. The blocks mined-out in 1998, 1999 and 2001 have a high natural water-table, creating powerful new springs of clean water that have flooded the lower excavations with 20 to 100cm of clear freshwater. The older eastern blocks (1998, 1999) support populations of small fish and some amphibians; a slow creek of clear water links a series of pools; and birch scrub, herbs and grasses are beginning to colonise the tailings and overburden mounds. Biodiversity is increasing, and the creek and pools serves as a fire-break. No muddy water or chemical have entered the river and, unlike elsewhere in Mongolia (Melchert 1998, Melchert & Mendsaikhan 1999, Farrington 2000), aquatic life and fish species seem unaffected.

Conclusions

The advantage of using high % gold recovery systems was completely lost due to the late start and early finish to the mining season, and a shortage of trucked pay-gravel due to frequent breakdowns of earth-moving equipment. The PAuSE NZ Hydraulic Riffled Sluice performed well, but for most of the time the IHC Conical Screen and IHC 2-Cell Jig were idle due to a lack of trucked feed.

The Russian-style method of mining by bulldozing overburden to the sides damaged 50% more of the valley floor's tree-cover than necessary, buried topsoil and sterilised some gold reserves. Regeneration of forests and emergence of wetlands is occurring on blocks mined only three years ago, even though no restoration or rehabilitation has been attempted. This is attributed to the very high water table, sheltered location and proximity to seeds and litter from the surrounding forest. The new wetlands constitute a useful fire-break in a fire-prone valley.

A number of natural and operational problems indicated that the method of mining is barely viable, and future mining with a pontoon-based washing plant merits consideration.

Acknowledgments

Considerable assistance and encouragement was received in 1999 and 2000 at the Bugant Mine from Mr. S. Jadamba, General Director of Uurt Co. Ltd. and the Mine Geologist Mr. Gansukh. Thanks are due to the EU Tacis Programme (SMEMON9601 project) that funded a Feasibility Study of Mining License 744A in February 2000 by Ir. William Kramer, General Director of ADMS of the Netherlands based upon desk study and fieldwork by Dr. Baatar Tumenbayar and a team of local specialists from Bemm Co. Ltd., that formed the starting point for the present study. The early encouragement of the Team Leader of SME9601 Mr. Renй Schara was much appreciated. Mr. Jim Loveridge of PAuSE Ltd of New Zealand was a constant source of encouragement and expertise and manufacture red in New Zealand the $25m^3$/hour PAuSE Hydraulic Sluice used in the full-scale tests. In 2001 Mr. Baatar Bat , General Director of BNP Progress Ltd. kindly agreed to the full-scale tests, and thanks are due to the local mine staff under the leadership of Mr. ?? the Mine Manager. The test would not have been possible without the dedication of the team headed by Gerrit Bazuin (Dutch), including B. Munkh-Ochir (Ochir Engineer), Ts. Lusanchultem (Ochir Mechanic), L. Purevdorj (Ochir Welder). Frank McBride overcame many electrical problems. Robin Grayson of Eco-Minex International Ltd. (EMI) gave helpful comments and edited the draft of the paper, and EMI funded a re-assessment of the Bugant Mine at the end of the 2001 season.

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