Winter testing of placer gold with a 3-inch KNELSON™ Concentrator

Dr. Baatar Tumenbayar (1) **& Robin Grayson** (2)
(1) Geological Director of Eco-Minex International Co. Ltd., Ulaanbaatar
(2) General Director of Eco-Minex International Co. Ltd., Ulaanbaatar
(1) tumenba@magicnet.mn (2) emiweb@magicnet.mn

ABSTRACT

An assessment of placer gold reserves was made in the depths of the harsh Mongolian winter at the Ikh Alt Gold Mine in the Zaamar Goldfield between 28th November and 7th December 1998. The maximum temperature was below minus 10˚C. Field descriptions support the re-interpretation of the bulk of the placer as being a thin sheet of solifluction material, not water-lain. The freezing conditions in the exposed steppe grasslands rendered panning impossible. 12 samples were taken to Ulaanbaatar for testing with a 3-inch laboratory-based KNELSON™ centrifugal concentrator. The KNELSON™ results support an upward revision of virgin reserves. The KNELSON™ results also proved economic gold concentrations in 2 of 4 samples taken from the tailings of the Russian-style gold washing plants (0.756g/m^3 and 1.974g/m^3) where gold losses seem to have been substantial. This corresponds with 51% losses by Russian-style sluices at the nearby Toson Terrace Mine determined with a 20-inch KNELSON™ (Gary Beaudoin 2000), and 37% losses for Russian-style sluices at the Ikh Alt Mine determined with an IHC sawtooth jig (Bazuin et al. 2001). Losses of 37% during 1993-97 equates to 245 kilos of gold, equivalent to $2 million cash flow (at a current gold price of 9 $/gram), and a financial loss to the Government of $50,000 in royalties and $200,000 in Sales Tax. This is typical of placer gold mines in Mongolia due to a lack of high percentage gold recovery systems.

Fig.1: *3-inch KNELSON™ centrifugal concentrator undergoing testing at the Tuul River in 1998. Later it was used for laboratory testing of samples taken in winter from the Ikh Alt Mine.*

Introduction

Professional geologists receive requests to make independent assessments of placer gold mines on behalf of third parties. Such requests may arise without regard for the season. In Mongolia this can mean being asked to assess a placer in life-threatening cold conditions.

This dilemma was addressed in the present investigation. Desk study of pre-existing reports was maximised, and fieldwork was minimised by taking relatively small samples and using a hand-held GPS rather then attempting to take conventional survey measurements. Panning was inconceivable due to the low temperatures. Instead samples were transported by jeep to Ulaanbaatar for testing in a laboratory-based 3-inch KNELSON™ centrifugal concentrator. This appears to be the first time in Mongolia that an assessment of a placer gold mine has been attempted in wintertime using a KNELSON™.

Introduction to KNELSON™ Concentrators

KNELSON™ concentrators are rare in Mongolia. Therefore it is worthwhile to outline the salient features of KNELSON™ concentrators for those unfamiliar with such equipment.

A KNELSON™ is an advanced type of centrifugal concentrator. The first centrifugal concentrators used a rotating bowl to create a centrifugal force powerful enough to enhance the differential settling of particles in order to form a valuable concentrate. However, a severe limitation was that after a few seconds the centrifugal force slammed particles against the inside wall of the spinning bowl creating a hard-packed bed. After that no more gold could settle. In other words, centrifugal concentrators of simple bowl-type are not commercially viable.

Bryon Knelson counteracted the hard-packing by injecting water into the bed of heavy minerals in order to keep it fluidised. To do this, small pores in the walls of the spinning bowl allowed water to be injected from a water jacket. The first KNELSON™ prototype was tested in 1980, but it was 1984 before exhaustive tests lead to the emergence of the forerunner of the current design. For the early history of the KNELSON™ concentrators the reader is referred to a paper published by the inventor, Bryon Knelson (1992).

Fig.2: *3-inch KNELSON™ concentrator, with its centrifugal ribbed cone removed and placed in the foreground.*
(Photo: courtesy of Knelson Inc.)

Examples of KNELSON™ Concentrators used in Placer Gold Recovery

Howley Mine of Metana Minerals N.L. in Western Australia: Initial testwork had been with a trommel-jig washing plant, but recovery was disappointing. Introduction of KNELSON™ concentrators increased gold recovery by 35%, and permitted reworking of 1 million m^3 of jig tailings despite the high clay content (Knelson & Edwards1990).

Bajo Cauca and El Bagre placers in Antioquia in Columbia: Coarse gold recovery had been between 40% and 70% using sluice boxes and jigs, and fine gold recovery had been very low. Tests with 3-inch and 7-inch KNELSON™ concentrators yielded recoveries of between 98% and 99.9% subject to the optimum water pressure being used, and gold recovery was were verified by amalgamation (Meza, Hartmann & Escobar 1994).

Toson Terrace Mine in Zaamar Goldfield, Mongolia: KNELSON™ concentrators proved very effective in test mining (Beaudoin 2000), being superior to Russian-style sluices. Setbacks occurred in 1997-99 with the failure of Java Gold (JVAG on CDN) at this mine using KNELSON™ concentrators - the fault being with management not technology (Grayson 2000).

Fig.3: *Three Trailer-mounted KNELSONs™ at the Toson Terrace Mine in Mongolia in 1997.*

Fig.4: *Closer view of KNELSONs™ at the Toson Terrace Mine, showing trommel.*

Introduction to the Study Area

The investigation was undertaken in part of the Zaamar Goldfield, the largest and most productive of Mongolia's placer gold mining areas. The study area is located 240 km from the capital city Ulaanbaatar, 100 km by asphalt road and a further 140 km by dirt road. The study area consisted of two placer gold deposits known as 'Jalga 44' (Urd Delent) and 'Denj' situated within the perimeter of Mining License 056 at longitude 48˚11'15-45" E, latitude 104ө 18' 30" to 104ө 20' 10" N in the administrative district of Zaamar Soum in Tov Aimag. The mining concession is approximately 2,400 metres long and 700 metres wide.

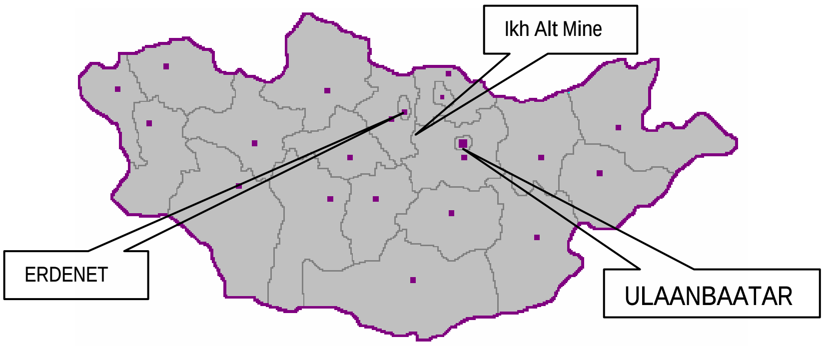

Fig.5: *Location of the Ikh Alt Mine in relation to Erdenet City and Ulaanbaatar City.*

The dominant topographic unit in the region in the broad Tuul valley, and the Tuul River is 1.9 km west of the study area. The Tuul River is one of the largest rivers of Mongolia, and is from 30 to 100 metres wide, 0.5 to 2.6 metres deep and flows at 0.5 to 1.5 metres a second. The study area (Mining License 056) rises from 966 metres above sea level in the west to hilly slopes some 1,200 metres above sea level in the east. The dominant vegetation is dry steppe grassland, with some marshy grassland by the small stream of Jalga 44.

The study area endures a harsh dry continental climate, ranging from -18˚C to -45˚in the coldest month (February) to +17˚to +35˚C in the warmest month (July). From mid-May to mid-October, the local rivers are not frozen, and this is the main period for mining.

The geology of the study area is typical of the Zaamar Goldfield. The underlying solid geology consists of Late Precambrian (Vendian) and early Palaeozoic (Cambrian) volcano-terrigenous metasediments (Darkhan Formation) overlain by Cambrian and Ordovician schists of the Zaamar Formation, cut by quartz veins, gabbros (of Ordovician and Devonian age) and granodiorites. In places are Carboniferous sandstones and Cretaceous siltstones and coal-bearing clays. However, the bulk of the lower ground is typically blanketed in Neogene basalts and sandy red clays, concealed and overlapped by Quaternary alluvial and delluvial sediments.

The main placer gold occurrences in the Zaamar Goldfield are thought to be sourced from the numerous gold-bearing quartz veins in the Zaamar region, such as those formerly mined at the Bumbat Mine by Mongolian Goldfields Corporation (now renamed Tyhee Corporation) in a joint venture with Mongolyn Alt Corporation.

In general the placers in the Zaamar Goldfield are Quaternary sediments, although some appear to be Neogene in age. Lack of dating by palaeontological remains or geophysical methods limits proper age estimation.

contact: emiweb@magicnet.mn

Previous Prospecting and Exploration

The placers in Mining License 056 were discovered in 1970-71 by a Mongolian/USSR joint survey team. Primary mapping at 1:200,000 scale was undertaken by B.M. Yakimov et al. (1971) and A. Baatar et al. in 1970-71. Mapping at 1:50,000 scale was undertaken by D. Jamtsaa & B. Dovjid in 1982 and by B. Munkhbat & B.U. Dubchenko in 1982, and geophysical mapping was undertaken by V.I. Shpilkov in 1984-85. Detailed mapping was conducted by K.A. Moskalenko in 1986-88. Further gold exploration was conducted by 'Tuuliin Angi' in 1988-91 and completed by 'Tuuliin Angi' in 1989-91. In the concession area of Mining License 056, three units of gold-bearing placers are documented in a report by C. Avirmed, D. Khishigsuren, Ts. Erdene, Ts. Tuya, B. Davaasambuu & Ts. Surenjav (1992) as follows:

DEPOSIT	OVERBURDEN	GOLD-BEARING SAND	AVERAGE GOLD CONTENT	AREA	LOCATION
I	0.5 – 2.7 m	1.0 – 1.5 m	0.969 g/m^3	190 m x 100 m	Exploration Line: 1644 (near)
II	0.5 – 0.8 m	0.4 – 1.8 m	1.198 g/m^3	610 m x 45 m	Exploration Lines: 1040 & 1042
III	0.2 – 0.6 m	0.5 – 1.6 m	0.929 g/m^3	-	Exploration Lines: 1042 & 1044

The gold reserves were estimated by Avirmed et al. (1992) as 447.1 kilos of C_1 reserves plus 104.7 kilos of C_2 reserves, totalling 551.8 kilos, calculated as follows:

BLOCK	AREA	VOLUME OF OVERBURDEN	VOLUME OF PLACER	AVERAGE GOLD GRADE	GOLD RESERVES
RESERVES OF JALGA-44 (URT DELEN)					
C_1-1	12,000 m^2	21,600 m^3	18,000 m^3	0.891 g/m^3	16.0 kg
C_1-2	25,900 m^2	69,900 m^3	41,400 m^3	2.032 g/m^3	84.1 kg
C_1-3	21,100 m^2	61,200 m^3	33,800 m^3	3.651 g/m^3	123.4 kg
C_1-4	5,500 m^2	13,800 m^3	6,600 m^3	7.773 g/m^3	51.3 kg
C_1-5	5,800 m^2	17,400 m^3	4,100 m^3	4.875 g/m^3	20.0 kg
C_1-6	11,900 m^2	47,600 m^3	11,900 m^3	1.922 g/m^3	22.9 kg
C_1-7	9,700 m^2	42,700 m^3	10,700 m^3	2.155 g/m^3	23.1 kg
Total C_1	80,600 m^2	243,000 m^3	115,800 m^3	2.327 g/m^3	269.5 kg
Total C_1-C_2	91,900 m^2	274,200 m^3	126,500 m^3	2.694 g/m^3	340.8 kg
RESERVES OF DENJ AREA					
C_2-1	7,000 m^2	18,900 m^3	9,100 m^3	1.114 g/m^3	10.1 kg
C_2-2	7,700 m^2	20,800 m^3	10,000 m^3	1.114 g/m^3	11.1 kg
C_2-3	12,100 m^2	3,600 m^3	15,700 m^3	0.778 g/m^3	12.2 kg
C_1-4	19,100 m^2	7,600 m^3	17,200 m^3	1.958 g/m^3	32.9 kg
C_1-5	11,000 m^2	0m^3	20,900 m^3	0.956 g/m^3	20.0 kg
C_1-6	176,700 m^2	53,700 m^3	115,100 m^3	1.083 g/m^3	124.7 kg
Total C_1	106,800 m^2	61,300 m^3	188,000 m^3	1.122 g/m^3	177.6 kg
Total C_1 + C_2	113,600 m^2	104,600 m^3	153,200 m^3	1.159 g/m^3	211.0 kg
TOTAL RESERVES:					
Total C_1	178,400 m^2	304,300 m^3	269,000 m^3	1.662 g/m^3	447.1 kg
Total C_1 + C_2	205,500 m^2	378,800 m^3	314,500 m^3	1.755 g/m^3	551.8 kg

The 'start' position of the reserves calculated at 551.8 kilos formed the basis of the take-up of Mining License 056 by Ikh Alt Zaamar Ltd. and subsequent mine planning, and was used in strategic studies by the Minerals Resources Authority of Mongolia (MRAM) in calculation of national reserves. However, infill exploration by geologists of Ikh Alt Zamaar Ltd. in the 1995 to 1998 seasons determined an additional 136.4 kilos of gold. This represents a 42% increase, bringing the total C_1+C_2 reserves to 788.2 kilos.

The additional reserves were found in 7 blocks - Block A (49.5 kilos), Blocks B+C+D (>50 kilos), Block G (16 kilos), Block I (12.1 kilos), Block K (8.3 kilos).

  contact: emiweb@magicnet.mn

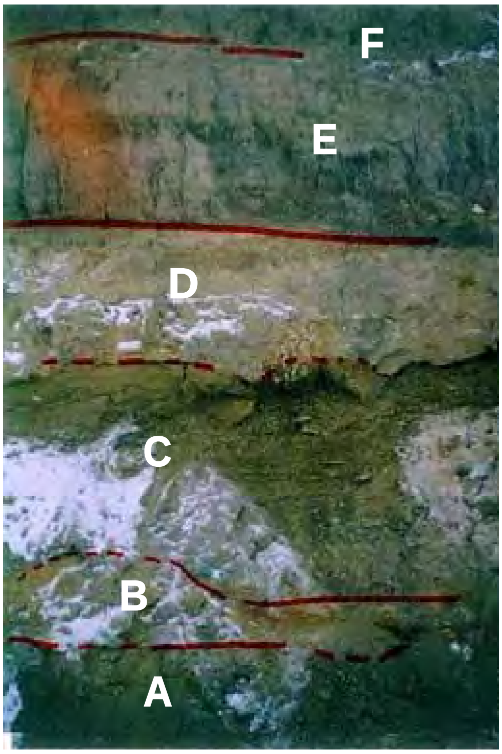

Fig.6: *Typical lithological section in Jalga-44 deposit (Urt Delen) at the Ikh Alt Mine.*

F = thin topsoil
E = dark clay (no gold)
D = gold-bearing sandy clay
C = gold-bearing sandy gravel + pebbles
B = weathered zone of clay
A = reddish basal clay (Neogene age?)

Mining History

Mining License No.056 was first issued in DATE and since that time has been held by Ikh Alt Zaamar Ltd., a local Mongolian company established in Ulaanbaatar on 6th May 1992, registration No. 634045, with Mr. Bat as General Director.

Facilitating the rapid increase in gold production from Mining License 056 was not only the increasing expertise and site knowledge of the deposit by Ikh Alt Zaamar Ltd., but also the successful implementation of contract mining arrangements with two companies: Bud Invest Ltd. (Deputy Director Mr. Tsogtbileg) mining the Denj part of the license area, and Shagai Ltd. (Deputy Director Mr. Sandag) mining the Jalga 44 part of the concession. These 2 'contract miners', i.e. Bud Invest Ltd. and Shagai Ltd., are daughter companies of Ikh Alt Zaamar Ltd. and Cosmo Co. Ltd. – the latter being a Singaporean-Mongolian joint venture (General Director Mr. Batbaasan). Being the holder of Mining License 056, Ikh Alt Zaamar Ltd. retained the right to make all gold sales from the concession.

In is important to note that the successful start-up and expansion of the mining activity was entirely by means of traditional Russian-style sluices.

The Ikh Alt Mine has been successful in achieving a year-on increase in gold production for each of the first 5 years of production, as shown by sales of gold the Mongol Bank by Ikh Alt Zaamar Ltd.:

YEAR	GOLD SALES	CUMULATIVE GOLD SALES
1992	0.0 kg	0.0 kg
1993	6.2 kg	6.2 kg
1994	35.5 kg	41.7 kg
1995	87.0 kg	128.7 kg
1996	96.2 kg	224.9 kg
1997	194.0 kg	418.9 kg

Methods

The study was conducted between 28th November and 7th December 1998, by a team headed by Dr. B. Tumenbayar. The study was executed in 4 stages: a) desk study; b) field study and field sampling; c) analyses of samples and reporting; and d) translation of selected documents. The co-operation of Mr. Bat, the General Director of Ikh Alt Zaamar Ltd. and his geological team and office staff was much appreciated.

A series of 12 spot samples were taken from different parts of Mining License 056. Sampling was generally straightforward but severely hampered by the extremely harsh winter conditions. Each sample was 0.02 to 0.25m^3 in volume (BCM = in-situ cubic metres). Eight of the 12 samples were taken from virgin (unmined) ground, and a further 4 samples taken from tailings of wash plants. The location of each sample was fixed by a hand-held Magellan Global Positioning System (GPS).

The 8 samples of virgin placer (BAZ-1, BAZ-2, BAZ-3, BAZ-4, BAZ-5, BAZ-9, BAZ-11, BAZ-12) were taken from the fresh walls of existing mining and trench excavations. Care was taken to compile a lithological section at each point sampled, in order to provide a context to facilitate interpretation of the results of the sampling. In particular, efforts were made to determine the relationship of the samples to the original ground surface and to the top of the underlying red clay of presumed Neogene age. Half of the 8 samples were taken from recently discovered blocks of new reserves (BAZ-1, BAZ-3, BAZ-5, BAZ-9), the remainder from reserves on the official balance.

The 4 samples of tailings (BAZ-6, BAZ-7, BAZ-8, BAZ-12) were taken from the tailings of the gold washing plants that had been active in the 1998 mining season.

The 12 samples were transported to Ulaanbaatar by jeep in sacks, for testing with a laboratory-based 3-inch Knelson centrifugal concentrator.

Fig.7a & 7b: *Sampling underway at the Ikh Alt Mine, locations BAZ-9 and BAZ-2.*

Set-up of KNELSON™ Centrifugal Concentrator

Ochir Leasing Ltd. imported into Mongolia a new 3-inch KNELSON™ centrifugal concentrator, model KC-MD3, complete with vibrating screen, air-freighted from the manufacturer, Knelson Inc. of Langley, British Columbia, Canada.

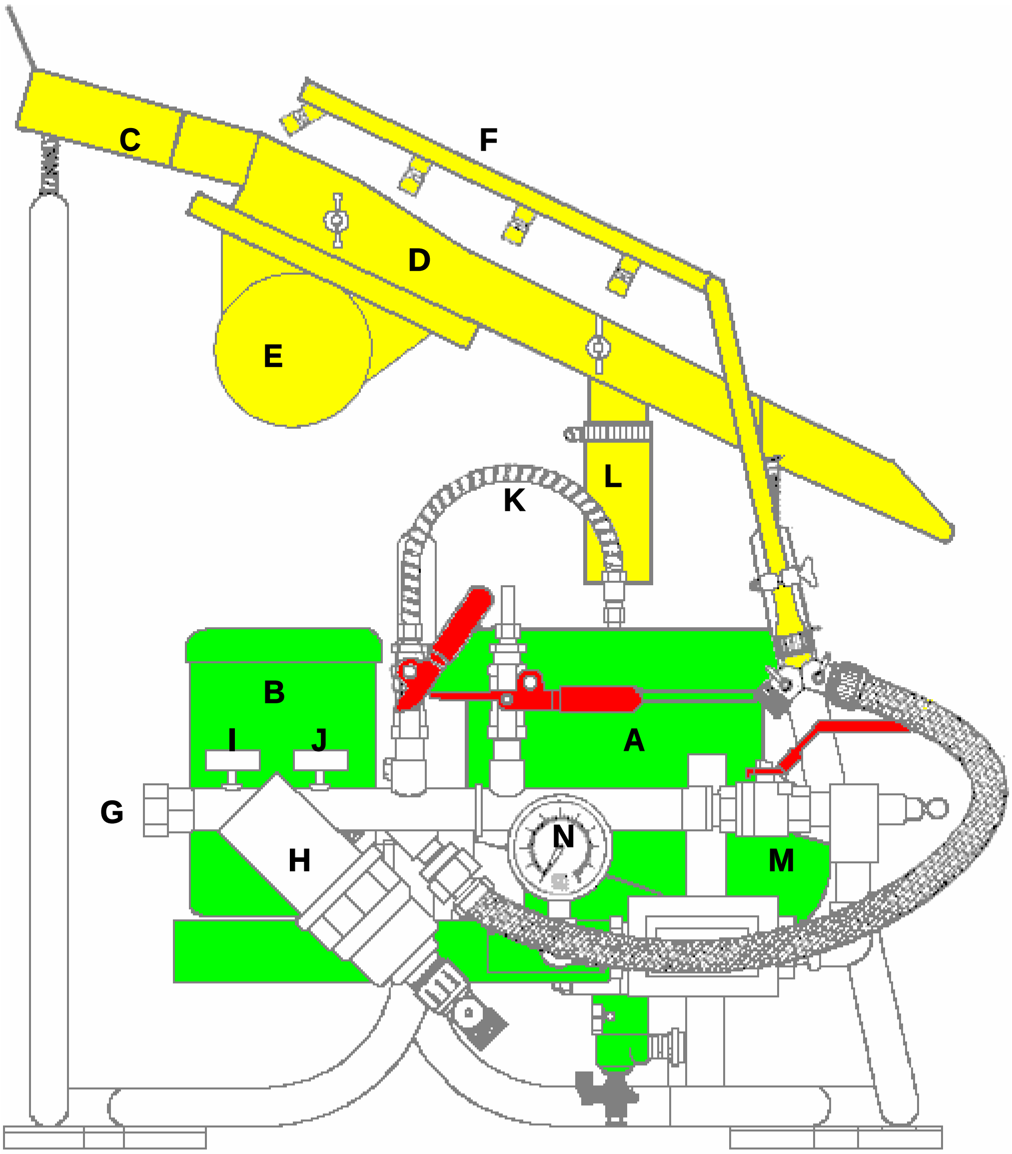

Fig.8: *Set-up of 3-inch KNELSON™ in the laboratory:*

A Centrifugal Concentrating Unit
B Electric Motor (single phase 1/6 HP)
C Vibrating Feed Hopper
D Vibrating Screen (1.7mm mesh)
E Vibrator (3,200 v.p.m., 1.7 amps)
F Spray Bar for the Vibrating Screen
G Water Supply Connection Pipe
H In-Line Water Filter (0.3mm mesh)
I Pressure Gauge (0-690kPa) upstream
J Pressure Gauge (0-690kPa) downstream
K Water for slurry feeding Concentrator
L Slurry Feed from Vibrating Screen
M 50mm diameter Tailings Outlet
N Indicator Dial for fluidisation

The assembly was placed on a laboratory table, and hooked up to electrical supply, clean water supply and a simple disposal system for tailings.

contact: emiweb@magicnet.mn

Laboratory Operation of KNELSON™ Centrifugal Concentrator

After weighing, each sample was spooned onto the Vibrating Feed Hopper and thereby onto the Vibrating Screen, where the samples were disaggregated by water jetting from the Spray Bar. Care was taken to ensure that only oversize particles (>1.7mm) were discharged from the chute end of the Vibrating Screen, and collected in a plastic bucket for disposal.

The slurry, consisting of a mixture of water and particles <1.7mm in size, was gravity-fed through the Vibrating Screen and into the KNELSON™ concentrator. The maximum rate of feed is 45kg per hour of <1.7mm solids, according to the manufacturer's instruction. Feed density can range from 0-75% solids with, in most cases, little effect on recovery rates.

The minimum sample size should be 4.5-7kg, but the manufacturers advise that "with most materials meaningful results will be obtained if fairly large samples are available (23-45kg)". The 12 samples ranged from 26.1 to 39.6kg, thus conforming to "fairly large samples".

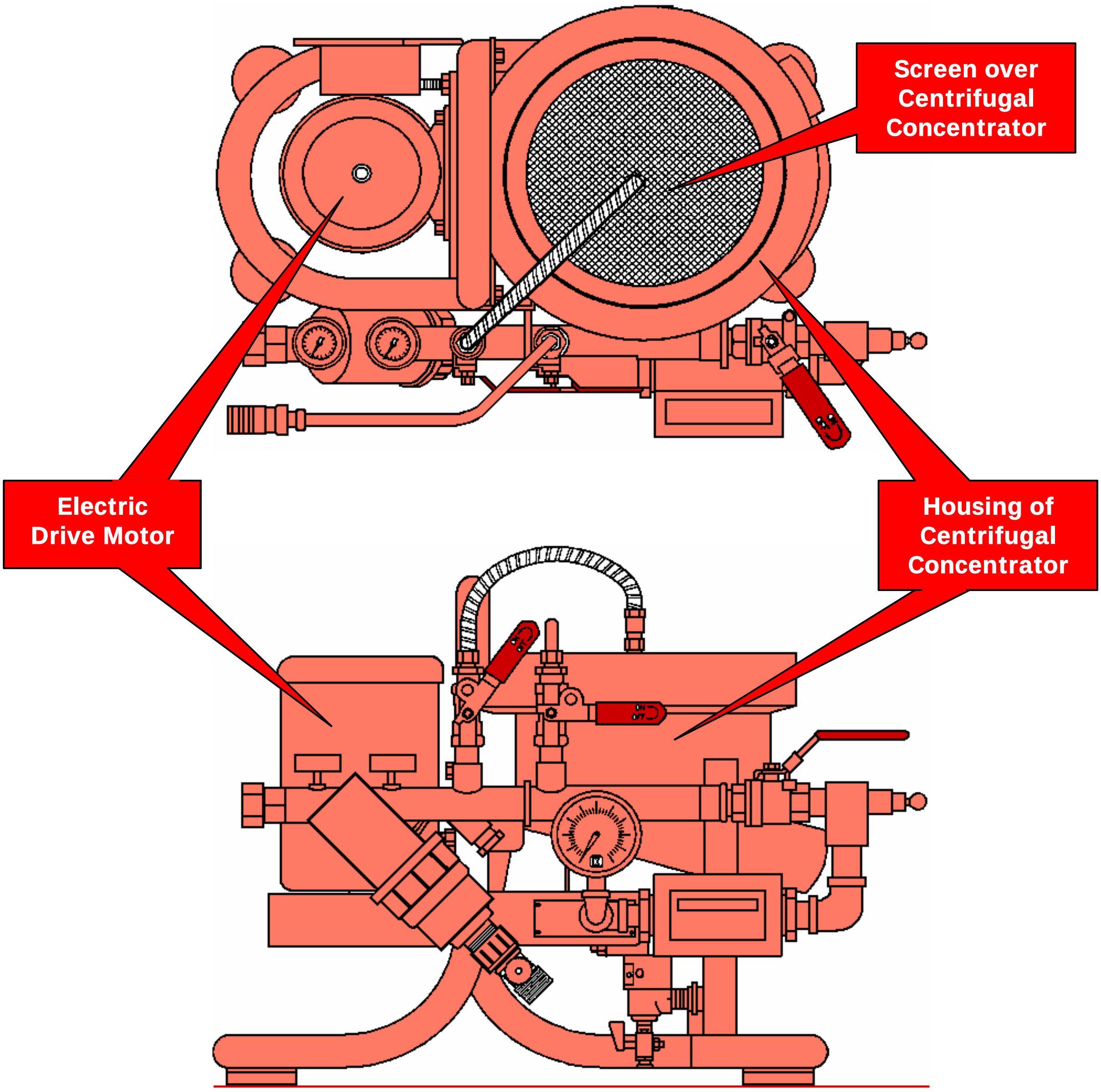

Fig.8: *Top view and side view of 3-inch KNELSON™ (Vibrating Screen omitted for clarity).*

Results

Results of KNELSON^{TM} Tests on Placer

The KNELSON^{TM} test results on 8 samples of virgin placer were as follows:

Sample	Location	GPS Co-ordinates	Weight	Gold Grade	Economic
BAZ-1	Block K	48°11'21"N - 104°19'39"E	26.1 kg	0.077 g/m^3	☒
BAZ-2	Block J	48°11'20"N - 104°19'20"E	27.0 kg	1.470 g/m^3	☑
BAZ-3	Block G	48°11'19"N - 104°19'39"E	39.6 kg	0.280 g/m^3	☑
BAZ-4	Block H	48°11'18"N - 104°19'28"E	27.9 kg	0.077 g/m^3	☒
BAZ-5	Block I	48°11'15"N - 104°19'05"E	36.5 kg	0.063 g/m^3	☒
BAZ-9	Block C	48°11'43"N - 104°19'25"E	29.3 kg	0.469 g/m^3	☑
BAZ-11	Block M	48°11'22"N - 104°20'07"E	29.1 kg	ABSENT	☒
BAZ-12	New Area	48°11'21"N - 104°19'50"E	39.7 kg	0.161 g/m^3	?

The result of the field examination of lithologies, combined with the KNELSONTM test results, permitted a tentative correlation of the deposits:

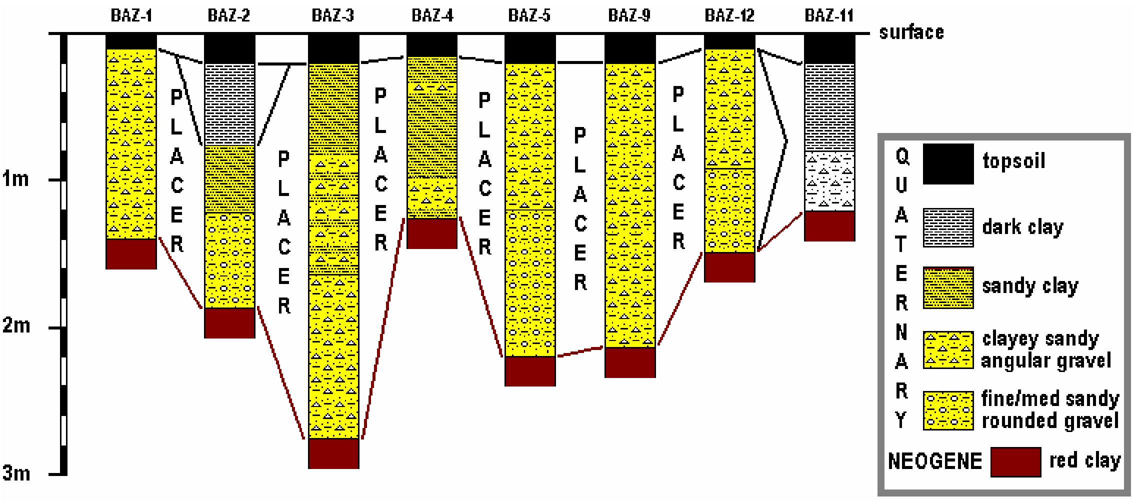

Fig.10: *Correlation chart of 8 sections in placer deposits at Ikh Alt Mine.*

The correlation chart shows the overburden to be very thin, often restricted to topsoil. The placer is thin, but quite variable in lithology. In 3 sections (BAZ-2, 5, 12), the placer has a basal unit of fine/medium sandy rounded gravel suggesting a water-borne origin. Otherwise a different origin is required, for the bulk of the placer is clayey with angular clasts, and upwards often becomes more clayey. The absence of fossils or persistent horizons prevented stratigraphic subdivision of the placer. The placer rests on a red clay believed to be of Neogene age.

Results of KNELSON^{TM} Tests on Tailings

The KNELSON^{TM} test results of 4 samples of tailings from the gold washing plants at the Ikh Alt Mine were as follows:

Sample	Location	GPS Co-ordinates	Weight	Gold Grade	Economic
BAZ-6	Tailings	48°11'29"N - 104°18'29"E	38.1 kg	0.049 g/m^3	☒
BAZ-7	Tailings	48°11'36"N - 104°18'37"E	39.0 kg	1.974 g/m^3	☑
BAZ-8	Tailings	48°11'43"N - 104°18'44"E	28.8 kg	0.756 g/m^3	☑
BAZ-10	Tailings	48°11'10"N - 104°20'04"E	32.8 kg	0.035 g/m^3	☒

contact: emiweb@magicnet.mn

Discussion

Origin of Placer Gold Deposits

The new field descriptions of the placer gold deposits permitted reconsideration of their origins. Previously the placers had generally been assumed to be entirely waterlain deposits. However, the predominance of ill-sorted angular rock clasts in a heterogeneous sandy-clayey matrix rules out the assumption that the bulk of the placers are waterlain. Instead it is suggested that most of the placers were deposited either by mudflows or by solifluction creep, as documented by Batbayar et al. (1999) for several excellently visible placers in the Sergelen Goldfield near Ulaanbaatar.

Reconsideration of the origin of the placers at the Ikh Alt Mine indicates that most of the gold is probably sourced from hard rock gold within a few hundred metres. The prevalence of mudflow or solifluction placers helps to explain why Mining License 056 continues to 'surprise' with additional reserves of placer gold being recently discovered.

In essence, the Ikh Alt concession area is considered to be plastered by a composite sheet of solifluction or mudflow genesis, close to its source, and therefore the geometry of the placers tends to be more unpredictable and more widespread than in the textbook case of a simple waterlain placer.

Rate of Depletion of Virgin Gold Reserves

The estimation of the rate of depletion of gold reserves from a placer deposit is not only a central issue for calculating the life of a mine, but also central to understanding the dynamics of the entire Mongolian placer gold mining industry. For instance, correct calculation of the depletion rate of C_1 and C_2 reserves should, logically, dictate the required replacement rate of C_1 and C_2 reserves to be added by gold exploration effort in order that either an individual mine or an entire goldfield should be able to continue at the current level of production.

The rate of depletion of the gold reserves of Mining License 056 can be estimated from the sales of gold the Mongol Bank by Ikh Alt Zaamar Ltd., totalling 418.9 kilos for the first 5 years of production (1993-97), with 5 consecutive year-on increases. Set against the estimated 551.8 kilos of reserves estimated to be present by Avirmed et al (1992) immediately prior to mining, only 133 kilos should have remained at the end of the 1997 mining season:

YEAR	GOLD SALES	CUMULATIVE GOLD SALES	RESERVES REMAINING
1992	0.0 kg	0.0 kg	551.8 kg
1993	6.2 kg	6.2 kg	545.6 kg
1994	35.5 kg	41.7 kg	510.1 kg
1995	87.0 kg	128.7 kg	423.1 kg
1996	96.2 kg	224.9 kg	326.9 kg
1997	194.0 kg	418.9 kg	133.0 kg

At first glance, this calculation indicates that at the end of the 1997 season the Ikh Alt Mine has only 133 kilos of remaining reserves. Such 'traditional' calculations are relied upon in mine planning, mine evaluations and in strategic assessments by Government.

However, the real situation was demonstrated to be quite different. Three factors rendered the above calculation void:

a) Gold losses into the tailings;
b) Recent discovery of additional reserves;
c) Underestimation of reserves by Soviet surveys.

<u>Gold losses into the tailings</u>: The KNELSON™ tests on samples from 4 of the tailings from Russian-style water cannon and sluices demonstrated that two of the tailings areas had a very high gold content (0.756g/m^3 and 1.974g/m^3). These tests are preliminary, but sufficient to indicate that a substantial percentage of gold was lost by the Russian-style wash plants. This was later confirmed by a comparative test with an IHC 3-Cell Sawtooth Trapezoidal Jig that indicated at least 37% of the gold content was being lost to the tails by the Russian-style sluices (Bazuin et al. 2001). A conservative 40% loss is used in the following table:

YEAR	GOLD SALES	CUMULATIVE GOLD SALES	NOTIONAL TAILINGS (40%)	RESERVES DEPLETION (incl. losses)	ORIGINAL RESERVES REMAINING
1992	0.0 kg	0.0 kg	0.0 kg	0.0 kg	551.8 kg
1993	6.2 kg	6.2 kg	4.1 kg	10.3 kg	541.5 kg
1994	35.5 kg	41.7 kg	27.8 kg	69.5 kg	482.3 kg
1995	87.0 kg	128.7 kg	85.5 kg	214.2 kg	337.6 kg
1996	96.2 kg	224.9 kg	149.9 kg	374.8 kg	187.0 kg
1997	194.0 kg	418.9 kg	279.2 kg	778.1 kg	- 126.3 kg

A negative figure for reserves is of course impossible, requiring explanation (see next section).

<u>Discovery of additional reserves</u>: Additional infill exploration by the mine geologists of Ikh Alt Zamaar Ltd. in the 1995-98 seasons detected the presence of additional reserves of gold were in 7 blocks – Block A (49.5 kilos), Blocks B+C+D (>50 kilos), Block G (16 kilos), Block I (12.1 kilos), Block K (8.3 kilos), and several further blocks appeared to be promising. The total of 136.4 kilos of gold represents a 42% increase on the original estimate of 551.8 kilos, bringing the total C_1+C_2 reserves to 788.2 kilos. However this increase is only just sufficient to allow current reserves of 8.9 kilos, once the combined effect of gold sales and gold losses are taken into account (136.4 – 126.3 kilos).

<u>Underestimation of reserves by Soviet surveys</u>: Current reserves of 8.9 kilos is an unrealistically low figure in view of the significant volume of virgin reserves yet to be mined. It seems likely that the original gold content of the Ikh Alt placers was systematically underestimated by the earlier Soviet surveyors. This factor is becoming more widely recognised. For instance, Walker 2001 describes how Cold Gold Mongolia Ltd. recovered 130% of the reserves stated in the Soviet reports for 3 blocks of the Yalbag Mine in northern Mongolia! Also Bazuin & Tumenbayar (2001) report high gold grades (0.5-5.0 grams/m^3) in all 13 samples taken from supposed overburden at the Bugant Mine in northern Mongolia. Systematic underestimation of placer gold reserves and gold content has also been recently reported across the border in the Buriat Republic of the Russian Federation, where Namelova et al. (2000) reported that: *"the portion of fine gold was 4 to 10 times greater compared with the value determined at the exploration stage" and attributed to "the use of low effective pan sampling in exploration works that doesn't permit to obtain high recoveries of fine gold."*

Estimate of Value of Gold Lost with the Tailings

Taking 37% losses as a conservative figure, then the value of the gold lost in the tailings of the Ikh Alt Mine over a 5-year period (1993-97) equates to 245 kilos of gold, equivalent to $2 million cash flow (at a current gold price of 9 $/gram), and a financial loss to the Government of $50,000 in royalties and $200,000 in Sales Tax. This is considered typical of placer gold mines in Mongolia due to a lack of high percentage gold recovery systems, as noted earlier by Grayson (1996 p.34) who suggested that gold losses to the tailings amounted to "at least $45 million." This figure subsequently increased considerably with the expansion of the placer industry.

Conclusions

Assessment of reserves of a placer gold mine is possible in winter, provided a GPS is used and samples are transported to a laboratory for testing. The 3-inch KNELSON^{TM} centrifugal concentrator plus Vibrating Screen proved effective to use in the laboratory.

Calculation of unmined gold reserves in Mongolian placers is more complicated than previously thought. As well as the major issue of gold losses to the tailings, the issue of systematic underestimation of the original reserves is also important, as well as additional gold reserves detected by additional exploration on a concession after mining has commenced.

Acknowledgments

The authors would like to thank the following people and organisations for assisting in various ways in the compilation and production of this paper: Mr. Bat, General Director of Ikh Alt Zaamar Ltd., facilitated the investigation of the deposits in the winter of 1998.

Ochir Leasing Co. Ltd. (UK-Mongolian joint venture) funded the winter 1998 study and kindly loaned the 3-inch KNELSON^{TM} centrifugal concentrator plus vibrating screen to permit recovery of gold from the samples under laboratory conditions in Ulaanbaatar.

References

Avirmed, C., D. Khishigsuren, Ts. Erdene, Ts. Tuya, B. Davaasambuu, Ts. Surenjav (1992) Urd Delengiin, Jalga-44 Terrace, Basis of Economics of Gold Mining Techniques *(in Russian)*

Batbayar, Minjin, Baasandorj Altanzul, Robin Grayson, Baatar Tumenbayar, Tseveen-Ochir Altantsetseg, Iain Barclay, Bat-Otgon Bat-Ochir & Gerrit Bazuin (1999) Solifluxion placers of the Sergelen Goldfield, Mongolia. *Mongolian Geoscientist, volume 14, p.116-119. (in English)*

Beaudoin, Gary (2000) Gold Test on the Toson Terrace Placer, Zaamar Goldfield of Mongolia. *World Placer Journal, volume 1, p.1-9. (in English)*

Dallas, William (1999) An Assessment of Environmental Impact Issues and Issues Relating to Gold Mining in the Zaamar Region, Mongolia: Executive Summary. *World Bank. Washington DC. 13 pp. (in English)*

Farrington, John (2000) Environmental problems of placer gold mining in the Zaamar Goldfield, Mongolia. *World Placer Journal, volume 1, p.107-128. (in English)*

Fedotov, K.V., V.I. Beloborodov, S.B. Leonov & K.H. Lestra (1997) Recovery of fine gold using efficient gravity separators. *Proceedings of 20th International Mineral Processing Conference, 21-26th September 1997, Aachen, Germany. p.551-610. (in English)*

Grayson, Robin (1996) Doing Business in Mongolia. *Mongolian Business Development Agency: Ulaanbaatar. Paperback edition. 155pp. (in English)*

Grayson, Robin (2000) The failure of Java Gold Corporation at placer gold mining in Mongolia. *World Placer Journal, volume 1, pp.10-30. (in English)*

Knelson, Byron (1992) The Knelson Concentrator: metamorphosis from crude beginning to sophisticated worldwide acceptance. '*Minerals Engineering '92' Conference in Vancouver, Canada, Cambourne School of Mines & Minerals Engineering Journal. 6pp. (in English)*

Knelson, Byron & Ron Edwards (1990) Development and economic application of Knelson concentrators in low-grade alluvial gold deposits. *AusIMM Annual Conference, Rotorua, New Zealand. p.123-128.*

Meza, Luis A., Willy Hartmann & Carlos A. Escobar (1994) Recovery of placer gold using the Knelson concentrator. *Innovations in Mineral Processing, p.339-347. (in English)*

Namelova, M.M., O.V. Zamyatin, V.M. Mankov, V.I. Bakhtia, T.B. Tararova & A.P. Yatsyk (2000) On the problem of forecasting and concentratability of placer material containing fine gold in Buriatiya. *Abstracts of 12th International Symposium on Placer & Weathered Rock Deposits, 25-29th September 2000, Moscow, Russia. p.120-122. (in English & Russian)*

  contact: emiweb@magicnet.mn