



Karelian gold

John Chadwick reports from one of the cleanest gold mines in the world in the farthest east boundary of the EU, with expanding production likely

Endomines' Pampalo gold mine is currently producing gold at an annualised rate of 800-900 kg. The mine is located on the 40 km-long gold-critical Karelian Gold Line, where Endomines controls all currently known gold deposits. The mine project was completed in December 2010, on schedule and in line with the budget at €20 million. Commercial production commenced in February 2011 as scheduled.

The Pampalo deposit, which remains open at depth, is located in the central part of the Karelian Gold Line, 5 km north of the village Hattuvaara. It is an Archean orogenic gold deposit in an intermediate pyroclastic unit, metamorphosed to greenschist - lower-amphibolite facies. It lies close to the border with Russia in the most easterly extremity of the European Union.

Plant capacity was increased from 230,000 t/y to 270,000 t/y by debottlenecking during 2011. Metallurgical testing demonstrated that the gold could be very efficiently extracted by gravimetric separation and flotation concentration. The best results indicated a recovery of more than 90%. As a result, this mine is very clean with minimal emissions, and none to the environment. Its tailings facility is full of what is effectively potable water.

No cyanide or acid is used and there is nothing harmful in the tailings. There is no Acid Mine Drainage (AMD). The target is for 100 % water recirculation.

Like so many of the mines coming on stream in Finland today, Pampalo is a former project of Outokumpu. It was discovered in 1990 by the Geological Survey of Finland and Outokumpu Mining undertook intensive exploration and test mining. Outokumpu carried out test mining first in 1996, as an open pit. Later in 1998-1999 there was limited underground mining down to a depth of some 100 m. As a result, Endomines came into the fortunate position of taking on a well-developed decline to more than 250 m below surface. Currently stoping is around the 220 m level and the decline today extends to 365 m below surface, to facilitate Pampalo Deeps exploration.

Outokumpu hauled the ore it extracted by road 400 km to both Vammala and Pyhäsalmi for beneficiation. A total of 114,372 t was mined, at an average gold grade of 15.3 g/t, producing 1,755 kg of

3D image of the three lenses of the Pampalo deposit. The section viewed from northwest. The gold mineralisation is shown in different colours. The colours light blue and red = existing declines, brown = open pit

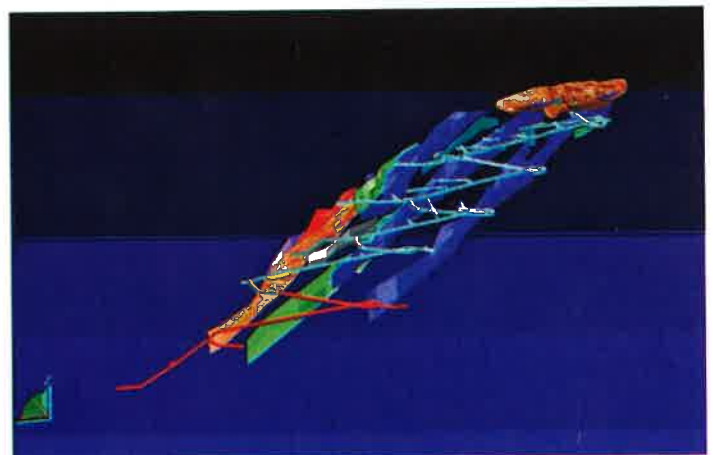
*Mucking by remote control.
Picture by Eija Hiltunen*

gold. Outokumpu ceased activities in 1999 and Pampalo was acquired by Dragon Mining.

Endomines was established in 1996 as a private company. It was registered at Hattuvaara, Ilomantsi, and explored north from Pampalo in 1996-2006, acquiring Pampalo in 2006.

Developing mining skills

Finland has an effective and somewhat unique way of addressing skills shortages in mining, through a national training institute. In North Karelia this is Pohjois-Karjalan aikuisopisto (PKKY) with colleges in Joensuu, Kitee, Lieksa,





Sandvik DL430-C being used on this occasion for sludge drilling and sampling to define the orebody in an area where only limited core drilling has been undertaken. Picture by Eija Hiltunen

Niittytahti, Nurmes and Outokumpu. The latter is the country's primary centre for learning mining skills.

Pohjois-Karjalan aikuisopisto (see box) has been a very important contributor to the successful development of Finland's latest two mines, Pampalo and Altona Mining's Kylylahti (article in the September MINEexpo, issue), both officially opened on that same day, May 25, a year apart; Pampalo in 2011 and Kylylahti this year.

At Pampalo PKKY is not only providing training but also contracting services. Endomines has a Sandvik DD420-S60C twin boom jumbo that together with PKKY's twin-boom Atlas Copco Boomer E2.drills all the development drifts to open up the stopes.

In this case, PKKY is working as a contractor and is also training drill operators for Endomines and other mining companies. Pampalo also has PKKY's Sandvik's DS410 rock bolter and its Normet MC 605 DA Anfo charger working under contract and providing training in an active mine. At this stage the contract for

PKKY's Normet charger. Picture by Eija Hiltunen



these machines ends at the end of 2012.

Pampalo mining plan is a design for sublevel bench cut-and-fill stoping (a modified Avoca mining method) with 14 m stope heights in the upper levels and 17-20 m stope heights in the lower levels. The lower stope height incurs higher stoping costs per tonne of ore but has lower costs in

consideration of rock reinforcement. In the future, stoping will move to the deepest level to minimise the losses of ore in horizontal pillars.

The choice of method was made to minimise the extent of hanging wall exposure during mining. The grade of the deposit prevents the use of higher cost cut-and-fill mining methods, which require cemented fill. This method allows simultaneous mining and filling of the stopes to minimise the span of the hanging wall exposed, reducing the potential for hanging wall instability and dilution.

The longhole drilling rig is a Sandvik DL430-C. It is a narrow orebody, 4-10 m wide. Cable bolting is the primary stope support method, using a Sandvik DS420-C cable bolting rig. Janne Muttonen, Resident Manager, is very happy with this rig. He explained that it is used to install 6-8 m cable bolts and can easily average more than 100 m of cable bolting in a ten-hour shift.

Stopes are mucked out by Endomines' Sandvik LH 514 LHD, which load into a contractor's fleet of SISU and Scania trucks (20-30 t) capacity for the haul to surface.

A Forcit MA 22 emulsion charger mounted on a Scania P340 truck chassis. Kemiitti 810 is a site sensitised pumpable emulsion explosive developed by Forcit for underground mining. The equipment on the truck automatically adjusts



This Sandvik DS420-C cable bolter is a popular and effective rig

the degree of charging in the boreholes suitable for all. It carries all the equipment needed: the detonators, ignition and emulsion needed for producing Kemiitti 810. When charging, the emulsion is converted into the explosive only within the borehole.

Green gold

This April, Endomines decided to proceed with increasing production capacity at Pampalo up to a maximum of 450,000 t/y. The decision was based on the results of a recent feasibility study. A second-hand refurbished mill was acquired before the end of last year, and this will now

A Forcit MA 22 emulsion charger mounted on a Scania P340 truck chassis. Kemiitti 810 is a site sensitised pumpable emulsion explosive developed by Forcit for underground mining. The equipment on the truck automatically adjusts the degree of charging in the boreholes suitable for all. It carries all the equipment needed: the detonators, ignition and emulsion needed for producing Kemiitti 810. When charging, the emulsion is converted into the explosive only within the borehole.





allow for a rapid capacity increase. An environmental permit application for the capacity increase was filed, and a decision is expected early next year. Preparations are underway with a view to starting test production at Rämepuro, which is likely to be the first satellite deposit to be developed. In addition to the second mill, more flotation cells will be added.

The plant expansion will allow for low grade, currently uneconomic, open-pit mineral resources to be converted to ore reserves which can be mined and processed at Pampalo. It will also ease problems with fine crushing.

The first thing that strikes you when entering the plant from the control room is the shaking tables. It is rare to see the gravimetric section of a plant so prominent, but it is a very key part of this facility. The 4,000 t/y of flotation concentrate assays 100-250 g/t Au, and the rest comes from the gravity circuit, recovering 30-60% of the gold, depending on the ore being treated at any time.

The crushing section of the operation comprises one jaw crusher and two cone crushers, delivering a 0-13 mm product to the mill. Metso designed the plant and provided much of the equipment, including a Metso TRN 3.0 x 4.8 m wet ball mill with grate discharge. It is equipped with an 800 kW ABB motor. The ore is ground to a P80 of >75 µm. There are six Metso RCS20 flotation cells and one Metso RCS 3 cell. There is also a Metso CT SFL10 - 5 thickener. Hannu Tahvanainen, Mill Superintendent, finds the plant's Numcore Flotation Watch system very effective. This is a froth flotation process control solution, recently acquired by Outotec that simply increases



*Alimak raise miner in action.
Picture by Eija Hiltunen*

recovery without contamination problems. By using 3D-imaging, the solution provides accurate, online information on froth stiffness and thickness of the froth bed. These froth properties can then be controlled by automatic adjustment of chemicals and frothers.

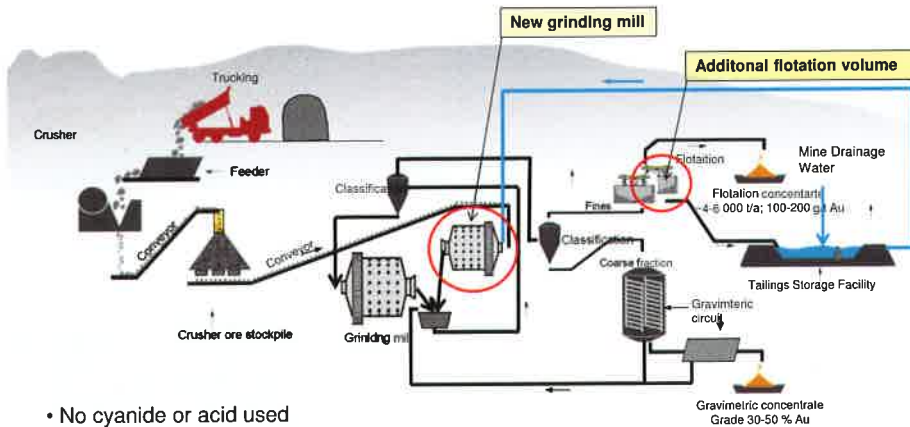
The first cyclone cluster comprises a Multotec distributor: D3-25/3 and Multotec cyclones: HC250-L10-1/A-A/60, fitted with a 100 mm vortex finder and 60 mm spigot. Another cyclone cluster comprises a Multotec D2-42/2 distributor and HC420-30-0/A-A/110 cyclones, fitted with a 185 mm vortex finder and 110 mm spigot. And the third has a D2-35/2 Multotec distributor and HC350-15-0/A-B/45 cyclones fitted with a 111 mm vortex finder and 45 mm spigot. Cyclone overflow goes to flotation and the underflow to the spirals and tables.

The gravity spirals were supplied by Downer EDI Mining - one bank of 12 Tripple-start LG7s. There are two Deister single-deck No6 2 kW shaking tables. One is left handed and one right handed.

In May Endomines AB signed an agreement to sell and deliver its gravimetric gold concentrate production from Pampalo to precious metals refiner K.A. Rasmussen AS, Norway. The volume of deliveries and estimated concentrate grade allow up to 100% of gravimetric concentrate production to be delivered to Rasmussen. The agreement is signed for a period of one year, with the option of renewal for successive one year periods.

Markus Ekberg, CEO of Endomines commented that "commercial test deliveries have proven to be mutually satisfactory. The agreement provides Endomines with flexibility, as it can balance its production between higher value gravimetric gold concentrate and flotation concentrate production volumes."

Pampalo is a very clean operation - water balance for the expanded mill capacity of 450,000 t/y



- No cyanide or acid used
- No harmful material in tailings
- No Acid Mine Drainage (AMD)
- Target 100 % water recirculation

The plant was designed for expansion from the outset





Finland's great mining skills training facility

Pohjois-Karjalan aikuisopisto (www.pkky.fi North Karelia Municipal Education and Training Consortium) is the organisation whose main function is to provide qualified vocational education in the county of North Karelia. Each year some 1,600 students, both young people and adults, obtain a vocational qualification at its institutes. It is owned by all 14 of the county's municipalities.

One of its strengths lies in effective cooperation; intercommunication between the College, the Adult Education Centre and the Upper Secondary Schools in the region as well as the North Karelia Polytechnic and, in the case of mining at Outokumpu, close ties with the industry itself. National indicators show that it is among the elite of Finnish education providers.

There are 20 educators specialising in training mining technologies attached to the Outokumpu college. The primary mining courses cover explosives and blasting, mining technology, mine development and mineral processing. The college also co-operates with GTK, the Geological Survey of Finland, for rock sampling education and training.

The standard courses in after-training, retraining adults to work in mining, cover underground or surface mining and mineral processing and most of the work is tailored to specific client mining company needs. Maintaining and improving adult learning skills, it takes one year to qualify – half the time being spent on theory and half practical.

In addition to the three machines at Pampalo, the college has two other Sandvik drill rigs – a DX 780 and a CHA 560 – and two small Commando rigs. There is also a surface drill simulator – a Sandvik DP1500i.

The institute intends also to buy an LHD, an emulsion charger, haul trucks and an underground drill simulator. The aim is always to have new equipment on which operators can train, so each unit in the fleet will be replaced within five years.

The most important types of education are vocational education and training (upper secondary level), adult education, vocational further and supplementary education and training, labour policy education, apprenticeship training, common non-vocational education, and summer university teaching.



Line of gold on one of the Deister shaking tables

Endomines is the leading partner in the TEKES Green Mining Project, "Responsible Gold" together with JOSEK, Outotec and GAIA-consulting. Stage 1 is evaluating possibilities to produce "traceable, responsible gold" using Endomines gold as a raw material and was to be completed by August 2012. Stage 2 will develop a prefeasibility study and investor plan, with the final investment plan established in Stage 3.

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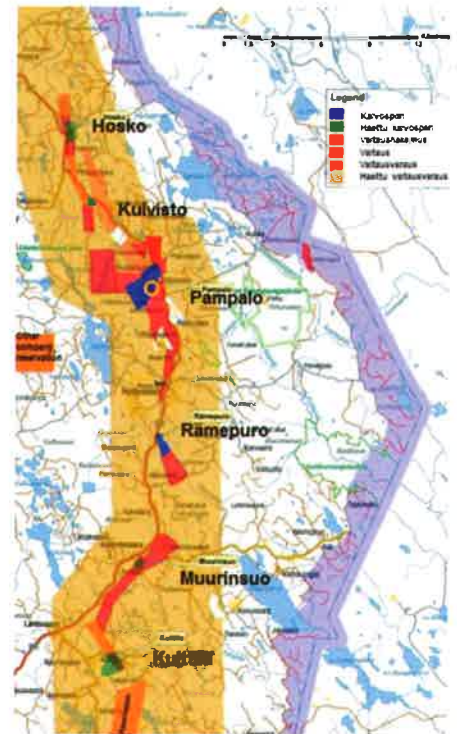
Along the Gold Line

Ekberg points to the similarities and the analogous Archaean geology in Ilomantsi (no gold mines in production in 2009) and the Southern Cross greenstone belt in Australia. The latter had four mines in production in 2009, and more than 40 had been closed over the time the belt has been producing:

Parameter	Ilomantsi (Karelian Gold Line)	Southern Cross
Belt length	90 km	110 km
Belt width	0.5–10 km	0.5–15 km
Gold exploration since	1986	1888
Total gold produced	55,000 oz	>10 Moz
Known reserves & resources	450,000	>2 Moz

main target in 2012, along with Rämepuro drilling, where pilot plant process testing is underway. The total 2012 drilling target is 8,000 to 10,000 m.

A combination of Endomines clean credentials and the otherwise generally poor employment opportunities in North Karelia mean the company is welcomed wherever it goes.



The Karelian Gold Line



Diamond drilling contractor Drillcon SMOY operating a new Sandvik core drill, mounted on a mini-excavator crawler chassis, underground at Pampalo

At the end of May, Endomines reported preliminary results from its current underground core drilling campaign at the Pampalo mine. Results were received from the first seven holes of a 15-hole, 739-m, campaign, which started in April 2012. This campaign focused on an area between the Pampalo and Pampalo East ore zones, and yielded a number of encouraging intercepts,

including 6 m @ 5.9 g/t Au, 12.6 m @ 5.2 g/t, and 9.8 m @ 5.0 g/t Au, in addition to the previously drilled intercepts yielding 9.2 m @ 4.1 g/t Au and 11.6 m @ 3.2 g/t Au.

The company says these results prove that there is a previously unknown “mineralised zone

between the currently known Pampalo and Pampalo East gold resources, at grades comparable with the previously known gold lodes at Pampalo. The drilling campaign will proceed further as planned upwards, down dip and along strike with a view to follow the mineralised zone.”

“These exploration results from the first exploration drillings in 2012 have confirmed the significant potential for further gold deposits in the immediate vicinity of the Pampalo ore”, said Markus Ekberg, CEO of Endomines. *IM*

Endomines estimates its properties currently hold Proven and Probable ore reserves of 1.6 Mt with an average gold grade of 3.5 g/t, with exploration producing promising results all the time. These reserves and resources are all located along the Karelian Gold Line - 120,000 oz in Pampalo and 60,000 oz in deposits close to Pampalo – with resources open for expansion. All satellites along the Gold Line are within trucking distance of the Pampalo plant.

The Karelian Gold Line comprises more than 40 km of gold mineralisation with excellent potential in Archean rocks. Endomines holds 400 km² in claims and reservations, including 23 known gold showings. It has been granted two mining concessions to date and five more are under application. An EIA (Environmental Impact Assessment) for the entire area is ongoing. A total of 65 new claim applications have been lodged and exploration is ongoing at a good pace.

Pampalo underground diamond drilling commenced early this year and surface diamond drilling there began in May. Korvilansuo is the

Gold ore reserves - Karelian Gold Line 31st Dec 2011

Deposit	Tonnes	Grade Au g/t	Oz	kg Classification	Consultant
Pampalo	10 000	3,0	965	30 Stockpiled	Endomines
	662 000	3,4	72 146	2 244 Proven	Outotec Oyj
	426 000	2,7	36 748	1 143 Probable	Outotec Oyj
SubTotal	1 098 000	3,1	109 859	3 417	
Pampalo East	200 000	1,5	9 645	300 Probable	MAPTEK
Pampalo Reserves total	1 298 000	2,9	119 504	3 717	
Hosko	13 000	8,5	3 553	111 Proven	MAPTEK
	116 000	10,0	37 295	1 160 Probable	MAPTEK
Hosko total	129 000	9,9	40 848	1 271	
Rämepuro	134 000	3,9	16 802	523 Probable	MAPTEK
Muurinsuo	67 000	3,0	6 462	201 Probable	MAPTEK
Grand total	1 628 000	3,5	183 616	5 711	

Mineral Resources – Karelian Gold Line 31st Dec 2011

Deposit	Tonnes	Grade Au g/t	Oz	kg Classification	Consultant
Pampalo	130 000	3,5	14 629	455 Inferred	Outotec Oyj
Pampalo East	21 000	1,5	1 013	32 Inferred	Runge Limited
Hosko	547 000	1,8	31 656	985 Inferred	Runge Limited
Rämepuro	61 000	4,1	8 041	250 Inferred	Runge Limited
Muurinsuo	786 000	1,5	37 906	1 179 Inferred	Runge Limited
Kuivisto East	37 000	3,2	3 807	118 Indicated	MAPTEK
Kuivisto East	145 000	1,0	4 662	145 Inferred	MAPTEK
Kuittila	275 000	2,6	22 988	715 Inferred	GSF, historical
Grand total	2 002 000	1,9	124 700	3 879	