



John Chadwick went to Arctic Sweden to find out more about the doubling in capacity of what is already Europe's largest copper mine

Operations at Aitik, outside the town of Gällivare, began in 1968. In 1980 its capacity was expanded from 8 to 12 Mt/y of ore, and then subsequently to some 18 Mt/y. In 2006 concentrator throughput was 18.5 Mt and 21.9 Mt of waste rock was removed. At feed grades of 0.4% Cu, 0.25 g/t Au and 2.72 g/t Ag in 2006, the mine produced 240,000 t of copper concentrate. This concentrate contained 66,100 t of copper, 35,700 kg of silver and 2,340 kg of gold.

Operator Boliden has approved the investment of SEK5.2 billion (about \$790 million) for the expansion of the operations (Aitik 36). This involves, among other things, the construction of a new concentrator, doubling capacity to 36 Mt. Aitik 36 will start operating in 2010. The Environmental Court announced on January 25 this year that Boliden had been granted the permit for the expansion. This year is the big one for spending on the expansion, approximately SEK2,500 million, following the SEK300 million spent in 2007. In 2009 some SEK1,900 million will be spent, and SEK 500 million in 2010.

Between 2007 and 2010 there is a four-year construction period, which should achieve

33 Mt annual capacity. Between 2011 and 2014, production will ramp up to 36 Mt. Current staffing totals 430 employees, of which 280 are in the mine. This number will increase with the expansion.

The expansion, according to Boliden, will raise even further the efficiency of a mine that is already one of the world's top performers. The company says the global average performance in ore mining is 15 t/manhour, and Aitik currently produces at 43 t/manhour. After the expansion, Boliden is expecting 55 t/manhour. It is also projecting life of mine cash costs falling from \$0.80/lb to \$0.43/lb. Furthermore, modern technology incorporated into new equipment and facilities will yield increased energy efficiency, improved water usage and reduced airborne emissions, better reclamation and better use of natural resources. All this extends the mine life from 2016 to 2025, while increasing copper, gold and silver production and adding new production of molybdenum. By lowering costs, ore reserves have been tripled.

Boliden has successfully replaced ore at Aitik through mine exploration. The deposit was first discovered in the 1930s, but had to wait for

the development of bulk surface mining technologies before a mine could be built to operate economically. When it was first put into production in 1968 the production was just 2 Mt/y and reserves were then estimated to amount to 50 Mt of ore. By 2006, Aitik had produced almost 450 Mt of ore (and more than 400 Mt of waste rock) and at the beginning of 2007, Proven reserves stood at 526 Mt grading 0.28% Cu, 0.2 g/t Au and 2 g/t Ag. In addition, there are 99 Mt in the Probable ore reserve category grading 0.28% Cu, 0.1 g/t Au and 2 g/t Ag. Measured and Indicated mineral resources amount to an additional 858 Mt. The latest (end 2007) figures are:

- Proven reserves 389.4 Mt at 0.29% Cu, 0.2 g/t Au, 2 g/t Ag and 31 g/t Mo
- Probable reserves 220.9 Mt at 0.28% Cu, 0.2 g/t Au, 2 g/t Ag and 43 g/t Mo
- Measured resources 444.9 Mt at 0.2% Cu, 0.1 g/t Au, 1 g/t Ag and 22 g/t Mo
- Indicated resources 523.2 Mt at 0.2% Cu, 0.1 g/t Au, 1 g/t Ag and 23 g/t Mo
- Inferred resources 79.9 Mt at 0.21% Cu, 0.1 g/t Au, 1 g/t Ag and 24 g/t Mo

Enhancing the economics of Aitik 36, the new concentrator will include a molybdenum

recovery circuit, providing Boliden with a new metal revenue source. Additionally, much of the stockpiled waste rock may become a commercial product in the future to be used in the construction of roads and as aggregate ballast. Attention is also focussing on producing products more suited to the construction industry from the waste rock mined in the future.

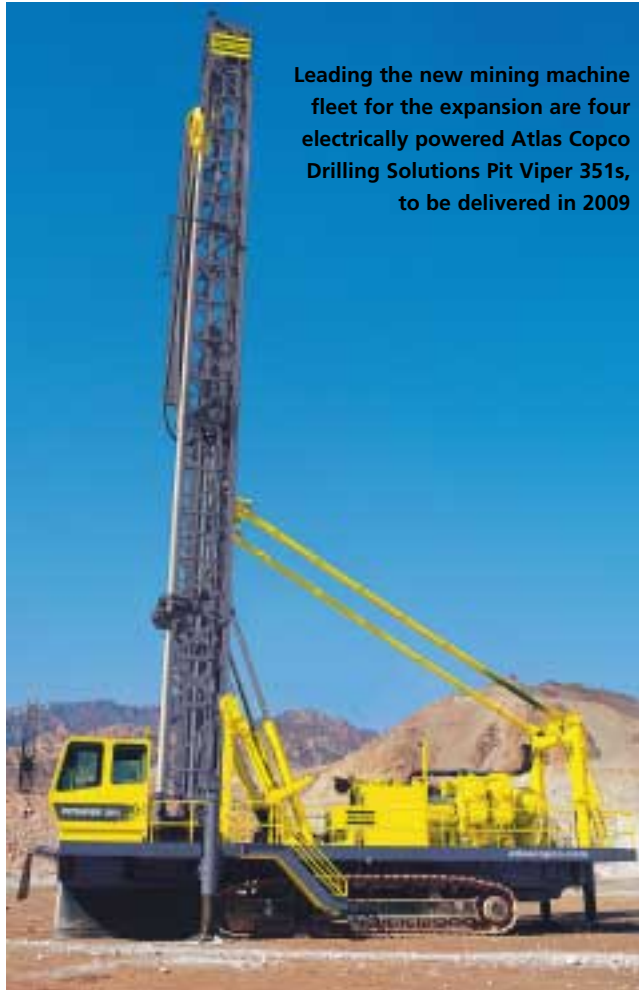
Boliden is an unusual company in that it has so much smelting capacity. It has seven mines in Sweden and Ireland and five smelters in Sweden, Finland and Norway. Output from the mines in 2007 was (in rounded figures) 333,290 t of zinc, 62,800 t of copper, 54,200 t of lead, 2.8 t of gold and 242 t of silver. The smelters that year produced 462,600 t of zinc, 314,900 t of copper, 70,000 t of lead, 15 t of gold and 380 t of silver. Aitik's ore production during the fourth quarter of 2007 was the highest for the year. The full-year figure, however, was lower than for 2006 due to lower grindability and the subsequent poorer mill throughput during the third quarter. As a result of the planned lower head grades and reduced ore production in the third quarter, copper production for the full year was down.

The average head grade of the ore mined, 0.32% Cu was lower during 2007 compared with 2006 (0.40%). Gold metal production was significantly lower in 2007 due to poorer head grades, in contrast to silver which enjoyed higher grades and metal production levels.

High capacity drilling

Leading the new mining machine fleet for the expansion are four electrically powered Atlas Copco Drilling Solutions Pit Viper 351s. Four will be delivered in 2009, with the first being commissioned in January, to start producing in February. With 56,700 kg of bit load and up to 107.6 m/min of air at 758 kPa, the 351 is one of the most advanced blasthole drills on the mining market. It is designed to drill from 269

ROC L8 used by contractor NCC for presplit holes. This is a special unit with wider and longer tracks than standard. It also has a raised superstructure. All this makes it a versatile machine. As well as presplit duties, it can be used for complete drill patterns when extra drilling capacity is needed for a fast pushback. Ranged behind this rig are two of the current Bucyrus blasthole drills



Leading the new mining machine fleet for the expansion are four electrically powered Atlas Copco Drilling Solutions Pit Viper 351s, to be delivered in 2009

to 406 mm diameter holes to depths of 19.8 m in a single pass. A standard carousel, which holds two additional 10.66 m rods, increases on-board depth capacity to 41.2 m.

The 351 cable feed system generates 56,700 kg of bit load and 31,752 kg of pullback. Retract speed is 42.7 m/min. Because of the cable system's light weight, the 351 can

operate a 'live' tower, allowing the tower to be raised and lowered without lowering the rotary head. An automated tensioning system adjusts the cable tension, eliminating down time for cable adjustment.

Aitik's Mine Manager, Patrik Gillerstedt, told *IM*: "What I like with the Pit Viper is the light mast which can be raised and lowered very fast. Our operators are in favour of the modern and up to date design of the cabs with joy stick operation and the RCS [Rig Control System] computerised control system."

Atlas Copco has successfully brought a CAN - Bus (Control Area Network) control system and automation to underground products and surface crawler drills. Drilling Solutions is using the same RCS technology on the large blasthole Pit Viper Series.

Dustin Penn, Product Manager, Large Blasthole Drills, explains that Atlas Copco has a proven automation track record including wireless control of underground drills, automated loading of LHDs, unmanned operation of an underground fleet and automated guidance of underground trucks.

"The PV-351 is using common components that have been used across other Atlas Copco RCS machines. This ensures knowledge throughout the worldwide service organization and good parts availability. The RCS also creates a platform for future automated functions on the ADS Pit Viper series of drills."

Drilling in ore, these new machines will continue with 311 mm diameter blastholes, as today, in 15 m bench heights with 2 m of sub



drilling. However, in waste the mine is considering using 203 mm blastholes. Gillerstedt explains that this should provide better fragmentation and therefore a better quality rock product for sale to the construction sector.

These Viper drills, and the Komatsu PC 5500 hydraulic face shovels hook up to the mine's 6,600 V power supply for power.

Further optimisation of blasting is under way. Over recent years the powder factor has been increased to 1.5 kg/t mined. Orica delivers a mixture of emulsion and ANFO into the holes. The mine sets the boosters, timing, etc. The mine is also doing a lot of work on different drill patterns (current standard is 7 m by 8 m) to accommodate different rock properties in different areas of the pit.

Contractor NCC uses three Atlas Copco ROC L8 drills on presplit holes and on a row of buffer holes between the presplits and the main blastholes. In February this year a new Roc L8 30 with aluminium feed was delivered, with another to come later in the year. These rigs use Secoroc DTH hammers – COP 54 or 64 units, with 3 m drill pipes.

The L8s drill 127-mm diameter holes at a rate of some 0.7 m/min. The L8 30 operates at high pressure (30 bar) and achieves the same penetration rate of 0.7 m/min with a 203-mm diameter hammer. That higher pressure, not unexpectedly, provides good clearing of rock chips.

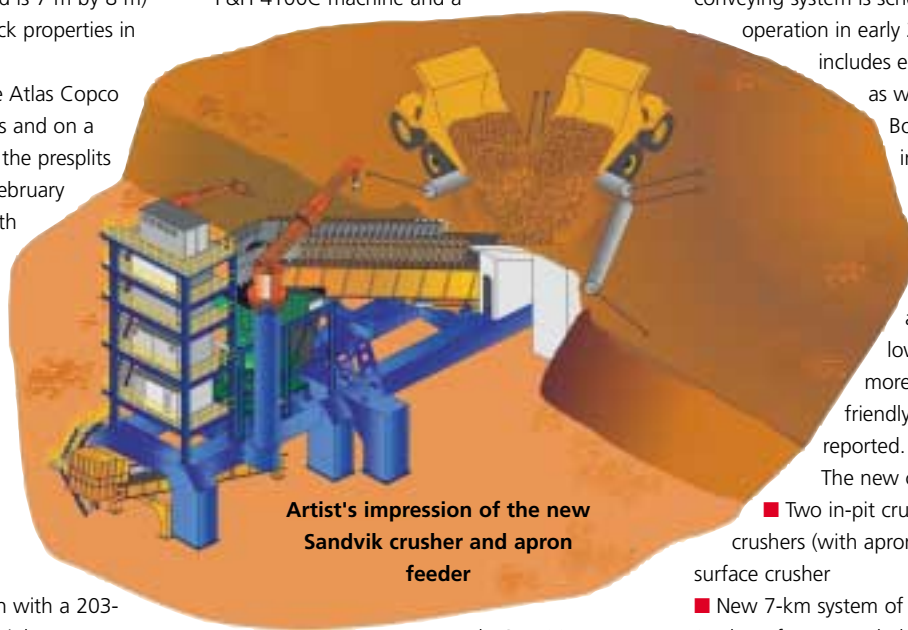
Expanded open pit

Pushbacks at the southeastern and northeastern ends and west side of the current pit will allow mining down to 600 m. Boliden is considering its options for new trucks (maybe 10) but they are likely to be electric drive and around 300 t capacity - probably Komatsu or the new Caterpillar units. Whatever is chosen, the mine will need fewer trucks because after expansion it will be using two in-pit crushers with a dedicated conveyor system hauling ore out of the pit. There is an existing crusher at the 165 m depth and the new Sandvik unit with apron feeder one will be installed at 285 m. The two will save thousands of kilometres of truck haulage as they save 300 m of vertical height from the haul. Far into the future, the plan is to phase out the 165 m crusher in about 2016, and around that time move the other down to the 315 m level.

Older units in the current truck fleet will be

retired, the eight MT 4000s definitely, and some of the current older Caterpillar fleet of four 789s will be converted to other duties – one each of the 789s becomes a water truck, a lowboy hauler for carrying drills and a road material hauler. There are also 11 793 B/Cs and six younger Cat 793Ds with many years of good service left in them.

The current loading fleet comprises two P&H 4100s, one Bucyrus 495 BII and a B-E 295, a fairly new Komatsu PC 5500 electrically powered (1,800 KW) hydraulic face shovel and, for mobility, two Cat 994 wheel loaders. Boliden plans to keep the 4100s operating along with the Bucyrus 495 and buy a new P&H 4100C machine and a



Artist's impression of the new Sandvik crusher and apron feeder

second PC 5500.

Komatsu Mining has a relationship of about 20 years with the mine, going back to Demag days when the first H485 shovel was delivered in 1989, and a second in 1991. The current PC 5500 electric drive front shovel has a 26 m³ bucket. The second is to be delivered in about the middle of this year.

The standard front shovel has a 28 m³. The 26 m³ bucket was chosen to accommodate heavy duty wear protection, to meet the heavy duty mining conditions at Aitik and the higher material density. Special options have been provided to ensure that steel structure and castings have sufficient impact value at -40°C and the material of construction of screws, bolts and electrical cables were selected for the -40°C ambient temperature. Preheating of hydraulic oil, gear oil, batteries and electrical cab base is provided to ensure start up after longer idle periods.

The auxiliary fleet comprises two Cat D10 dozers, three Cat 16H graders and five Cat 980G wheel loaders. Gillerstedt favours the latter units for cleanup around the excavators.

“They are quicker than the dozers and more efficient for cleanup,” he explained.

Trucks and shovels are controlled by Caterpillar's MineStar system, which has recently been upgraded to the 2.1.2 version.

In-pit crushing

Sandvik is supplying a complete in-pit crushing system, valued at some €125.5 million, consisting of two complete primary gyratory crushing stations as well as overland conveyors and feeders. The system will have a capacity of 8,000 t/h and will transport the ore 7 km, with the conveyor running underground for almost half of that distance. The new crushing and conveying system is scheduled to be put into

operation in early 2010. Sandvik's order includes engineering and erection as well as start-up services.

Boliden's decision to invest in a conveying system reduces the use of truck haulage and the system will provide higher availability, considerably lower running cost and be more environmentally friendly than trucks, Sandvik reported.

The new crushing set up will be:

- Two in-pit crushers - semi-mobile crushers (with apron feeders) - and one surface crusher
 - New 7-km system of conveyors, including 3.5 km of conveyor belts in underground drifts
- As the diagram of the new Aitik layout shows, belt conveyors will carry the ore out of the pit and feed to the new concentrator via a surface crusher facility and intermediate storage.

Contractor Bergteamet is driving the 2.8 km of conveyor tunnels, which will include two transfer stations, each 80-100 m long and about 20 m high. Final design of these stations is still to be completed. In general the conveyor tunnels are 9 m wide and 5.5 m high, but some sections reduce to just 35 m². There are also some service cross drifts to mine. The contract is due to finish at the beginning of 2009.

From the 285-m level in the pit, the first conveyor tunnel rises at a gradient of 1 in 10, changing to 1 in 7 for the final section to surface. Bergteamet is employing one Atlas Copco L2C Boomer jumbo (with COP 1838 drifters) and an E2C with 3038 drifters, each using 48-mm Secoroc SR50 ballistic button bits. Using 5.5 m drill steels they are drilling 5 m holes. There is also a scaling unit. Rock is



Komatsu Mining PC 5500 electric drive front shovel with a 26 m³ bucket. The second is to be delivered in about the middle of this year. The smaller bucket was chosen to accommodate heavy duty wear protection, to meet the mining conditions at Aitik and the higher material density. Special options have been provided to ensure that steel structure and castings have sufficient impact value at -40°C and the material of construction of screws, bolts and electrical cables were selected for the -40°C ambient temperature. Preheating of hydraulic oil, gear oil, batteries and electrical cab base is provided to ensure start up after longer idle periods

loaded out by a sub contractor using a Cat 980 wheel loader.

Sune Onnerlov, Bergteamet's Project Manager says the drill rigs are "working well", averaging 18 hours/day with a 55 m advance the best achieved so far in one week. He is looking for this to rise to 75 m/week. He says the main difference between the two rigs is the COP 3038 on the E2 which he describes as "a really powerful drill."

These jumbos are equipped with ABC Total with a computer that controls the movements of the booms and the feeds. They are moved between the holes by the computer as per sequence defined in the drill-pattern. The operator however has the possibility to take over the control at any time by moving the levers for that function. The Tunnel Manager software generates drill plans and follows up on the results.

Onnerlov explained to International Mining that they had been surprised at the large amount of water make into the development drifts that was hindering progress. At the time of IM's visit, the development crews had to use cartridge explosives for blasting because of the water. A charging truck, to be supplied by Kemit, was to be introduced, which would allow the use of emulsion explosives.

Shotcreting is difficult in these conditions and to make matters worse, it is acid water. Roof support relies on grouted Kiruna bolts which are placed by a special Sandvik Robolt brought in from the old Laisvall lead mine. Bergteamet is placing a lot of bolts, up to 5 m long in the transfer stations. Bergteamet will fully equip these conveyor tunnels. It is using a special tunnel-grade, steel fibre reinforced shotcrete.

Onnerlov is concerned about cavitation on the rock drills pistons and shanks due to the very aggressive water, which is worse in the summer months. One of the solutions being employed is to use plastic guttering to drain the water away.

To the plant

The conveyors deliver run of mine ore from the in-pit crushers to the surface crusher station and from there to the new concentrator, sited on a hill and able to use gravity to deliver to the tailings management facility. Surface crushing is primarily for ore from the future satellite pits.

Skanska has been contracted on Aitik 36 for project works including concrete structures for crushers and conveyors, two ore storage facilities, a service workshop as well as road and civil engineering work. The contract amount is about SEK460 million. The project is being carried out by Skanska Sweden's special unit for industrial construction, IME.

The concentrator will be based on cutting-edge technology and on results from large scale tests. Two of the largest grinding mills commercially available will replace today's five grinding mills. The new facilities will include:

- Two milling lines with a nominal capacity of 2,200 t/h - primary 22.5-MW mill, 11.58 x 13.72 m, with ring motor
- 26 x 160 m³ flotation cells
- Depyritisation flotation cells (reducing the acid generation potential of the tailings)
- Three pressure filters (replacing dryers and cutting dust emissions to zero)
- New water treatment system in operation in 2009
- New concentrate terminal in 2009
- Truck workshop in operation in 2010
- Welding shop in operation in 2015

Two completely new circuits in the new concentrator are to be the molybdenum recovery circuit and CIP circuit for gold recovery. Flotation recovers 40-50% of the gold but the CIP will significantly increase gold recovery. The molybdenum circuit can be turned on or off as prices dictate.

Metso Minerals will supply the grinding circuits in an equipment order worth some €39 million. Metso's order comprises two AG mills

and two pebble mills and the company will also supply engineering, erection and start-up services. The 11.58 m by 13.72 m AG mills will be the largest ever supplied by Metso Minerals.

Outotec won the contract to supply the complete flotation circuit for Aitik. Boliden had already ordered engineering services from Outotec for the same project. The total value of these contracts is approximately €25 million. Outotec's scope is this engineering and supply project comprises 52 flotation cells fully installed with auxiliary systems. The TankCell® units will feature the latest field-proven and patented FloatForce™ mixing technology developed by Outotec. The deliveries will be completed during 2009.

In addition to this flotation contract, Outotec is currently delivering a regrinding pebble mill for Aitik.

The metal concentrate produced at Aitik is railed to Boliden's Rönnskär smelter in Skelleftehamn. A new rail line will be built which will save the trucking of concentrate into the town of Gällivare and rehandling there. This line will also help the sales of construction rock.

A long life

Diamond drilling in the area began in 1957 and 272,000 m had been completed by November 2007. Exploration drilling between that date and 2001 totalled 108,000 m (39.7 % of the total).

Further into the future, there is great exploration potential for continued expansion of mine life. To the north across Lake Sakajärvi, Liikavaara Östra has 31 Mt of ore investigated and measured down to 200 m depth. There is potential for more ore below 200 m and potential in areas with increased copper head grades. To the west of Aitik, Salmijärvi contains 40 Mt, studied down to 120 m depth, but not at deeper levels. On the other side, Aitik Östra has 10 Mt confirmed down to 200 m, with potential for more at greater depth. The eastern edge of the Aitik orebody contains Cu-Au sulphide zones with high grades. Finally, sulphides in open pits to the north and south of Aitik were found by rock and moraine sampling in 2005-2006, and merit further exploration. **IM**