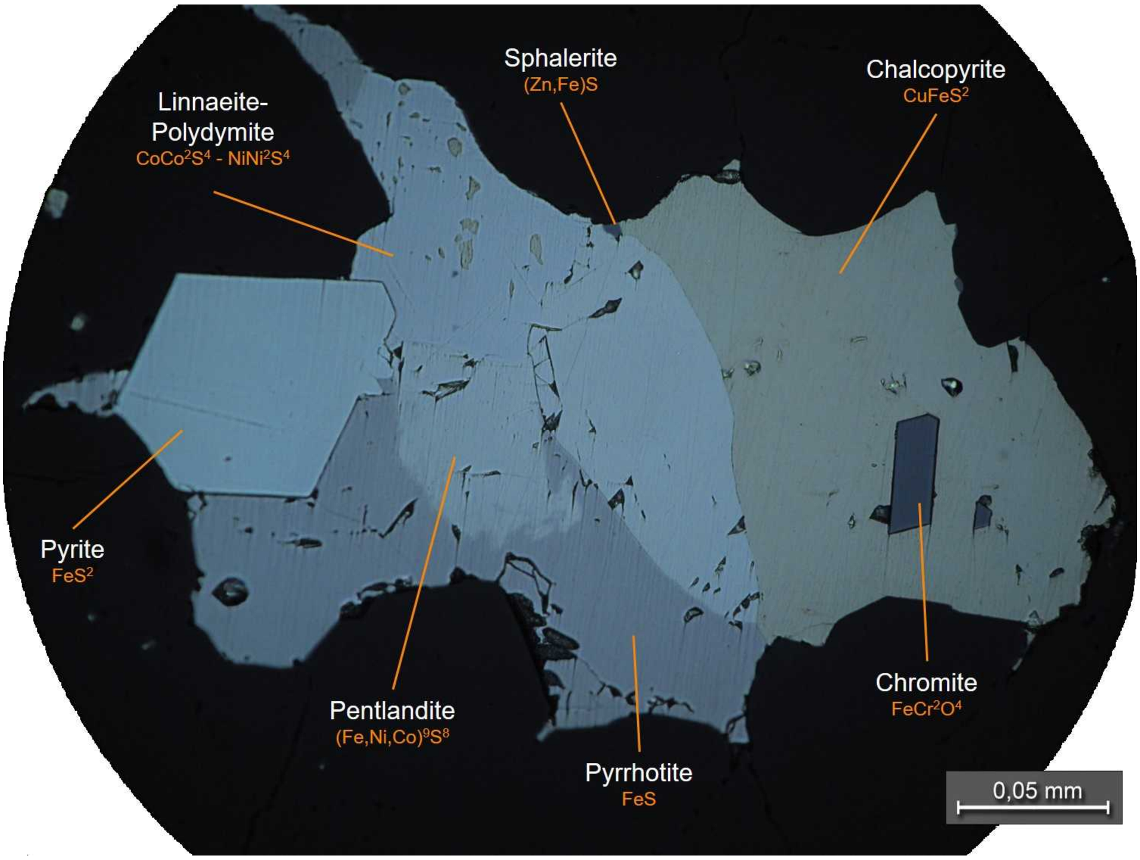
NEW BOLIDEN

Boliden Summary Report

Mineral Resources and Mineral Reserves | 2019

Kylylahti



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1 SUMMARY

Kylylahti Mineral Reserves and Mineral Resources at 31.12.2019 are represented in Table 1. Mineral Reserve is 0.50 Mt (million metric tonnes), a decrease of 0.83 Mt from previous year. Mineral Resource estimate was not updated due to the short life of mine. All Mineral Resource (measured, indicated, and inferred categories) as calculated per 31.12.2018 has been excluded from this report. There are no plans to convert any of the Mineral Resource into Mineral Reserve. The judgment is that it is not a reasonable prospect for eventual economic extraction. The Kylylahti mine is closing during 2020 and then to move any of the 2018 Mineral Resource into a Mineral Reserve will be a major step in the future.

Table 1: Kylylahti Mineral Reserves and Resources 31.12.2019

Classification	2019						2018					
	kt	Cu (%)	Au (g/t)	Zn (%)	Ni (%)	Co (%)	kt	Cu (%)	Au (g/t)	Zn (%)	Ni (%)	Co (%)
Proven Mineral Reserves	**392**	**0.73**	**1.08**	**0.33**	**0.24**	**0.18**	843	0.87	0.87	0.44	0.22	0.19
Probable Mineral Reserves	**110**	**0.32**	**1.77**	**0.11**	**0.27**	**0.10**	493	0.35	1.11	0.13	0.27	0.13
Total Mineral Reserves	***503***	***0.64***	***1.23***	***0.29***	***0.25***	***0.16***	*1 336*	*0.68*	*0.96*	*0.33*	*0.24*	*0.17*
Measured Mineral Resources							2 510	0.56	0.24	0.30	0.25	0.14
Indicated Mineral Resources							3 639	0.34	0.36	0.21	0.27	0.11
Inferred Mineral Resources							737	0.08	0.02	0.05	0.42	0.04
Total Mineral Resources							*6 886*	*0.39*	*0.28*	*0.22*	*0.28*	*0.11*
Note: Zinc is only recovered from M2 ore type. In other ore types nickel and cobalt is recovered instead of zinc. Mineral resource estimate was not updated for 2019.												

2 GENERAL INTRODUCTION

This report is issued annually to inform the public (shareholders and potential investors) of the mineral assets in Kylylahti held by Boliden. The report is a summary of internal / Competent Persons' Reports for Kylylahti. Boliden is changing reporting standard from Fennoscandian Review Board (FRB) to the Pan-European Reserves and Resources Reporting Committee (PERC) "PERC Reporting Standard 2017". The PERC Reporting Standard is an international reporting standard that has been adopted by the mining associations in Sweden (SveMin), Finland (FinnMin) and Norway (Norsk Bergindustri), to be used for exploration and mining companies within the Nordic countries.

The PERC standard has clearly defined requirements on reporting and on Competent Persons. Boliden is currently in the process of updating procedures and many of the reports and estimations summarized here are compiled according to the previous standard. We consider this data accurate and reliable. The process of creating PERC compliant estimations, studies and reports for all Projects and Mines is underway.

2.1 Pan-European Standard for Reporting of Exploration Results, Mineral Resources and Mineral Reserves – The PERC Reporting Standard

PERC is the organisation responsible for setting standards for public reporting of Exploration Results, Mineral Resources and Mineral Reserves by companies listed on markets in Europe. PERC is a member of CRIRSCO, the Committee for Mineral Reserves International Reporting Standards, and the PERC Reporting Standard is fully aligned with the CRIRSCO Reporting Template.

The PERC standard sets out minimum standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves in Europe.

2.2 Definitions

Public Reports on Exploration Results, Mineral Resources and/or Mineral Reserves must only use terms set out in the PERC standard.

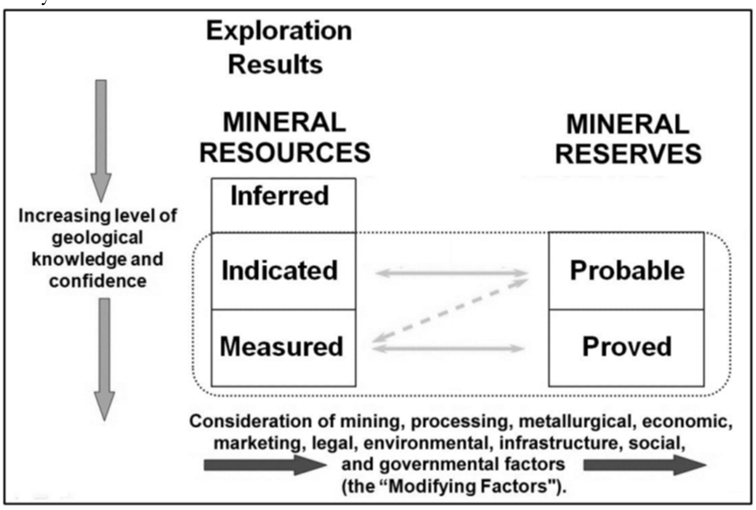


Figure 2.1. General relationship between Exploration Results, Mineral Resources and Mineral Reserves (PERC 2017)

2.2.1 Mineral Resource

A Mineral Resource is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction.

The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling.

2.2.2 Mineral Reserve

A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource.

It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.

2.3 Competence

Multiple participants have been involved and contributed to this summary report. Roles and responsibilities are listed in Table 2.

Table 2. Contributors and responsible competent persons for this report.

Description	Contributors	Role
Compilation of this report	Markus Malmberg	Senior Mine Planning Engineer
Assisting compilation of report	Peter Svensson	Manager Field Exploration
Mineral Resource	Gunnar Agmalm	Competent Person
Mineral Reserve	Thomas Hedberg	Competent Person
Other contributers		
Geology	Juha-Matti Kekki	Project Geologist
Exploration	Teemu Törmälehto	Head of Section Exploration
Resource Estimation	Gunnar Agmalm	
Reserve Estimation	Markus Malmberg	
Mineral Proscessing	Timo Suominen	Metallurgist
Mining	Markus Malmberg	
Environmental and legal permits	Sanna Juurela	Senior Geologist
	Kari Janhunen	Manager of HSE
Financial	Antti Eskelinen	Business Unit Controller

3 KYLYLAHTI

3.1 Project Outline

Kylylahti is a polymetallic Cu-Au-Zn-Ni-Co(-Ag) underground mine, where ore is mined between 150 and 810 meters below surface. The ore is processed at the Luikonlahti mill, 43 km from the mine by road.

The mined out tonnage in 2019 was 681 kt. 2019 production is shown in Table 3. Copper remains to be the most important metal followed by gold on the second place, but the significance of cobalt and nickel has also increased.

Kylylahti production 2019						
	Tonnage (kt)	**Cu (%)**	**Au (g/t)**	**Zn (%)**	**Ni (%)**	**Co (%)**
Mined	681	0.76	0.88	0.37	0.23	0.18
Milled	716	0.74	0.86	0.35	0.23	0.18
Note: Zinc is only recovered from M2 ore type. In other ore types nickel and cobalt is recovered instead of zinc.						

Table 3: Kylylahti mine and mill production 2019.

3.2 Major changes

Kylylahti Mineral Reserve decreased 0.83 Mt to 0.50 Mt. Mining accounted for 0.68 Mt decrease and 0.10 Mt ore was lost due to cobalt price decrease.

The Kylylahti Mineral Resource has been excluded from this report, since there are no plans to convert any on the Mineral Resource into Mineral Reserve. The judgment is that it is not a reasonable prospect for eventual economic extraction.

3.2.1 Technical studies

No major technical studies were made during the year.

3.3 Location

Kylylahti mine is located in Polvijärvi municipality, eastern Finland about 42 km northwest of the city of Joensuu and 2 km west of the local center of Polvijärvi (Figure 2). Mined ore is transported by road 43 km west to Boliden Kylylahti's Luikonlahti mill (Figure 3).

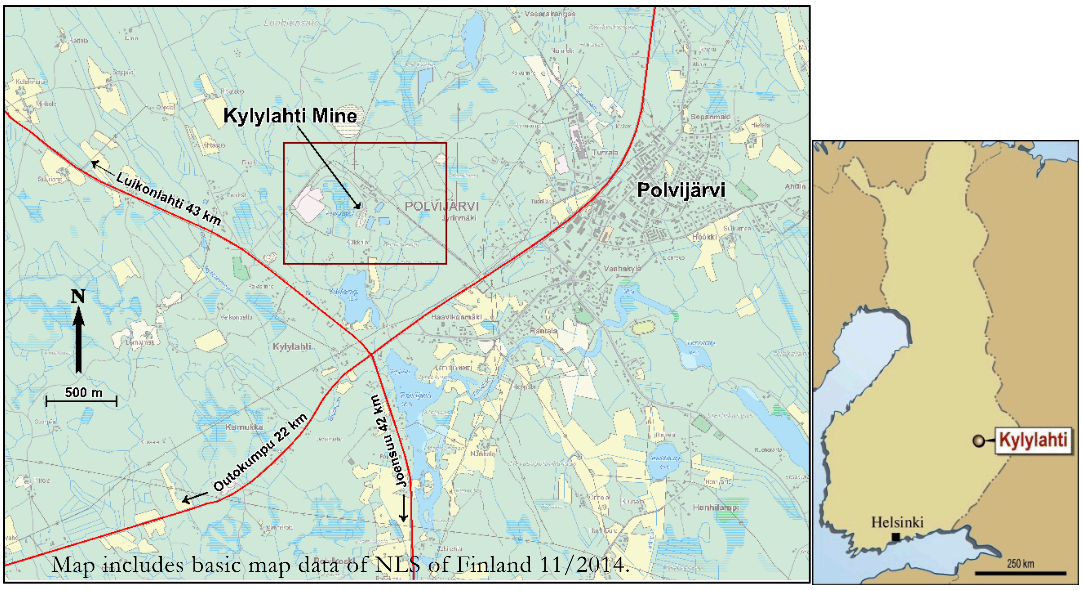


Figure 2: Location map for the Kylylahti mine.

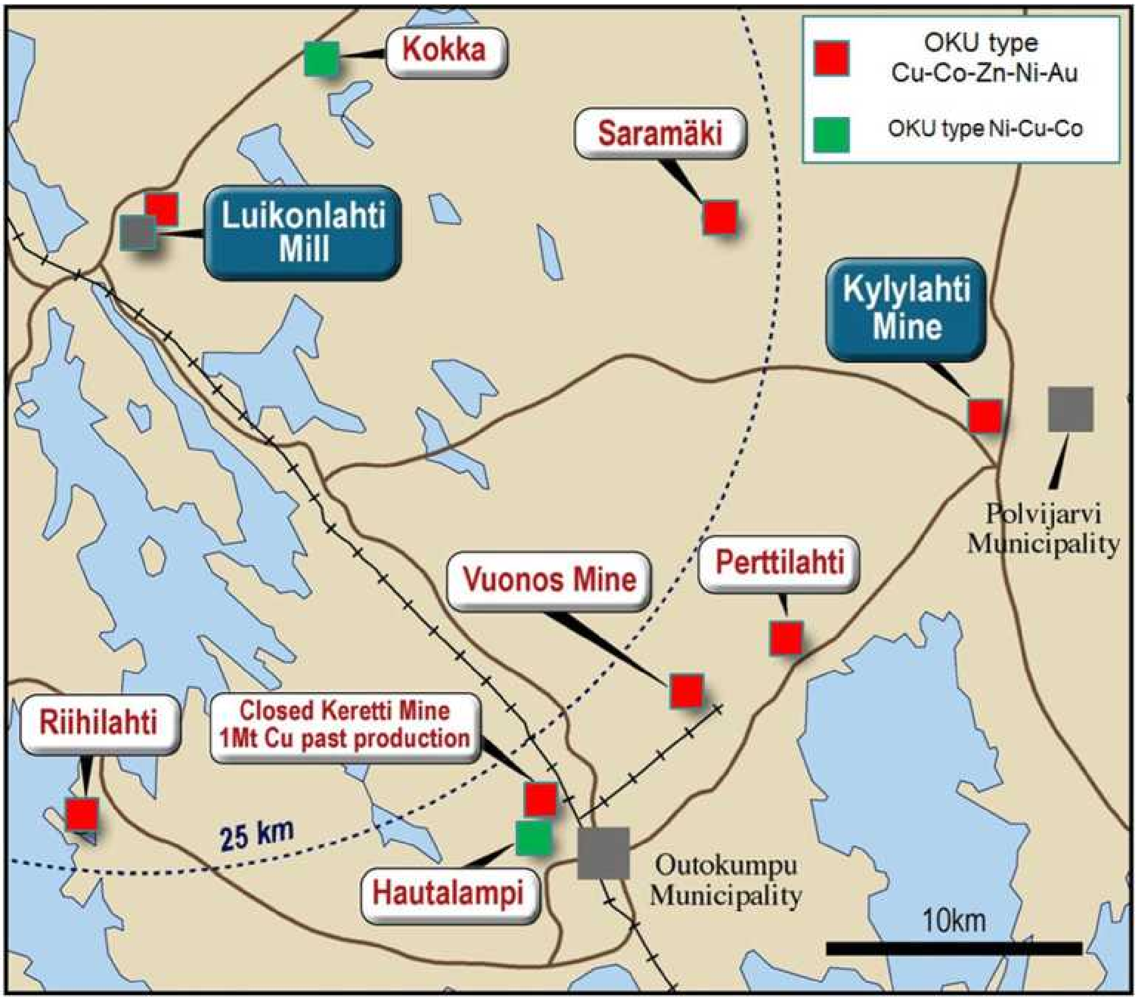


Figure 3: Map of the Outokumpu area showing the location of the mine and mill.

Sulphide concentrates, containing payable copper, gold, zinc and silver, are further trucked to Boliden Mineral AB's Kokkola and Harjavalta smelters located respectively about 360 and 470 km to the west and southwest of Luikonlahti mill. Nickel concentrate containing nickel and cobalt is trucked to Kokkola and shipped to external customer.

3.4 History

Kylylahti yearly production is presented in Table 4.

Table 4: Kylylahti historic production.

Kylylahti yearly production			Milled grades				
	Mined tonnage (kt)	Milled tonnage (kt)	Cu%	Au g/t	Zn%	Ni%	Co%
2011	2						
2012	380	369	1.44	0.57	0.59	0.14	0.23
2013	609	605	1.64	0.66	0.69	0.16	0.24
2014	671	669	1.74	0.62	0.64	0.15	0.26
2015	719	733	1.72	0.76	0.70	0.16	0.28
2016	816	797	1.63	0.85	0.64	0.17	0.27
2017	766	809	1.30	1.07	0.53	0.20	0.26
2018	791	785	1.01	0.98	0.41	0.21	0.20
2019	681	716	0.74	0.86	0.35	0.23	0.18
Total	5435	5483	1.39	0.82	0.56	0.18	0.24

A short summary describing the discovery and development of Kylylahti is presented in Table 5.

Table 5: Major milestones in the Kylylahti project.

1984	Discovery of the Kylylahti deposit by Outokumpu Mining.
2004	Vulcan Resources (Altona Mining Ltd) acquisition of Kylylahti deposit.
2005-2008	Deep drilling of the Kylylahti deposit.
2008	Feasibility study completed.
2010	Acquisition of the Luikonlahti mill and board decision on Kylylahti mine execution.
2010	Construction of the Kylylahti mine started.
Feb 2012	First copper concentrate.
Jul 2012	Ramp-up completed. Kylylahti mine and Luikonlahti mill operating at designed rate 550ktpa.
Jan 2014	Milestone of 1 Mt of ore mined achieved at Kylylahti
Oct 2014	Boliden acquisition of the Kylylahti mine and Luikonlahti mill.
Apr 2015	First Nickel concentrate produced from hanginwall Au-ores.
Oct 2016	First Knelson gold concentrate produced from hanginwall Au-ores.
Oct 2016	Milestone of 3 Mt of ore mined achieved at Kylylahti
April 2018	Feasibility study's LOM production 4200kt of ore mined
2018	Commercialization of nickel and cobalt concentrates completed
May 2019	Milestone of 5 Mt of ore mined achieved at Kylylahti

3.5 Ownership and Royalties

Both Kylylahti mine and Luikonlahti mill are 100% owned and operated by Boliden Kylylahti (Boliden). Mondo Minerals B.V. (Mondo) owns a mining license (Vasara) to north of the Kylylahti licenses. Boliden and Mondo have a co-operative agreement which allows Boliden to explore and mine base metals from Mondo's Vasara mining license. Equally Mondo has a right to explore and exploit talc formations on Kylylahti mining license. (Figure 4).

The land area footprint affected by mining and associated activities is estimated to approximately 890 ha in Kylylahti and 1500 ha in Luikonlahti. Numbers are based on current practice in environmental permitting process including 500 m buffer zone around the mining licenses and adjacent, relevant lakes and rivers (Polvijärvi lake and Viinijoki river in Kylylahti and mixing zone towards the Rauanjoki river south of Luikonlahti). Boliden owns surface right only for mining license areas i.e. 670 ha. Because of the close location of the Polvijärvi center to the Kylylahti mine, a large part of the Kylylahti footprint area of the surrounding land is populated. The remaining land area is mainly used for forestry and agriculture. In Luikonlahti it is vice versa, i.e. the majority of the footprint area is used for forestry.

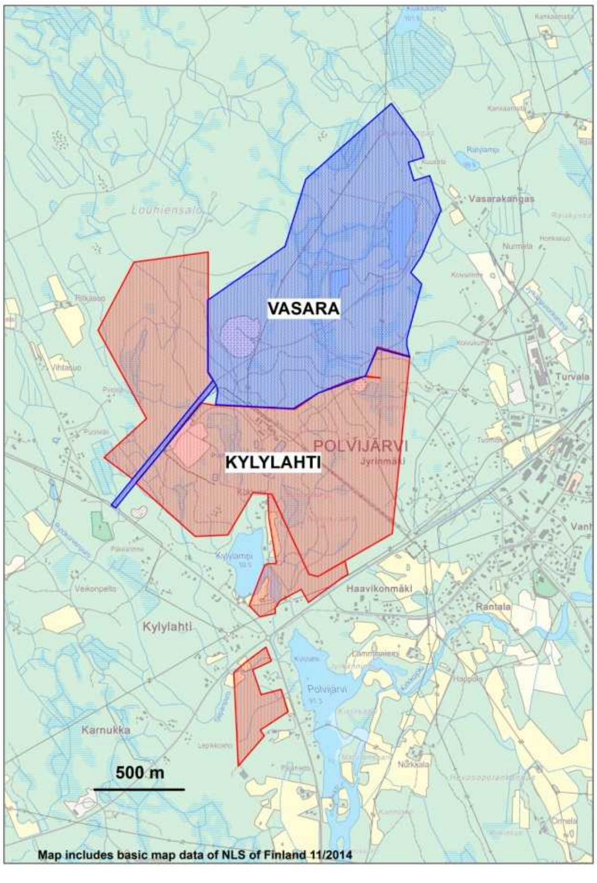


Figure 4: Map showing Kylylahti (Boliden) and Vasara (Mondo) mining licenses.

According to the Finnish Mining Act an annual excavation fee has to be paid for the Kylylahti mining area landowners (mining area does not include auxiliary areas). The excavation fee is divided into two criteria: 1) fixed hectare based fee that is 50€ per hectare and 2) 0.15% of the sales revenue of the concentrates produced during the year.

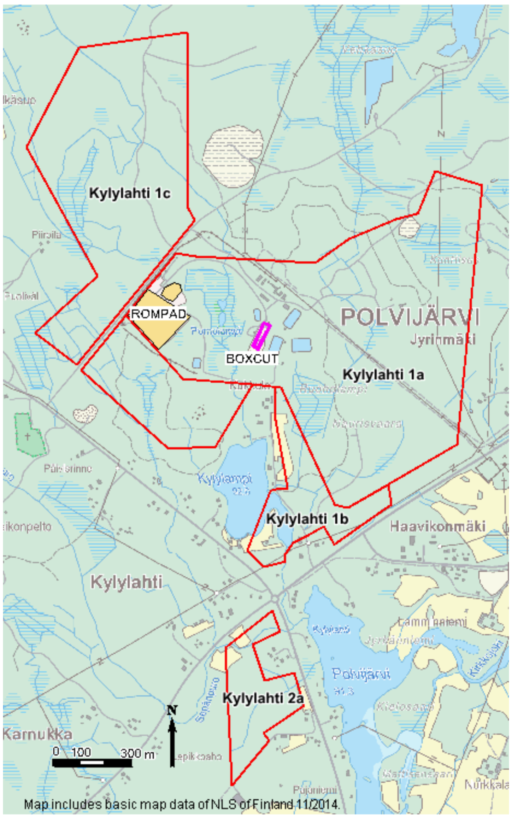
3.6 Permits

3.6.1 Mining concessions

The Kylylahti mining block consists of 4 licenses totaling 180 ha. Luikonlahti mill site also consists of 4 licenses totaling 490 ha (Table 6, Figure 5). All mining concessions are 100% owned by Boliden.

Table 6: Mining concessions at Kylylahti.

Concession	Area (ha)	Expiration date
Kylylahti 1a	92	
Kylylahti 1b	12	
Kylylahti 1c	67	
Kylylahti 2a	10	
Luikonlahti 553	377	
Petkel I + II	17	
Petkellahti	61	
Luikonlahti KL2013:0003	33	15.10.2023
Total	**669**	



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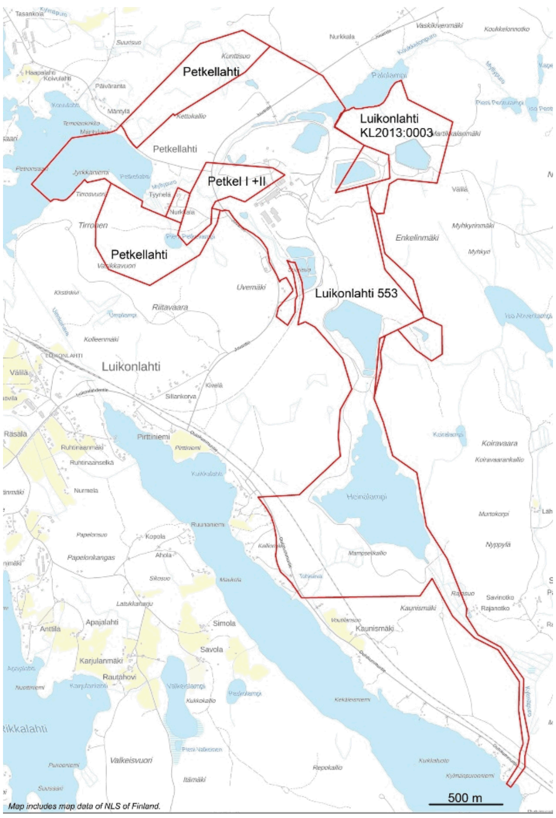

b)

Figure 5: a) Map showing Kylylahti mining licenses. b) Map showing Luikonlahti mining licenses.

3.6.2 Exploration tenements

In addition to mining concessions Boliden is the holder of 4 exploration tenements totaling 324 ha within the Kylylahti district (Table 7, Figure 6). Tenements are located above the depth extensions of the Kylylahti formation. All the tenements are valid until 2020. Notable is that the permit Kylylahti 2-4 which is located closest to the interpreted depth extension of the Kylylahti deposit has option only for one year extension after the current expiration date. All the permits are 100% owned by Boliden.

Table 7: Boliden held exploration tenements in the Kylylahti area.

Tenement	Area (ha)	Expiration date	Age at expiration (yrs)
Kylylahti 2-4	147	2020-08-05	14
Polvikoski	171	2020-09-03	11
Kylylahti 6	6	2020-10-15	11
Kylylahti 7	2	2020-04-01	4
Total	**326**		

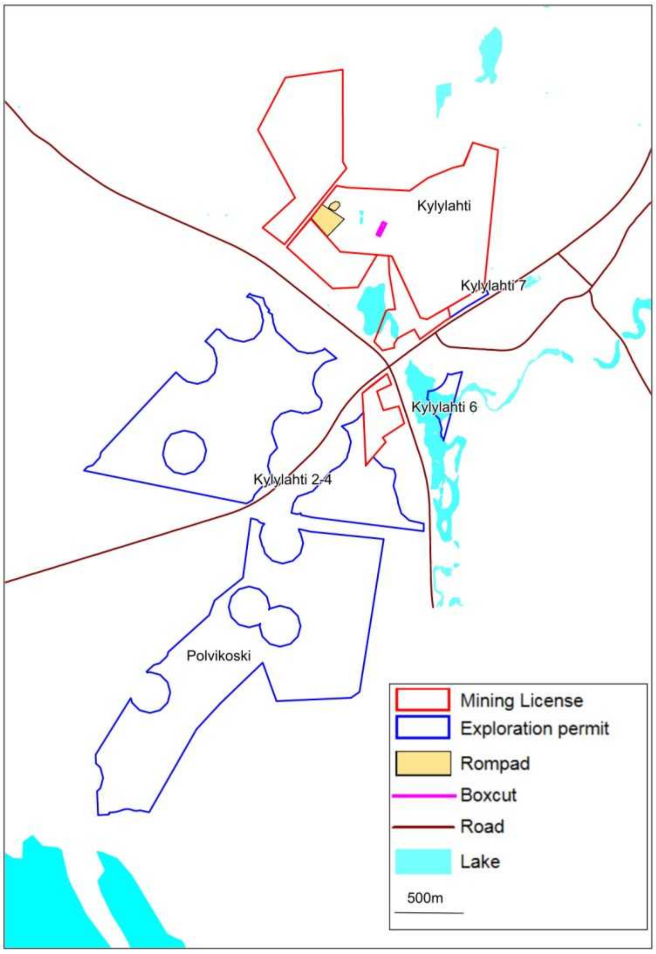

Figure 6: Map showing Boliden held exploration tenements in the Kylylahti area.

3.6.3 Environmental permits

Boliden holds and maintains all of the necessary environmental permits for mining and concentrating the Kylylahti deposit. Current permit regulations allow for the mining and concentrating of up to 800 ktons of ore per year. Kylylahti and Luikonlahti environmental permits were reviewed in 2016 and both are valid.

3.7 Geology

3.7.1 Regional geology

Outokumpu mining camp is located in eastern Finland within the North Karelia Schist Belt (NKSB). In the east and northeast, NKSB is bordered by Archean Karelian craton. In southwest the delimiting units are Paleoproterozoic island arc complexes accreted by Svecofennian orogeny.

The NKSB itself consists dominantly of folded and imbricated metasedimentary sequences representing two major tectonic-stratigraphic units. The older, 2.5-2.0 Ga, Sariola and Jatuli sequences comprise autochthonous, shallow-water cratonic to epicratonic metasedimentary deposits resting discordantly on the Archaean gneissic basement (Kohonen & Marmo 1992). The younger, 2.0-1.90 Ga, Kaleva sequences contain mainly deeper water turbidite deposits. Lower Kaleva rocks are considered autochtonous, but most voluminous Upper Kaleva rocks, that surround Kylylahti on all sides, are of allochtonous origin with depositional age of 1.95 – 1.92 Ga (Lahtinen et al. 2010). Upper Kaleva rocks were thrust over onto current location from direction that now lies in west 1.92 – 1.87 Ga ago (Peltonen et al 2008).

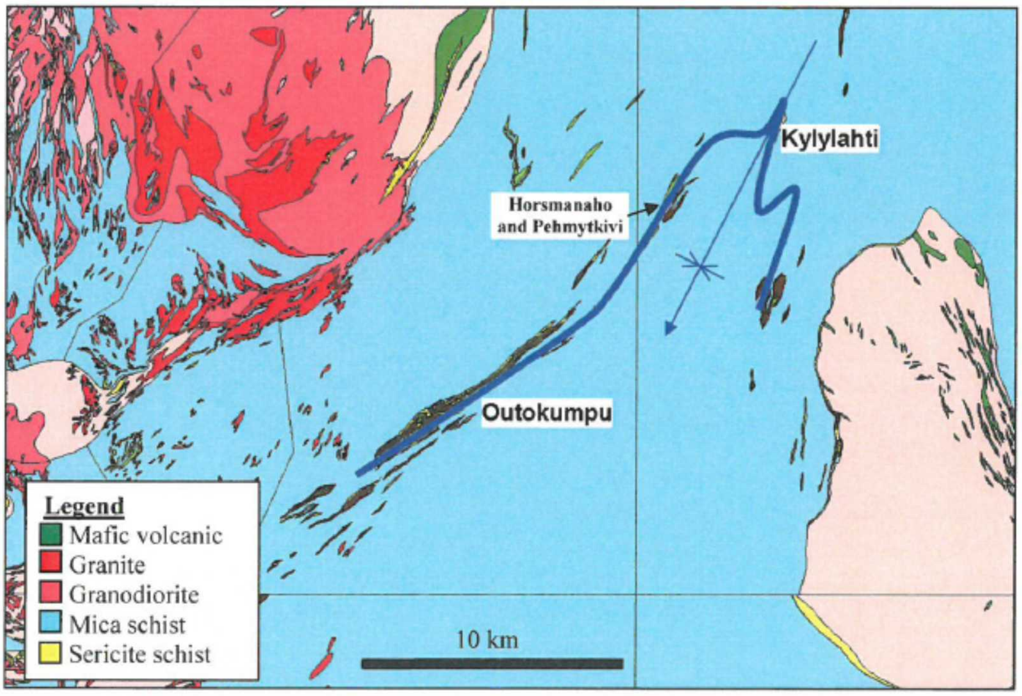

Figure 7: Geology plan showing the location of the Kylylahti deposit in the nose of the regional synform that hosts the Outokumpu district. Blue lines show simplified trace of the synform.

3.7.2 Kylylahti geology

Kylylahti is a polymetallic sulphide deposit featuring a 1.5 km long, north-northeast elongated group of lenses with a sub vertical attitude, that plunges from surface to the south southwest at approximately 30 degrees. The mineralized lenses have an average sub vertical height of approximately 150 m. Each lens has width ranging from 2 to 60 meters.

The hanging wall of Kylylahti deposit is an ophiolithic mantle fragment thrust onto place with the Upper Kaleva rocks. Mostly this once metaperidotitic ophiolite consists of serpentinite, but has later altered on the sides into talc-carbonate, skarn and quartz-sulphide rocks. These serpentinites, along with its alteration products, form a distinctive association (the Outokumpu Association or Outokumpu assemblage). This rock assemblage is almost thoroughly crosscut by mafic dykes appearing as chlorite schists and less altered metagabbros. These complexly altered ultramafic and mafic rocks nowadays occur as pods or lenses enclosed in the footwall black schists belonging to Upper Kaleva.

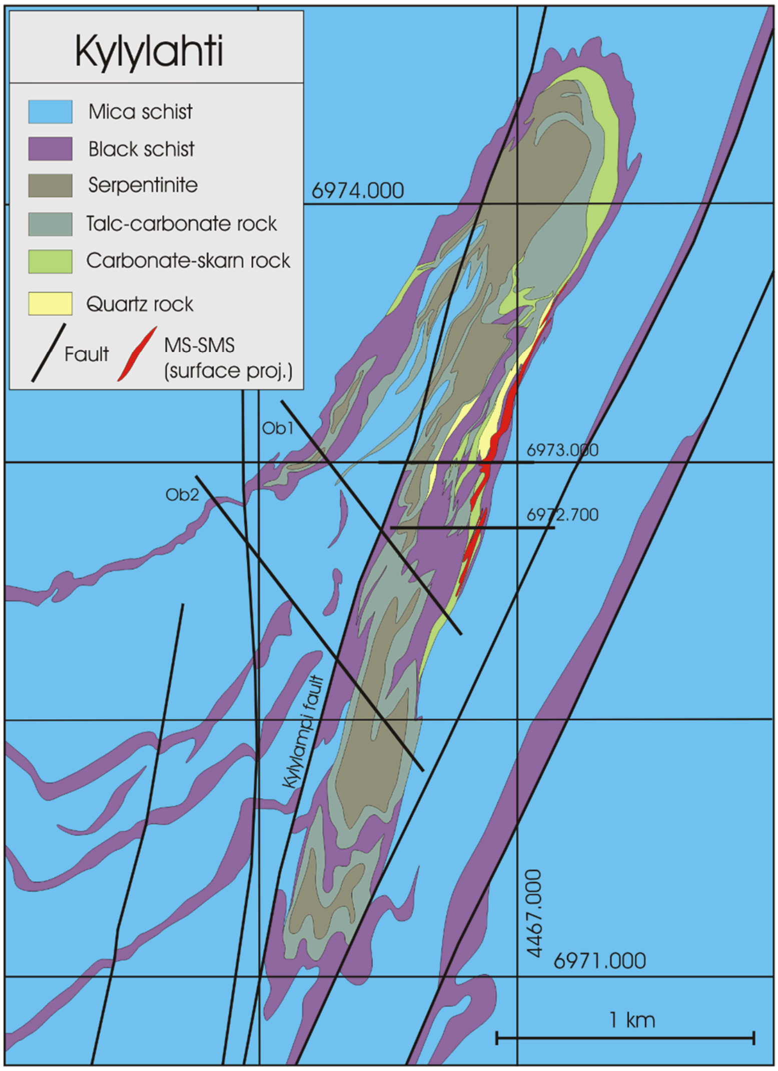

Figure 8: Kylylahti complex, showing surface projection of the massive-semimassive sulphide mineralization. Picture from Kontinen et al. (2006).

3.7.3 Kylylahti mineralization

In Kylylahti, the Outokumpu assemblage, along with the Upper Kaleva rocks are folded into tight synformal fold structure, with the mineralisation located along the near vertical eastern limb. Here, along or close to the carbonate-skarn-quartz rock to black schist interfaces, two main types of Co-Cu-Zn sulphide mineralization are present:

1) semimassive-massive sulphide lenses
2) sulphide disseminations in the carbonate-skarn-quartz rocks immediately paralleling the massive-semimassive lenses.

The semi-massive mineralisation comprises 25% to 60% sulphide. Mineralogy wise this mineralization type consists of predominantly pyrrhotite, pyrite and chalcopyrite, with subordinate local accumulations of cobalt-rich pentlandite, sphalerite, cobaltite and gold. It ranges in thickness from 5 m up to 50 m.

Structurally, semi-massive mineralisation at Kylylahti occurs in three elongated lenses, which strike to the northeast, dip near vertically to the northwest and plunge at between 25° and 40° to the southwest. The total length of the mineralised corridor is defined to approximately 1.5 km. Lenses are named the Wallaby, the Wombat and the Gap.

The semi-massive zone grades sharply into the disseminated ore over one to two meters, although isolated pods of semi-massive mineralisation may occur entirely within the disseminated zone.

The disseminated zone, situated at the hanging wall, contains medium to coarse grained sulphides (5% to 25% sulphides) and veinlets, with pyrrhotite predominating and lesser amounts of chalcopyrite, pyrite, cobalt-rich pentlandite, sphalerite and linnaeite-polydymite. Disseminated zones host Cu-dissemination ($0.4<Cu<1.0$) and Co-dissemination ($Cu<0.4\%$ and $Co>0.1\%$) domains. These two domains within the disseminated zone are the main domains hosting 'NiCo'-ores. Mafic dykes crosscut most of the disseminated zone.

The disseminated zone is locally gold-rich. Three distinct Au-domains can be identified: Au-Cu-dissemination, Au-Ni-dissemination and Au-Cu-Ni-dissemination. All gold-bearing zones have the Outokumpu assemblage skarn and quartz rocks as host rocks.

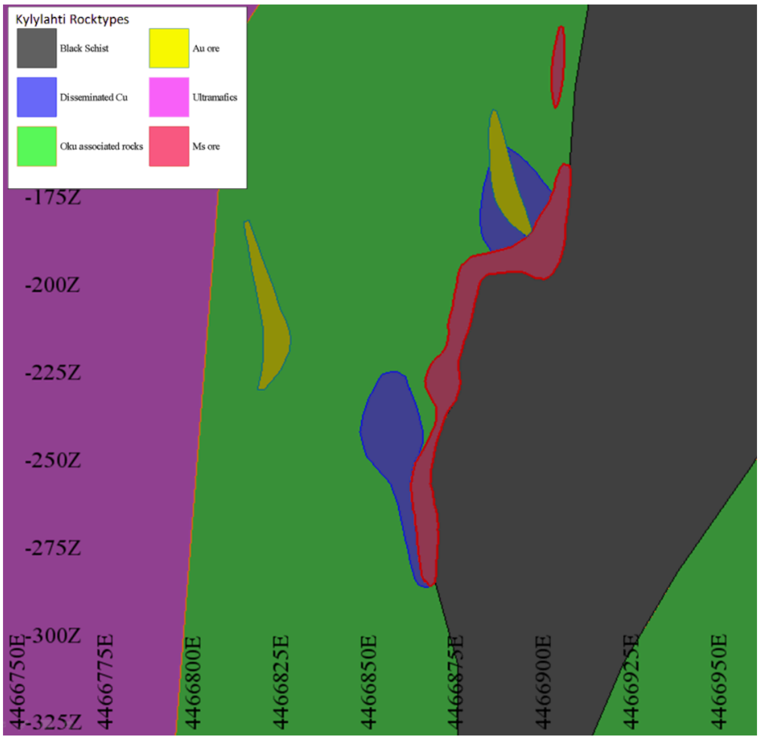

Figure 9: East-west cross-section 6972 995mN showing main geological rock types of Kylylahti formation and location of Kylylahti ores at Wallaby elevations.

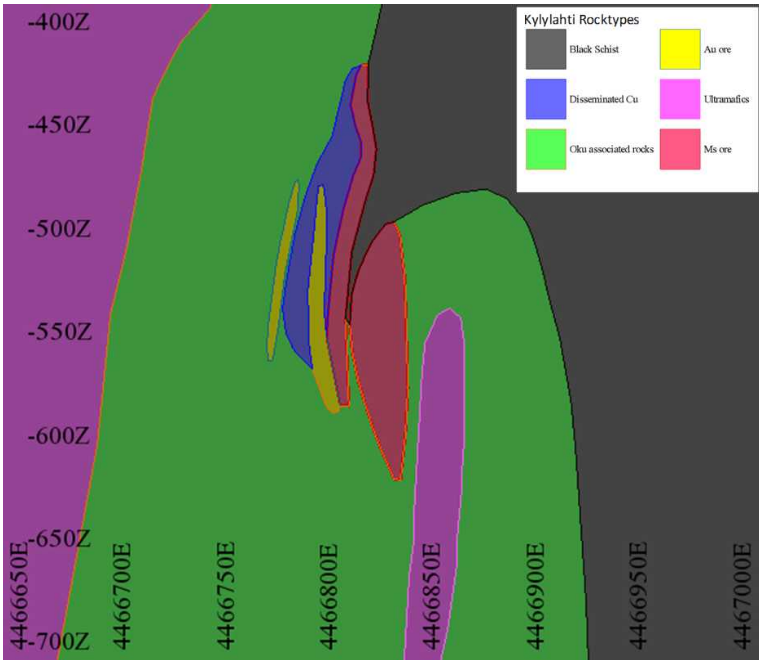

Figure 10: East-west cross-section 6972 935mN showing main geological rock types of Kylylahti formation and location of Kylylahti ores at Wombat elevations.

The Outokumpu-style deposits are currently thought to have formed due to complex multiphase processes involving remobilisation of copper-cobalt-zinc sulphide rich rocks deposited on the ancient sea floor and their interaction with nickel sulphide rich rocks within the Outokumpu assemblage. (Kontinen et al. 2006).

3.8 Drilling procedures and data

3.8.1 Drilling and sampling techniques

The deposit was sampled using diamond drillholes and face samples of the underground development. 2019 production drilling was performed by drilling contractor Nivalan Timanttikairaus Oy and exploration drilling by Arctic Drilling Company. All drilling was supervised by Boliden personnel. All the drillholes were logged for geology and sampled by Boliden personnel. Face sampling lines have been laid out horizontally and perpendicular to ore contacts and sampled by Boliden personnel.

3.8.2 Downhole surveying

Collar surveys for surface drill holes are dominantly done by a DGPS instrument with an accuracy of 10-50 cm. Underground collars are picked up by a Boliden surveyor using tacheometer instrument with an accuracy of 10 cm. Face samples are located using underground pickups of the face cuts. The accuracy of face sample collar locations is 50 cm.

The current practice is to survey downhole deviation for all the drillholes that are longer than 50 m. Maxibor measurements were used for production downhole surveying and gyro for both underground and surface exploration drill holes. Short underground holes were surveyed for dip and azimuth by tacheometer at collar point.

3.8.3 Sampling

Approximately 50% of the production diamond core was cut to half core before submitting to assaying and 50% was assayed as full core. Face samples were collected as chip samples using rock hammers at predominantly 1-meter intervals. Sample breaks match geological contacts.

Diamond core sample preparation is done by crushing the whole sample, splitting the sample by riffle splitter to 1000 g and pulverizing the 1000 g subsample. Face sample preparation is done by crushing the whole sample, splitting by riffle splitter to a subsample size of 150 g and then pulverizing the whole subsample. Industry best practice procedures are followed in the sample preparation for diamond core and face samples. Core duplicates and check assay repeats are systematically assayed to ensure the quality of sampling and subsampling.

Core losses are recorded as an individual interval on the core logging sheets and are not included in sampling. Core recovery is regarded to be high in Kylylahti drilling and exceeds 99%. Face sample chips are collected and a representative amount is recovered to assaying.

All the exploration drill holes have been cut to half core and prepped similar way as production drill core.

3.8.4 Logging

All diamond core and face samples are geologically logged. Geological logging contains all the required detail for defining geological and ore boundaries and is appropriate for resource estimation. Logging of the diamond core records geological unit, lithology, texture, grain size, sulphides and sulphide textures. All core is photographed. Logging of the face samples records geological unit and lithology. In addition about 25% of the diamond core is also geotechnically logged.

3.8.5 Density

Bulk densities have been measured using the common water immersion method to measure dry densities from diamond core samples. The bulk density database covers about 40% of the assay database representing all domains with adequate density. Bulk density has been estimated into parent blocks using an ordinary kriging estimation method.

3.8.6 Analysis and QAQC

Production drill holes were either prepped by Boliden personnel in Polvijärvi logging facilities and assayed in internal Luikonlahti laboratory for base metals by Boliden personnel or prepped and assayed in ALS laboratories. Gold was always assayed in ALS. Face samples were always prepped in Polvijärvi logging facilities and assayed in Luikonlahti for base metals and for gold in ALS. Check duplicate samples were taken in 1:30 ratio and assayed in ALS for original Luikonlahti assays and in Luikonlahti for original ALS assays. All the exploration drill holes have been prepped and assayed in ALS for all the elements. Duplicate check assay samples has been collected also for exploration samples.

Production diamond drilling is assayed using aqua regia digestion and ICP-MS finish for base metals and additional elements (Cu, Co, Ni, Zn, S, Fe and Ag) in ALS and by XRF in Luikonlahti. Only a fraction of all the diamond hole samples have been assayed in Luikonlahti using XRF. Face samples are assayed using an aqua regia digestion and ICP-MS finish. Gold assaying is always done by fire assay. Aqua regia digestion is a partial method for nickel and a total method for other base metals. For the style of Kylylahti copper-gold mineralization this method is considered to be appropriate. Sulphur exceeding 10% was further assayed using total sulphur method LECO.

Certified Reference Materials, blanks and duplicates are inserted in sample batches as per QAQC procedures. Duplicates are inserted in a 1:20 ratio and standards and blanks are inserted in a 1:20 ratio. QAQC samples are monitored on a batch-by-batch basis and samples in each failed batch are reassayed. QAQC performance is also monitored and reported on a monthly basis; no biases and inaccuracies have been observed.

Exploration samples have been assayed using both aqua regia and four-acid for multielements and fire assay for gold. Similar QAQC procedures have been followed.

3.9 Exploration activities and infill drilling

In 2019, only one exploration campaign was carried out in Kylylahti project. During 2016 – 2018, Kylylahti mine project participated into collaborative seismic project between the University of Helsinki, the Geological Survey of Finland, and the Institute of Geophysics at the Polish Academy of Sciences. Project was called CG-MIN project and aimed develop cost-effective geophysical seismic imaging techniques for supporting deep mineral exploration in Europe. As a result of the project, one interesting deep reflector was interpreted straight beneath the known Wombat massive ore body.

For 2019, drill-testing of this reflector was the only exploration target. The reflector was thought to be caused by the contacts between the mica and the black schist, indicating the bottom of the Kylylahti synform. However, due to the interesting location of the reflector, it was decided to test it.

Drilling was carried out from the mine at -580z drill cuddy. The 750-meters long hole was successfully reached into interpreted reflector. Drilling showed the strongly folded variations between mica and black schists, confirming the original geological model. After the drilling was completed, an on-hole magnetic survey was carried out. Survey pointed out a similar weak anomaly as the one seen in the upper contact which is caused by black schists.

Infill drilling was carried out in two separate programs. Total underground infill drilling was 3670 meters in 2020.

3.10 Mining methods, mineral processing and infrastructure

3.10.1 Mining methods

The main mining methods used in Kylylahti are transverse and longitudinal open stoping (or longhole stoping) with cemented rock fill (CRF) and/or waste rock used as backfill. Transverse stoping is used in the wide parts of the orebody and longitudinal stoping in the narrow parts. The typical spacing between production levels is 30 m. Due to the gentle dip of the orebody, stoping in the main production areas have started from the bottom at the northern end of the orebody and advanced upwards (see Figure 16). Smaller production areas are located at the top of the orebody, and ore pillars have been left below the levels where mining has started. Most of the ore in the horizontal pillars will be mined before closing the operation. Some stopes are located near or within existing access tunnels and these will be mined out at the end of mine life.

Transverse stoping advances in two stages. First, a 10 m wide block perpendicular to the orebody, so called primary stope, is mined and backfilled with CRF. Later, the remaining 15 m wide block, so called secondary stope, is mined and backfilled with waste rock (see Figure 11: Example of secondary transverse stoping.Figure 11). In longitudinal stoping, the stoping advances along the orebody. When a longitudinal stope is mined out, the end towards the next stope in mining sequence is backfilled with CRF while the rest of the stope is backfilled with waste rock. Then the next stope is blasted against the CRF backfill (see Figure 12).

Stopes are drilled with longhole drill rigs. Both upwards and downwards drilling is used due to the high level spacing and curvy shape of the ore. Charging is normally done with emulsion, which is pumped into the blast holes. While impulse detonators are used in development blasts and small stope blasts, electronic detonators are often used in large/complex stope blasts.

Once a stope has been mined out, it will be scanned using a laser scanner (or Cavity Monitoring System, CMS, see examples of scanned stopes in Figure 11 and Figure 12). The backfilling of the stope will not start before the scanned stope shape is checked and it is considered safe and ready for backfill. The result of the stope scan is also used to obtain dilution and ore loss parameters. The combined parameters from all stopes are used to analyze and update the planned dilution and ore loss parameters for future stopes.

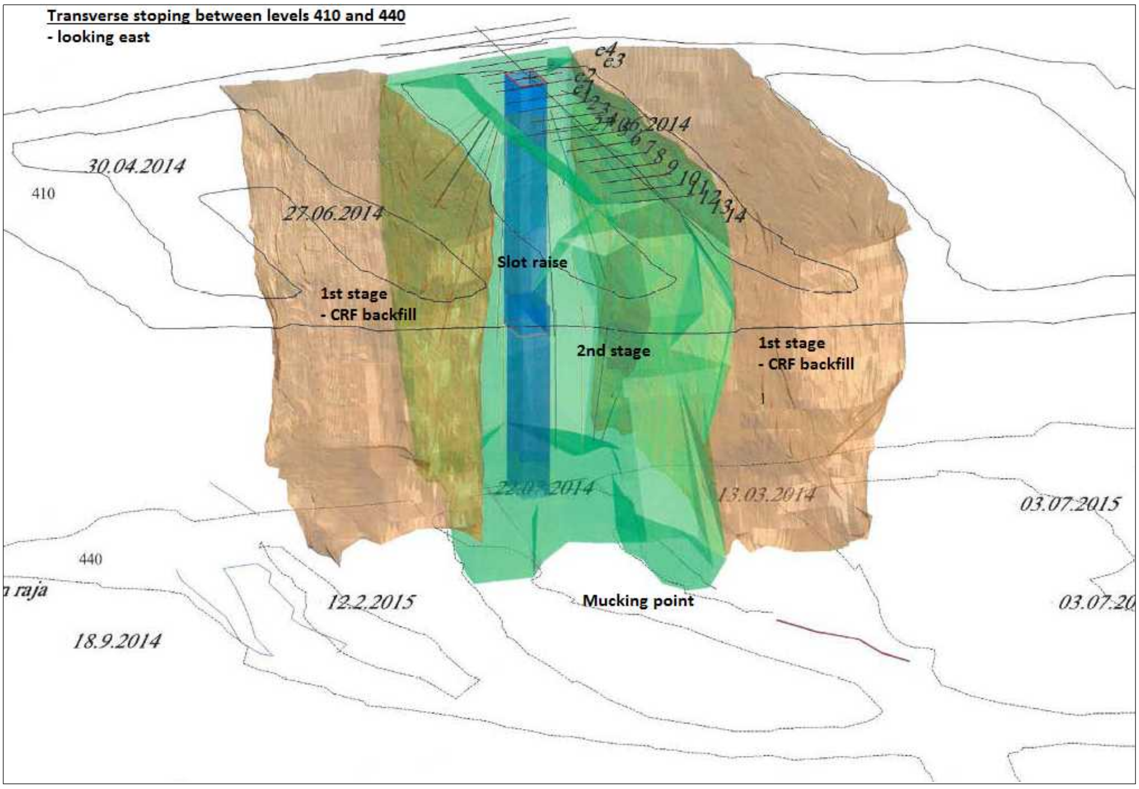

Figure 11: Example of secondary transverse stoping.

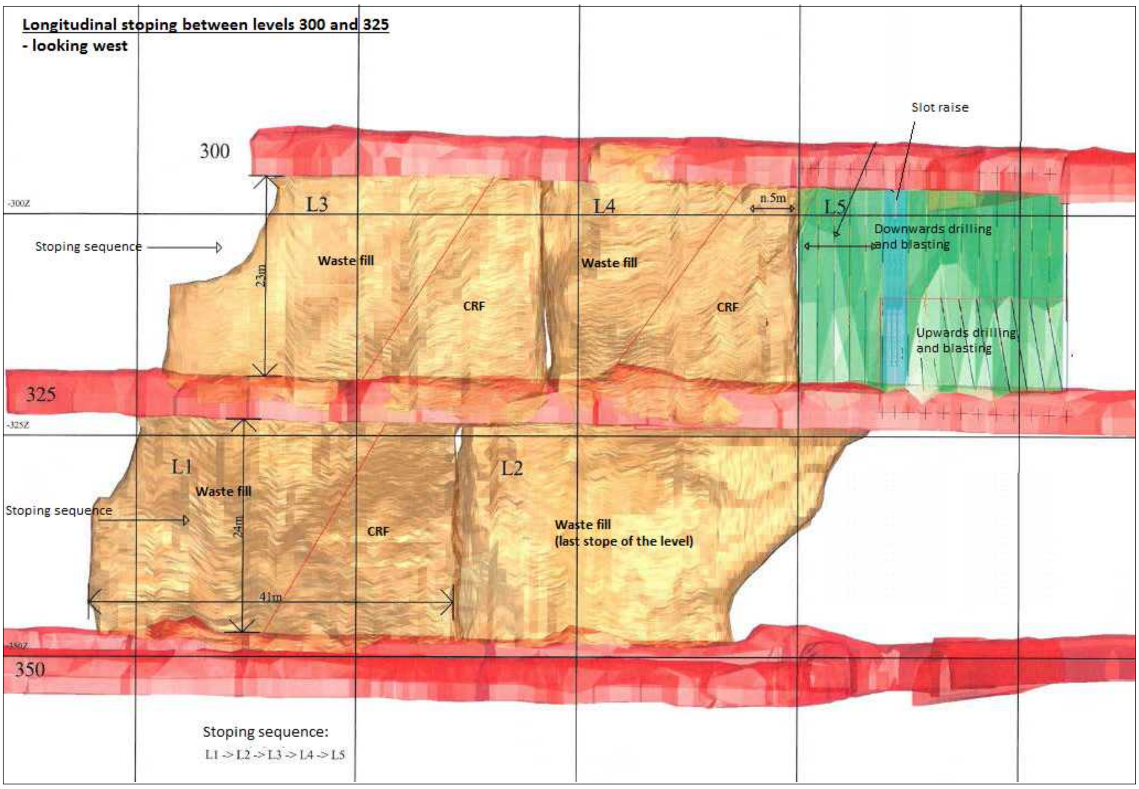

Figure 12: Example of longitudinal stoping.

Ground conditions at Kylylahti are generally very good. However, as the mining proceeds, the rock stresses concentrate into certain areas within the mine, causing a need for additional rock support. Similarly, when re-accessing old development drifts, the original support is typically outdated and needs to be re-installed. This may cause additional costs and delays in production. The high rock stress and the damage it causes to production tunnels could in some cases result in having to abandon stopes or partial stopes. Most of the mine is in final mining stage and ground conditions are closely reviewed on stope by stope basis.

Some of the remaining stopes are located near the decline and exhaust air shafts. A new decline tunnel will be built to access the deeper parts of the mine after the stopes near the current decline have been mined out. The exhaust air route will, however, be cut off by the nearby stopes. Therefore, at the final stage of the mine exhaust air will move mostly along the decline, which will increase the time to ventilate the mine after blasts. The removal of fixed equipment and cables will start from the bottom of the mine and advance upwards when they are no longer needed for production. Similarly, water pumping from the bottom of the mine will cease once production levels are mined out.

3.10.2 Mineral processing

Ore from the Kylylahti mine is transported by trucks 42 km to the Luikonlahti concentrator. The comminution steps at the concentrator involve crushing by jaw crusher, two cone crushers and grinding in three stages, first with a rod mill in the primary stage and ball mills in the subsequent secondary and tertiary stages. The third stage grinding is conducted in closed circuit, with classification by hydrocyclones and cyclone underflow fed to the mill. Gravity separation is performed on the tertiary mill product using a Knelson concentrator, in order to separate coarse grained gold at an early stage in the process. Flotation is carried out in a three-stage process: copper-gold flotation, zinc or nickel flotation and sulphur flotation to avoid deposition of acid forming solids in the low sulphur tailings pond. The second cleaner tail stream from the copper circuit is fed back to the tertiary ball mill for regrinding. The flowsheet of the plant is schematically illustrated in Figure 13.

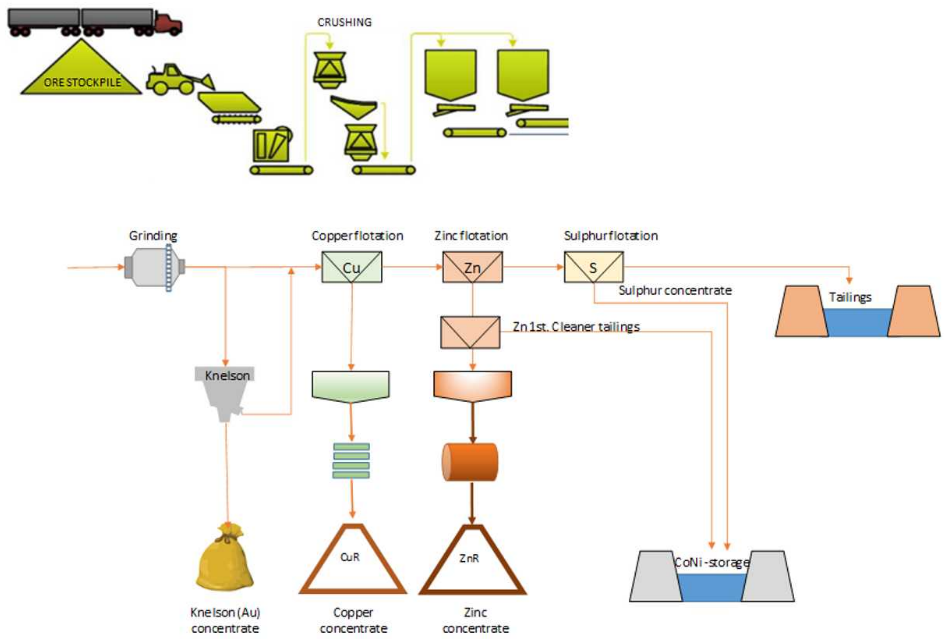

Figure 13: Schematic flowsheet description of the Luikonlahti mill. The setup slightly varies depending on ore type.

Ores which are processed to produce a zinc concentrate generate a sulphur concentrate in the third stage. This concentrate also contains some cobalt and nickel. The sulphur concentrate and the first zinc cleaner tailings streams are combined and deposited in the high sulphur tailings pond. There is an ongoing project to find an economically feasible process to recover refractory cobalt and nickel from these tailings. In addition, there is an increasing volume of ores with floatable nickel-cobalt. For such ores, the zinc flotation cells are utilised for nickel and cobalt flotation and in this case zinc is floated in the sulphur flotation and deposited with the high sulphur tailings.

The mineral concentrates are dewatered using thickeners and pressure filters. Four concentrates are produced: gravity gold, copper-gold and zinc or nickel-cobalt concentrates. The gravity gold, copper and zinc concentrates are transported by trucks to Boliden's smelters in Finland. The nickel-cobalt concentrate is transported by trucks to Kokkola port and from there onwards for further processing.

3.10.3 Infrastructure

The mine infrastructure is completed. Ore and waste rock is hauled with trucks using a 1:7 inclined decline tunnel. Deepest point of the mine is 810 m below surface. Access tunnels connect the decline to the mining areas. Other tunnel infrastructure includes tunnels for e.g. social quarters, maintenance, ventilation, water management, electrification, CRF mixing and exploration. Ventilation tunnels are connected by vertical shafts, divided into separate routes for fresh air and exhaust air.

The main ventilation fans are located on surface. During winter, fresh air is heated using liquid gas. Excessive water from the mine is pumped on surface to water treatment ponds before releasing it to Lake Polvijärvi. The mine is connected to the 110 kV national electric grid. Ore is first hauled to Run-of-Mine Pad (ROM Pad) on surface before transportation by road to Luikonlahti mill. Next to the ROM Pad, there is a waste rock area, where external waste rock is brought to be used in stope backfill. Other surface infrastructure includes e.g. offices and social quarters, storage halls, maintenance halls, parking lots and other road infrastructure.

Figure 14: Surface infrastructure of Kylylahti mine.

Luikonlahti mill area consists of production facilities, laboratory, tailings dam, settling ponds and non-payable cobalt-nickel storage ponds.

Figure 15: Luikonlahti mill.

3.11 Prices, terms and costs

Normally, mineral reserve update would be done by using long term planning prices, but due to the short life of mine, the mineral reserve estimation was done by using short term planning prices. Prices used are presented in Table 8. Terms are in line with industry practices and are taken into account when calculating Net Smelter Return (NSR) value.

Table 8: Short term planning prices.

Commodity / Currency	**Short term planning prices, 2019**	**Short term planning prices, 2018**
Copper	USD 5998/tonne	USD 5985/tonne
Zinc	USD 2461/tonne	USD 2414/tonne
Gold	USD 1416/tr.oz	USD 1227/tr.oz
Nickel	USD 13350/tonne	USD 12924/tonne
Cobalt	USD 13/lb	USD 29/lb
EUR/USD	1.13	1.19

Concentration process parameters used for NSR-value formation are ore type specific. Different ore types and concentrates produced from them are presented in Table 9.

Table 9: Different ore types and concentrates produced from them. Each ore type has different process parameters.

Ore type / Concentrate produced	M2	M4	M5	M6	M7
Cu concentrate	x	x	x	x	x
Au gravity concentrate	x	x	x	x	x
Zn concentrate	x				
Ni-Co concentrate		x	x	x	x

Kylylahti mine has four different cutoff scenarios that are used for mine planning and to generate the mineral reserve estimation. Cutoffs are based on estimated operational costs. The most important cutoff is the cutoff value of 49.4 €/t that a whole stope needs to exceed (Scenario 3 below). The different mining scenarios that have been investigated are listed shortly below. Concentrate transportation costs have been taken into consideration in NSR-calculation.

- **Scenario 1:** Cutoff-grade for marginal stope ore next to a stope that will be excavated.
- **Scenario 2:** Cutoff-grade for development material that could be alternatively used in backfill.
- **Scenario 3:** Cutoff-grade for stope ore that justifies the development for the stope. Additionally, the stope ore needs to cover the cost for development that is needed to mine the stope. This is evaluated case by case.
- **Scenario 4:** Cutoff-grade for development ore that justifies the development without stoping.

3.12 Mineral Resources

All Mineral Resource (measured, indicated, and inferred categories) as calculated per 31.12.2018 has been excluded from this report. There are no plans to convert any of the Mineral Resource into Mineral Reserve. The judgment is that it is not a reasonable prospect for eventual economic extraction. The Kylylahti mine is closing during 2020 and then to move any of the 2018 Mineral Resource into a Mineral Reserve will be a major step in the future.

The tonnage and grade of the former Mineral resource calculation did not include those volumes of the block model used to calculate the mineral reserve for the Kylylahti stopes and development. Nevertheless, chapter 3.12.1 is of high importance since it is the basis for the current Mineral reserve, which is reported in chapter 3.13 and listed in Table 10.

3.12.1 Calculation and classification methods

PERC compliant resource estimation and model has not been done in 2019. The estimated mineral reserves are based on the Kylylahti grade control model, which was created in July 2019 and later updated for each stope entering production. Following paragraphs are describing the estimation methods used in that model. The geostatistic used in grade control model is based on 2018 R&R estimation.

Ordinary Krieging was used as an estimation method for grade control model as it was considered to be best estimation method for the Kylylahti style of deposit. Previous Kylylahti resource estimates have also been completed using Ordinary Krieging. Ordinary kriging estimation was used to estimate gold, cobalt, copper, nickel, zinc and sulphur grades into parent blocks for all the domains.

Estimation was carried out using Surpac 6.9. In previous resource model, the geostatistical review has been made by using Supervisor 7.04. Since estimation is based on production model, the geostatistic used in this estimation is the same as the one used in the previous R&R-model for 2018. That is to say, no statistical re-evaluation has been done for this estimation.

Kylylahti mineralization is very visual. Logging information was used as guidance for creating geologically controlled envelopes of mineralization.

Drillhole sample data was coded using domain wireframes for ore zones and rock codes for main rock types. Coded sample data was composited to two meters downhole lengths using a best fit-method. The process created only a small number of short composite lengths with little impact on evaluation. Composites were declustered using a 20 x 20 x 40 meters cell declustering method for geostatistical comparative purposes.

Extreme outliers of sample population were topcut based on statistical analysis (grade histograms, log probability plots and examination of CV's). Topcuts were applied to gold (2.0g/t in the disseminated copper and 12.5g/t in the hangingwall gold-lenses) and zinc (2.0% in the disseminated copper domain and 2.0% in the hangingwall gold lenses). Other elements did not require any topcutting.

Directional variograms were modelled using normal score transformation for the massive and disseminated copper domains for gold, cobalt, copper, nickel, zinc and sulphur. Back-transformed variograms were used in the estimation. Grade continuities showed good agreement with known geology. Modelled variograms had about 100 meters variogram ranges in the principal direction, 40 meters ranges in the intermediate direction and about 25 meters ranges in the minor direction, with low nuggets of 10-20%.

The block model was constructed using 2.5 x 2.5 x 10.0 meters parent block sizes with standard subcelling to 0.625 x 0.65 x 2.5 meters. Two estimation passes were carried out for all the domains. Search distances of 75 meters x 37.5 meters x 25 meters, with minimum of 8 and a maximum of 14 samples were applied in first pass search. 300 meters x 150 meters x 100 meters, with minimum of 2 and a maximum of 10 samples were applied in the second pass search for the blocks not informed in the first pass search.

The block model validation included the following steps:

- 2D and 3D visual checks between sample grades and model grades.
- Sample vs domain grade checks inside the domains.
- Composite vs raw metal and length checks.
- Kriging metric checks (regression slope and kriging efficiency) for estimation quality.
- Volume comparisons of the solids versus the block model.

- Comparison against the previous block model.
- Reconciliation of data against the production model and mill is available and regularly used to validate grade control models.
- Previous resource models were used to validate the new grade control models.

3.13 Mineral Reserves

Kylylahti Mineral Reserve dated 31.12.2019 totals 503 kt at 0.64 % Cu, 1.23 g/t Au, 0.29 % Zn, 0.25 % Ni and 0.16 % Co. Tonnage has decreased by 833 kt from 1 336 kt of the previous update. Comparison of December 2018 and 2019 mineral reserve tonnage and grades is shown in Table 10 and Table 11. Schematic views of the distribution of the different reserve classifications in Kylylahti mine can be seen in Figure 16 and Figure 17.

Table 10 Mineral Reserves Kylylahti 2019-12-31

Classification	2019						2018					
	kt	Cu (%)	Au (g/t)	Zn (%)	Ni (%)	Co (%)	kt	Cu (%)	Au (g/t)	Zn (%)	Ni (%)	Co (%)
Proven Mineral Reserves	**392**	**0.73**	**1.08**	**0.33**	**0.24**	**0.18**	843	0.87	0.87	0.44	0.22	0.19
Probable Mineral Reserves	**110**	**0.32**	**1.77**	**0.11**	**0.27**	**0.10**	493	0.35	1.11	0.13	0.27	0.13
Total Mineral Reserves	***503***	***0.64***	***1.23***	***0.29***	***0.25***	***0.16***	*1 336*	*0.68*	*0.96*	*0.33*	*0.24*	*0.17*
Measured Mineral Resources							2 510	0.56	0.24	0.30	0.25	0.14
Indicated Mineral Resources							3 639	0.34	0.36	0.21	0.27	0.11
Inferred Mineral Resources							737	0.08	0.02	0.05	0.42	0.04
Total Mineral Resources							*6 886*	*0.39*	*0.28*	*0.22*	*0.28*	*0.11*
Note: Zinc is only recovered from M2 ore type. In other ore types nickel and cobalt is recovered instead of zinc. Mineral resource estimate was not updated for 2019.												

Table 11: Comparison between December 2018 and 2019 reserves

Mineral reserve grades and tonnage comparison			
	Dec18	**Dec19**	**Change %**
Tonnes kt	1336	503	-62 %
Cu %	0.68	0.64	-6 %
Au g/t	0.96	1.23	28 %
Zn %	0.33	0.29	-13 %
Ni %	0.24	0.25	4 %
Co %	0.17	0.16	-5 %

Mineral resource estimate was not updated in 2019 due to short life of mine. Therefore, Kylylahti Mineral reserve is based on grade control models, which were derived from the previous year's resource estimate, and it matches the mine production plan on 31.12.2019.

Included in the mineral reserve calculation are all volumes within the designed stoping and ore development shapes with appropriate dilution and ore loss applied to each stope.

Dilution and ore loss are analyzed from completed stopes, and the planning parameters are adjusted at least once per year if necessary.

Planned development shapes include overbreak from sidewalls and no ore loss or dilution is assumed in them. Stope dilution is defined as a 50 to 60 cm layer of waste rock from each waste sidewall of the stope. Therefore dilution percentage varies depending on the width of the orebody. Dilution from CRF backfill and from waste fill below are also estimated when calculating final stope tonnage and grades. Ore loss parameters are based on experience from previous stoping. Ore loss is fixed at 8% in longitudinal stoping and depends on the width of the orebody in transverse stoping. Additional dilution / ore loss is added case by case if e.g. the shape of the stope is complicated.

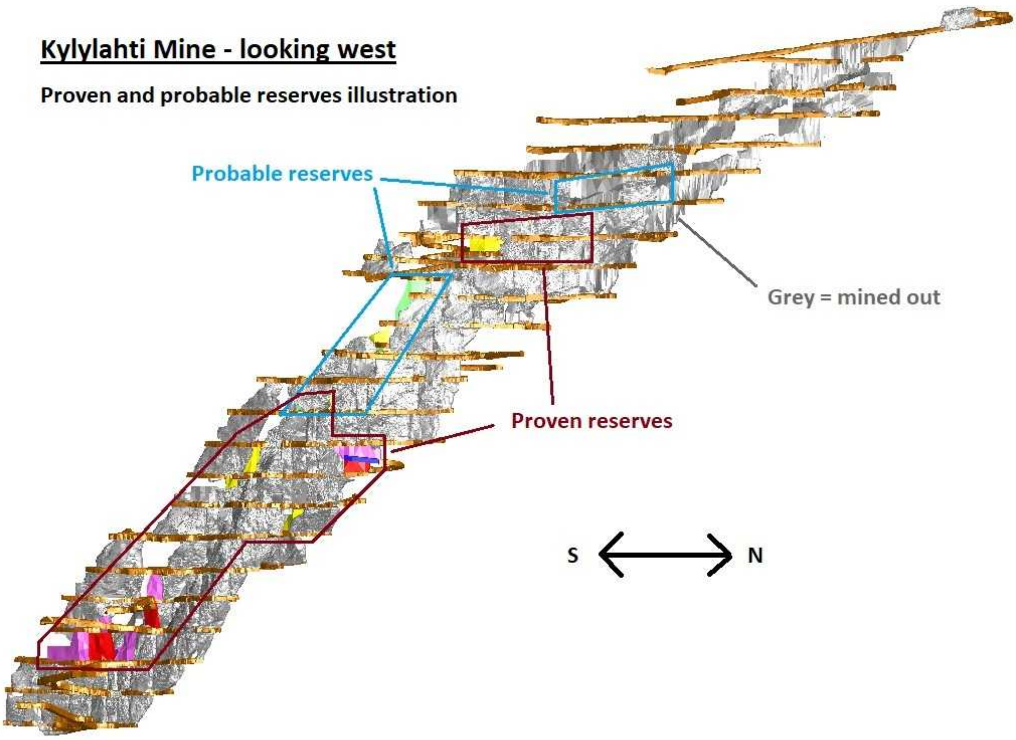

Figure 16: Location of proven and probable mineral reserves at Kylylahti mine with December 2019 reserve planned and mined out stopes as a background – looking west.

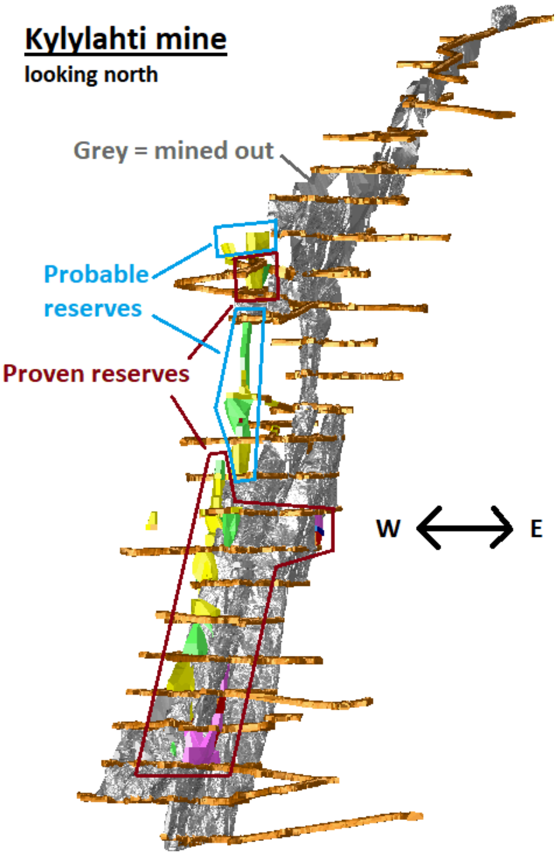

Figure 17: Location of proven and probable mineral reserves at Kylylahti mine with December 2019 reserve planned and mined out stopes as a background – looking north.

3.14 Comparison with previous year/estimation

3.14.1 Changes in Mineral Reserves

An explanation to the changes in mineral reserve from the previous year is shown in Table 12.

Table 12: Explanation of changes to mineral reserve from 2018 to 2019.

	Wal	Wom1	Wom2		Total
	kt	kt	kt		kt
Mineral Reserves 2018	**167**	**595**	**574**		**1336**
Mined (total)	-80	-269	-332		-681
Mined outside reserve					0
Upgrading from resource					0
Exploration					0
Economic Assumptions	-24	-51	-26		-101
Technical	-10	-8	-20		-38
Geological, infill		-13			-13
Written off					0
Adjusting	0	0	0		0
Minreal Reserves 2019	**53**	**253**	**196**		**503**
Change	-114	-341	-378		-833
Change %	-68 %	-57 %	-66 %		-62 %

As seen in Table 12, mining during 2019 accounted for a reduction of 681 kt from the previous year's reserve. Updated geologic model based on infill drilling defined reserves more accurately but did not cause considerable changes in reserve tonnage. The main decrease in tonnage was a result of cobalt price falling during the year.

3.14.2 Changes in Mineral Resources

All Mineral Resource (measured, indicated, and inferred categories) as calculated per 31.12.2018 has been excluded from this report.

The tonnage and grade of the former Mineral resource calculation did not include those volumes of the block model used to calculate the mineral reserve for the Kylylahti stopes and development. Nevertheless, chapter 3.12.1 is of high importance since it is the basis for the current Mineral reserve. Infill drilling done during 2019 defines the Mineral Reserve more accurately but did not cause enough changes to justify changes of the Mineral Resource calculation.

3.15 Reconciliation

Production reconciliation between mine claimed grade and the mill back-calculated feed grade is monitored and reported on monthly basis. Kylylahti mine claimed grade is calculated using loader's scale weights corrected by moisture for the tonnage, aerial weighted face grades (mimicking diamond core/channel samples in the sample collection) for the development ore and block model grades inside the grade control model with dilution and ore loss corrections for the stope ore. Monthly reconciliation is corrected for the stocks as end of month stocks typically contains 25-75% of monthly tonnages and therefore can cause significant differences. Monthly reconciliation at the Kylylahti mine is typically inside acceptable 10% variation limits. Reconciliation over different periods is presented in Table 13.

Table 13: Reconciliation over different periods.

Mill actual vs mine claimed (Dec 2019 recon report)						
	Month	3 months	6 months	12 months	YTD	LOM
Cu	105 %	97 %	99 %	97 %	97 %	98 %
Au	120 %	103 %	102 %	101 %	101 %	94 %
Zn	110 %	95 %	93 %	99 %	99 %	97 %
Co	97 %	95 %	92 %	98 %	98 %	96 %
Ni	102 %	105 %	102 %	104 %	104 %	100 %
S	111 %	101 %	100 %	104 %	104 %	99 %
Tonnes	108 %	107 %	103 %	104 %	104 %	101 %

Stocks correction was not applied to the annual reconciliation. Annual production reconciliation over the period 2011-2019 is presented in Table 14.

Table 14: Production reconciliation at Kylylahti over the period 2011-2019.

	2011	2012	2013	2014	2015	2016	2017	2018	2019		LOM	LOM Difference
Mined ore (kt)	2	380	609	671	719	816	766	791	681		**5435**	1 %
Milled ore (kt)	0	369	605	669	733	797	809	785	716		**5483**	
Mined Cu%	0.97	1.51	1.66	1.74	1.74	1.63	1.37	0.96	0.76		**1.41**	-1 %
Milled Cu%		1.44	1.64	1.74	1.72	1.63	1.30	1.01	0.74		**1.39**	
Mined Au g/t	0.54	0.58	0.66	0.65	0.75	0.85	1.08	1.03	0.88		**0.83**	-1 %
Milled Au g/t		0.57	0.66	0.62	0.76	0.85	1.07	0.98	0.86		**0.82**	
Mined Zn%	0.46	0.57	0.72	0.63	0.71	0.65	0.59	0.43	0.37		**0.58**	-3 %
Milled Zn%		0.59	0.69	0.64	0.70	0.64	0.53	0.41	0.35		**0.56**	
Mined Ni%	0.12	0.14	0.16	0.15	0.15	0.17	0.19	0.23	0.23		**0.18**	0 %
Milled Ni%		0.14	0.16	0.15	0.16	0.17	0.20	0.21	0.23		**0.18**	
Mined Co%	0.22	0.24	0.26	0.27	0.28	0.28	0.28	0.21	0.18		**0.25**	-4 %
Milled Co%		0.23	0.24	0.26	0.28	0.27	0.26	0.20	0.18		**0.24**	

It is interpreted that the Cu, Au and Zn grade deviations for 2019 are in acceptable levels of +- 10%. This is consistent with the previous five years of production and indicates a high level reliability to the block model for these metals.

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