Bergvesenet

Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
7272				
Kommer fra ..arkiv	**Ekstern rapport nr**	**Oversendt fra**	**Fortrolig pga**	**Fortrolig fra dato:**
Scandinavian Highlands A/S		Scandinavian Highlands A/S		

Tittel

Outline of the Surpac 3D reconstruction of the Bruvann Ni Mine, Ballangen, Norway. Statur report.

Forfatter	Dato År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Jebens , Martin	30.04 2007	Scandinavian Highlands A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Ballangen	Nordland		13311	Narvik

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Malmberegning		Råna Bruvannsfeltet
Råstoffgruppe	**Råstofftype**	
Malm/metall	Ni, Cu	

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Gruvens drifter er remodelert ved bruk av Surpac 5.2, 3D modellerings software. Etter dette er en blokkmodell av gruven behandlet med kriging for å få fram malmmengden.
Blokkmodellen viser en stor tonnasje over 0,45 % Ni som var cut-off under gruvedriften. Tar en bort all malm over 0,45 % Ni, får en en tonnasje som er lik det som er drevet ut.
Gjennstående malm (measured ore) er beregnet til 9,15 MT med 0,364 % Ni. En har ikke beregnet Cu, men antar den tilsvarer 1/4 av Ni.
Modelleringen og malmberegningen er gjort i henhold til The JORC code som er den australske koden for å raportere malmletings resultater, mineralressurser og malm reserver.

VEDLEGG 1 av 1
J.nr. 07/00320-1

Outline of the Surpac 3D reconstruction of the Bruvann Ni mine. Ballangen, Norway.
Status Report.

30.04.07

Abstract

The former Bruvann Ni mine, which closed in 2002, is situated in northern Norway, 40 kilometers from Narvik. It is located close to a harbor with access to the Atlantic Ocean, European interstate road E6, large national airport and with all infra structure intact around the mine.

The mine has been re-modelled using Surpac 5.2, 3D modelling software. All data used to re-model the mine (drill hole data, stopes, drifts and ramp outline) have been given by former geologists at the Bruvann Ni mine and the Norwegian Directorate of Mining. All drifts, stopes and ramps were turned into solids and triangulated using Surpac. Further, all solids were validated and show no failures. After re-modelling the mine a block model was made using kriging.

The block model shows a high tonnage above a cut-off of 0.45% Ni. This was the cut-off when the mine was operating. Removing all ore in the model having a cut-off above 0.45% gives a total tonnage which is very similar to what has been mined.

At present time the remaining measured ore is estimated to be 9.15Mt with a grade of 0,364% Ni. This is a conservative evaluation since some ore with grades above 0.45% Ni probably can be found in pillars.
Copper is present in the ore. Nickel and copper have a ratio of 4:1 (NGU ore database). Therefore, copper tonnage is 2.287Mt. This is an estimate since no Cu values are available.

Introduction

The following is a status report made by Scandinavian-Highlands of the reconstruction of the Bruvann Ni mine using Surpac 5.2, 3D computer modelling software.

All data used so far to model the mine were delivered by Lisbeth Storhaug, former mine geologist at the Bruvann nickel mine, the Norwegian Geological Survey (NGU) together with the Norwegian Directorate of Mining (Bergvesenet). Data include drill holes (position, drill direction, lithology and geochemistry), measured faults, stopes, drifts, ramps and surface maps.

The goal of this project is to make validated solids of all drifts, stopes, and ramps inside the mine. Further to make a geochemical database to produce a block model of the Ni values in the mine area extracting the volume and ore already removed.

In the following the JORC coding (Joint Ore Reserves Committee) has been implemented. The JORC code is the Australasian code for reporting of exploration results, mineral resources, and ore reserves. It sets out minimum standards, recommendations and guidelines for public reporting in Australasia of exploration results, mineral resources, and ore reserves.

Estimation and reporting of a mineral resource study should according to JORC entail the following steps:

- Geological interpretation:
  1. Confidence in the geological interpretation of the mineral deposit.
  2. Nature of the data used and any assumptions.
  3. The effect of alternative assumptions made.
  4. The use of geology in guiding and controlling mineral resource estimation.

- Dimensions:	1. Extent and variability of mineral resource expressed as length, plan width and depth.
- Bulk density:	1. Assumed or determined.
- Estimation and modelling:	1. Nature and appropriateness of the estimation techniques applied and key assumptions, including treatment of extreme grade values, domaining, interpolation parameters and maximum distance of extrapolation from data points. 2. The availability of check estimations, previous estimates and/or mine production records and whether the mineral resource estimate takes appropriate account of such data. 3. Assumptions made regarding recovery of by-products. 4. Any assumptions behind modelling of selective mining units. 5. The process of validation, the checking process used the comparison of model data to drill hole data, and use of reconciliation data if available.

It is not the purpose of this report to evaluate further JORC coding criteria. Though, this should be done preparing a feasibility study.

Geology

The Bruvann Ni deposit belongs to the Råna mafic-ultramafic intrusion. The intrusion, which was emplaced during the Caledonian orogenic period 400 Ma ago, is situated 40 km southwest of Narvik in northern Norway. The intrusion covers an area of about 70 km2 and is generally surrounded by garnet bearing gneiss (fig. 1).

The deposit consists of several lenses which are separated by faulting. The main fault zone (fig.4) divides the nickel deposit into Ostmalmen (eastern ore body) and Vestmalmen (western ore body). The vertical distance between the two ore bodies is 75 to 200 meter. Ostmalmen is subdivided into Sydost dagbrudd, Kronpillar - 385 level and Dypmalmen. Vestmalmen is subdivided into Dinosaurmalmen, Sydmalmen and Nordmalmen (Storhaug 2000).

The mineralised zone extents approximately 900 meter in an east-west direction and 700 meter in north-south direction where Vestmalmen is dipping towards west and Ostmalmen is dipping towards south (Storhaug 2000).

The outline of Vestmalmen in UTM33, WGS 84 is;

Y: 7581500 – 7580700

X: 580150 – 579800

And outline of Ostmalmen using UTM33, WGS84 is;

Y: 7581150 – 7580800

X: 580575 - 580000

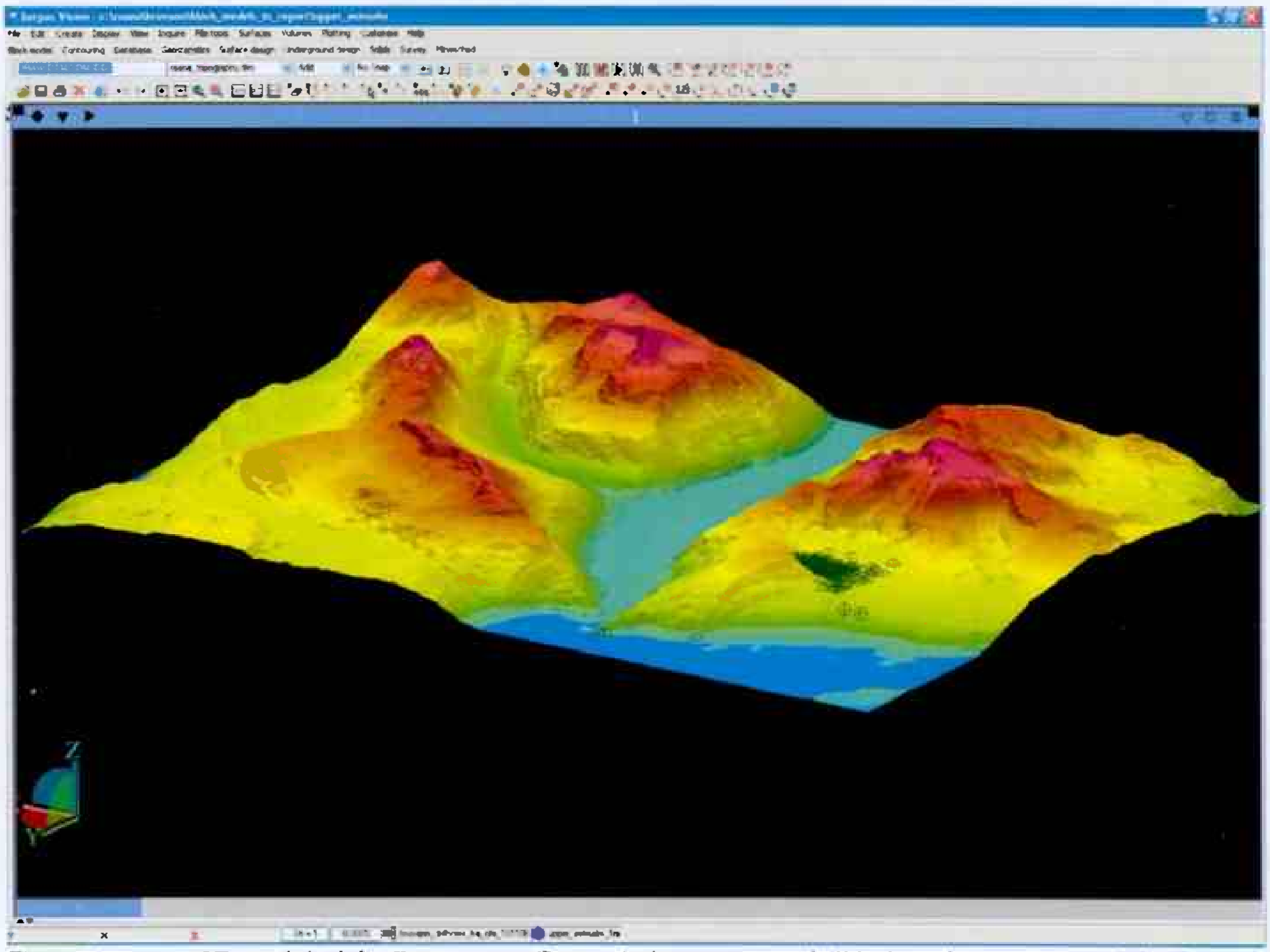


Figure 1: 3D model of the Raana area. Green circles represent drill holes. The Bruvann Ni mine is situated in the area with high concentration of drill holes.

The nickel mineralisation is mainly observed in the ultramafic rocks (only peridotite) close to the contact with surrounding gneisses. Further, nickel has only been mined from peridotite and is a disseminated mineralization. Though, massive and semi massive ore exist near the southern contact to the gneisses. This mineralisation type has been discovered on both sides of the main fault zone. The main nickel carrier is pentlandite but other sulphide minerals such as pyrrhotite and chalcopyrite also occur. Olivine contains approximately 0.09% Ni in its lattice (Storhaug 2000 after Palosaari and Jounels 1994). Additionally, the sulphide mineralisation contains copper. The nickel: copper ratio is 4:1. This project has only received very few data on analysed copper and tonnage mined. Because of mining and 3845 drill holes made, the geological confidence is high.

Mine history and methods

History

The following is a resume from the NGU ore database.
Small scale mining at the Råna intrusion started in 1880. The first licence at Bruvann was taken in 1915 and in 1918 Bjørkåsen Gruber drilled 369 meters. Further, Raffineringsverket Kristiansand did diamond drilling in 1937 with a total of 930 meter.
During the Second World War a 700 meter long drift was made together with 4035 meter of diamond drilling. After the war the first resource calculation was made which showed a tonnage of 4 Mt, 0, 5% Ni. In 1961 NGU made a more detailed calculation showing 2.1 Mt, 0.5-0.6% Ni.
In 1969 the Canadian mining industry came to a stop because of a long standing work conflict. Consequently, Stavanger Staal decided to find a local Ni supply. In the period between 1970 and 1975 Stavanger Staal and NGU made a detailed geophysical investigation of the area together with 24743 meter diamond drilling. Based on this work, the Norwegian geological survey made a resource calculation of the deposit. With cut-off 0.15% Ni the calculation showed 4.6Mt ore containing 0.33% Ni, and 0.08% Cu. To validate these results, Falconbridge made a resource calculation using the same data.
The calculation was made with cut-off at 0.3%, 0.4%, 0.5% and 0.6% Ni and gave a tonnage of 26.6Mt, 12.7Mt, 7.8Mt and 3.6Mt respectively.
In 1989 Leonard Nielsen and Sønner a/s applied for a mining license and began mining under the name Nikkel og Olivin a/s. The drift was based on sale of nickel to Outokumpu in Finland, who bought Nikel og Olivin a/s in 1993. Outokumpu fully-owned the Bruvann nickel mine until its closure in 2002.

Mining methods

The mining method used was sublevel stoping and top slicing. Sublevel stoping is a mining method in which ore is blasted from different levels of elevation but is removed from one level at the bottom of the mine.

In top slicing, the drilling and loading drifts are developed in the middle of the planed stope. The stope is opened using a transverse drive and an opening slot at one end of the stope.

Ore was blasted towards this opening slot using jumbos with 2 meters spacing. Distance between levels was normally 20 meters and drift size for drilling drifts was 5 x 5 meters. A remote controlled LHD transported the muck (Storhaug 2000).

The mine closed in 2002 and was sealed off. Since then it has been filled with water. Further, level -35 and -20 has been filled with waste.

Processing plant and further mining equipment was sold. Though, all infra structure is left, including harbour and roads as well as easy access to Narvik. This will reduce the expenses should the mine re-open. Further, Scandinavian Highlands is at the moment working on the possibility of leaching the remaining nickel out of the ore. This could further reduce mining expenses.

Geographical coordinate system

All mine data available to Scandinavian Highlands were given in NGO 1948 (V) coordinates. In this part of Norway the UTM-zone is 33 and map datum is WGS 84. The NGO 1948 (V) coordinates were converted to UTM-zone 33, WGS 84 by importing them as CSV files to CordTrans v 2.2. Strings defining ramps and drifts having NGO 1948 (V) coordinates were compared to strings having UTM33, WGS84 coordinates to validate the transformation. Z is measured referring to Northern Norway (1967) 0 level.

To reduce the number of digits of the x axis coordinates on the maps at the Bruvann nickel mine, the three first digits were not used. Therefore, the x axis of all data received was multiplied by 1150000. Further x and y coordinates had to change place when imported to CordTrans v 2.2.

Drill hole data

Drill hole data from 3845 drill holes (diamond drill holes and sludge drill holes) from the mine delivered to Scandinavian Highlands consist of a header table, survey table, sample table and lithological table. The columns in the header table are; hole name, x, y, z, azimuth, dip, length, in the survey table; hole name, depth, azimuth, dip. Sample table columns consist of; hole name, from, to, Ni, Nibr, Cu, Co, Febr, S, Au, test, Cr2O3, MgO, CaO, Fe, Zn, Ag, Mn, Pt and finally the columns in the lithological table are hole name, from, to, rock type (see fig. 2 for Ni values of all drill holes).

Drill hole collar coordinates and start azimuth were measured using electronic tachymeter. The survey points which were used in the measurement were normal mine survey points. Drill hole dip deviation was measured in the drill holes each 10 meter using electric inclinometer (Storhaug 2000). Only the drill holes in the survey table were surveyed for dip direction and/or azimuth. These values are used in stead of those in the header table. Dip direction and azimuth for all other drill holes are found in the header table (see fig. 2 for position of drill holes).

Naming of diamond drill holes is not very systematic. All drill holes made by NGU in the seventies start with BH while drill holes made in the sixties starts with a D. Other drill holes from the nineties and twentieth century are named the following way:

Diamond drilling	1990-1991	bh-1-90	bh-68-91
Diamond drilling	1992	bh-69-91	bh-171-91
Diamond drilling ramp	1993	R-1-93	R-27-93
Diamond drilling own rig	1993	bh-172-93	bh-341-93
Diamond drilling from surface	1993	db-1-93	db-33-93
Diamond drilling	1994	R-28-94	R-72-94
		V-2-94	
		bh-414-94	bh-418-94
Diamond drilling own rig	1994	bh-342-94	bh-408-94

Diamond drilling	1995	bh-419-95	bh-544-95
		R-73-95	R-79-95
		H-1-95	H-4-95
Diamond drilling	1996	bh-545-96	bh-680-96
		R-80-96	R-89-96
Diamond drilling	1997	bh-674-97	bh-808-97
		N-1-97	N-16-97
Diamond drilling	1998	bh-809-98	bh-903-98
		N-17-98	N-25-98
		H-5-98	H-19-98
		PG-3-98	PG-4-98
Diamond drilling	1999	bh-904-99	bh-985-99
		R-91-99	R-99-99
		S-1-99	S-18-99
Diamond drilling	2000	bh-986-99	bh-1024-00
		S-19-00	S-23-00
		db-34-00	db-66-00
Diamond drilling BG	2001	BG-1-01	BG-64-01
Diamond drilling SMOY	2001	db-67-01	db-95-01
Diamond drilling own rig	2001-2002	bh-1025-01	bh-1155-02

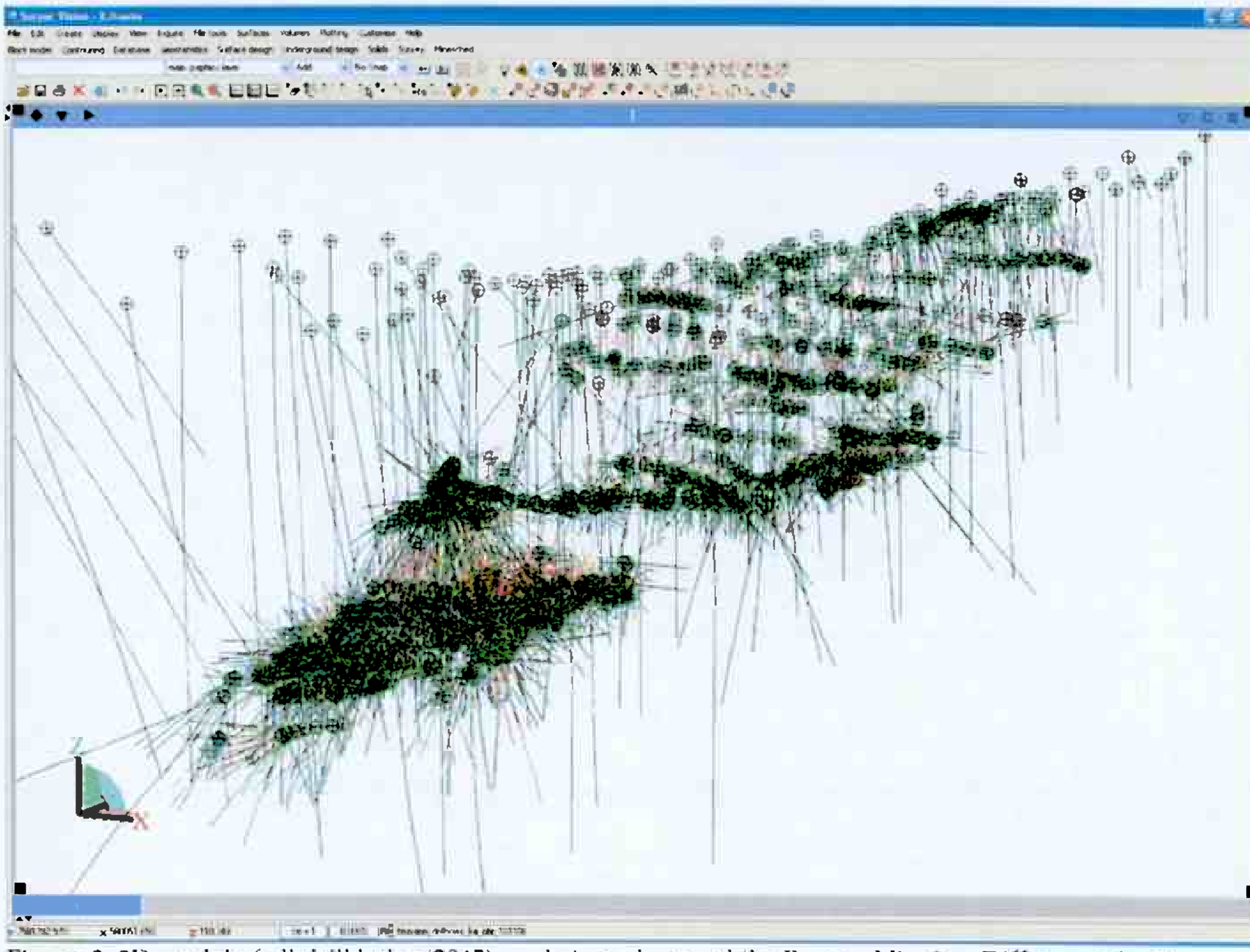


Figure 2: 3D model of all drill holes (3845) made in and around the Bruvan Ni mine. Different colours represent different Ni values.00

Samples were given consecutively numbers. Assay samples from drill holes done by Nikkel and Olivin A/S (nineties and twentieth century) are normally about 2 meters. Lithological boundaries and mineralisation grade variations were used when determining drill core to the assay interval. In case of grade variation shorter assay intervals than 2 meters were used. Drill core recovery is normally close to 100% (Storhaug 2000).
The assay interval of the NGU drill holes is always two meters irrespective of lithological changes.

Further, some 40 density determinations have been done at the geoanalytical laboratory, Outokumpo. The density determinations were done from pieces of drill core.
According to these determinations the average density is 3.39. This value has been used calculating all resource estimations (Storhaug 2000) (appendix 1).

Sludge drilling has been done systematically in the Vestmalm and in certain areas in the Ostmalm, in all the production areas. The drilling has 10 to 12.5 meter spacing except in areas with massive ore where 6.25 meter spacing were used. Each sludge drill hole sample is about 1.8 meter (Storhaug 2000).

All drill cores have been split in half using a hydraulic splitter except for those drilled later than 2000, which have been all crushed for assaying. A part of the drill cores have been transported to NGU´s national core storage at Løkken, but it is unclear how many.

Modelling drifts, ramps and stopes

The mine infrastructure was converted from Microstation95 to text files which were imported into Surpac as string files. The strings outline drifts, ramps and stopes (fig. 3). The transformation of data from Microstation95 to text files changed the appearance of strings, outlining drifts and ramps. At all levels, strings were broken and/or connected to strings at different levels and incorrect strings at the same level. All drifts and ramps were consequently edited in Surpac to get a continuous and unbroken outline. In areas containing a large number of failures the editing was compared with mine maps found at NGU and Bergvesenet in Norway.

After editing, all strings were cleaned for foldbacks, excessive number of points and duplicate points.

Further, string direction was checked in the string file summary and all strings not having clockwise orientation was turned clockwise. Additionally, all drifts were separated in levels and triangulated one by one. This way a lot of smaller solids were created which minimized the amount of failure during triangulation.

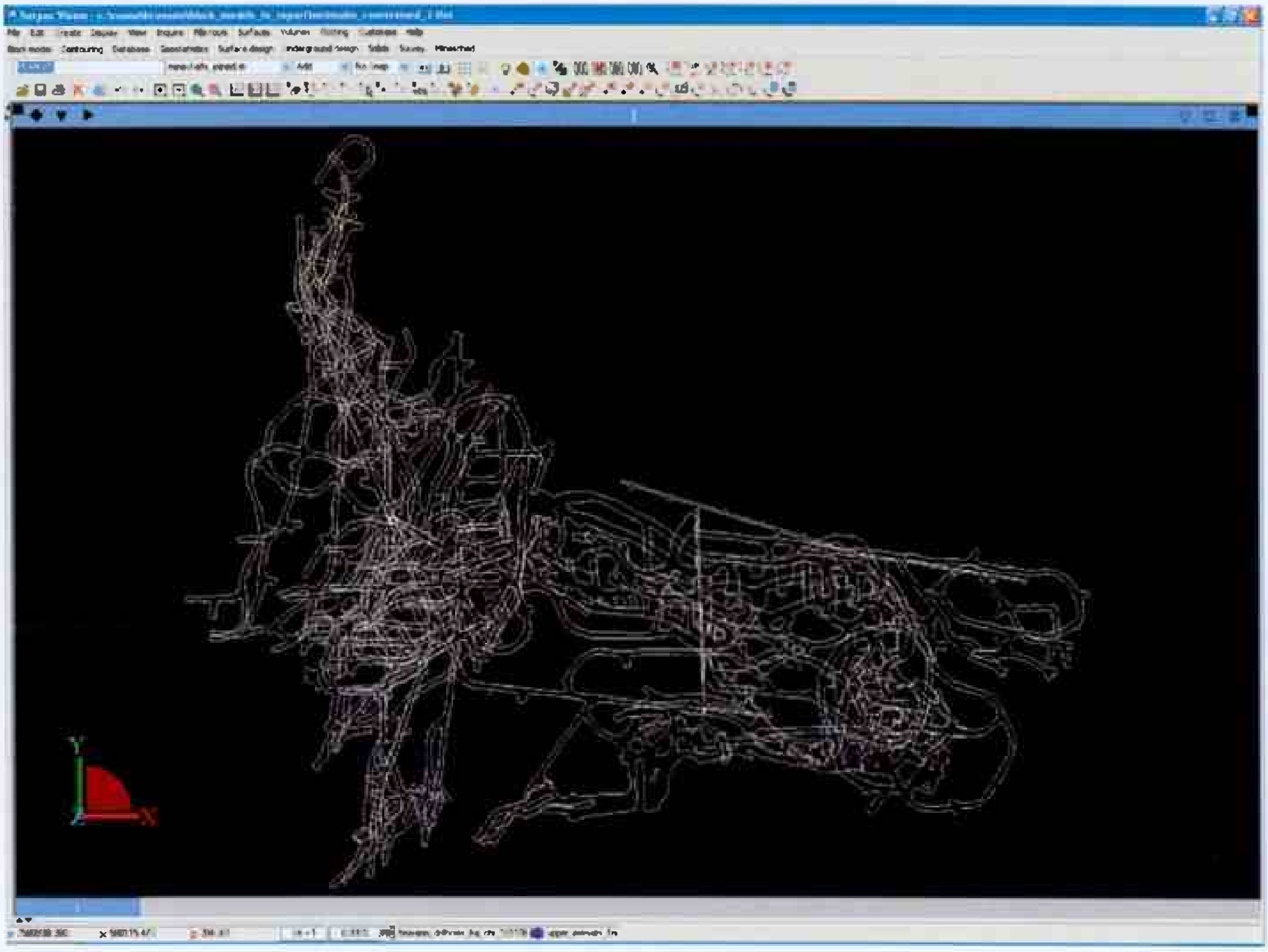


Figure 3: 3D model of strings outlining drifts and ramps in the Bruvann mine.

Strings outlining drifts and ramps were 1.2 meter above floor surface. To turn drifts and ramps into a 3D model the strings were copied by bearing and distance.

At the time the 3D modelling was made the height of drifts and ramps was known to be between 5 and 6 meters below the 235 level and up to 8 meters above the 235 level. Consequently, the height of drifts and ramps was set to be 5.5 meters below the 235 level and 7 above the 235 level.

Therefore, below the 235 level strings were copied 1.2 meter downwards (azimuth –90) and 4.3 meter upwards (azimuth 90) giving the drifts the height of 5.5 meters. Above level 235 the strings were copied 1.2 meter down and 5.8 meter up giving the drifts a height of 7 meters.

New knowledge has shown that drifts below the 235 level are approximately 6 meters. Above the 235 level the 385, 367 and 340 levels are approximately 8 meter high, the 320, 300, 280 and 260 are around 7 meters high while the final levels are around 6 meters high.

Changing the height of drifts and drives would result in more precise volume estimation. Though, it should be mentioned that drifts generally do not contain mined ore, and will therefore not change the volume of interest (Øystein Pettersen pers. com.).

The strings outlining the drifts and ramps at all levels were triangulated using triangulation inside segments and triangulation an end segment. Triangulation algorithm used was new algorithm with transforms. Following, each solid was validated and checked for duplicate triangles, invalid trisolation edges and self intersecting triangles.

Solids which contained internal failure were corrected by editing points on the strings or optimise, delete redundant points and delete duplicate vertices in the trisolation (fig. 4).

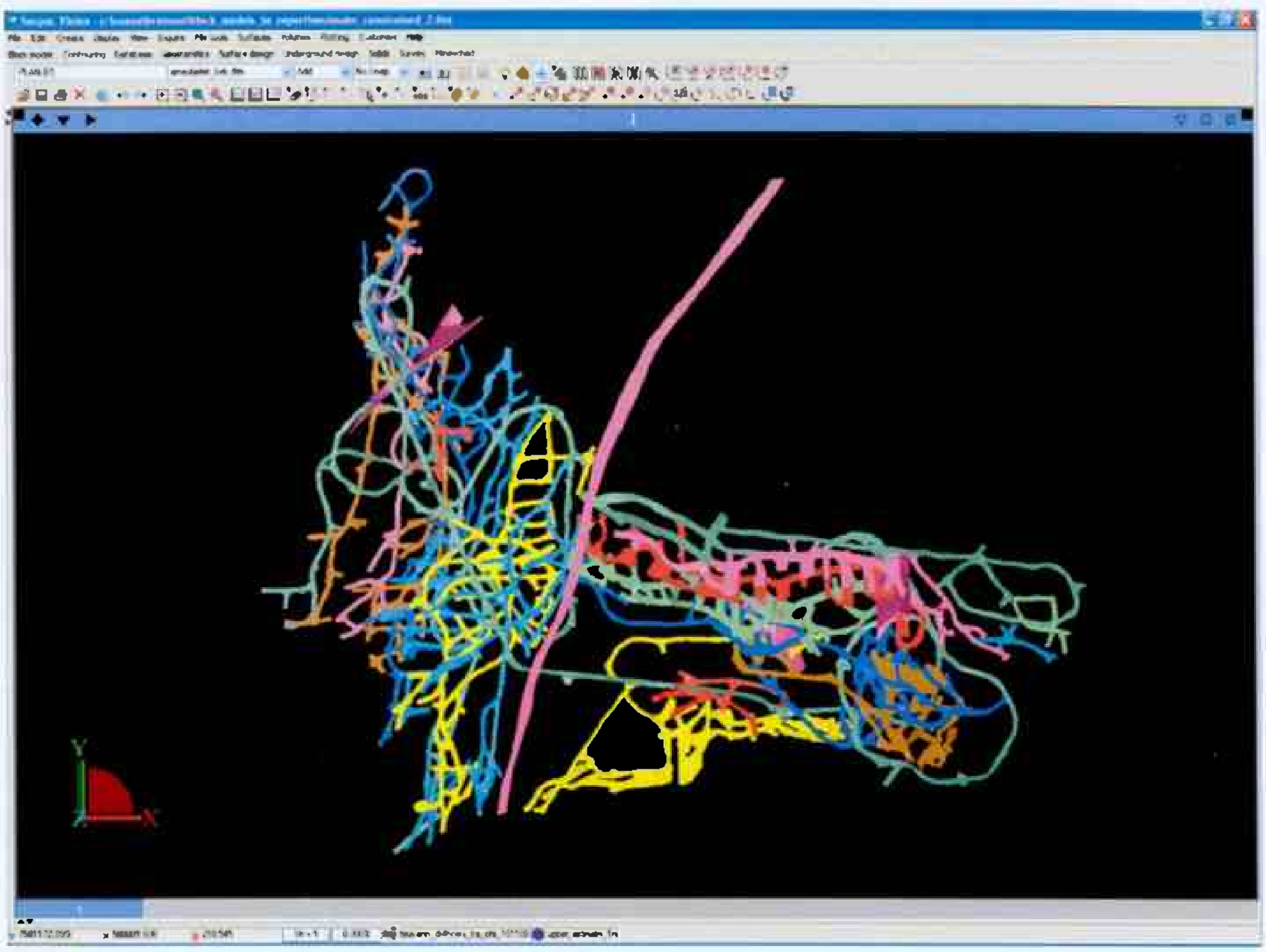


Figure 4: 3D model of all drifts and ramps. Pink line in the middle represents a major fault separating Vestmalmen (left of fault) from Ostmalmen (right of fault).

At many levels the drifts split up and join again further inside the mine outlining an area which was not mined. Triangulating the drift would include this area into the drift. Therefore, the area which was not mined was defined by a surface and cut away by using cut solid above or below a DTM (surface). In many cases, the intersection gave rise to consolidating triangles. In order to get validated solids a few points were moved or erased to remove the consolidating triangles.

Strings outlining stopes from Vestmalmen did not contain a great number of failures. Though, many strings were open and edited in Surpac to become closed. The outline of the stopes in Vestmalmen has been validated by Lisbeth Storhaug and by comparison with old mine maps. In the mine, stopes were measured with an interval of 8-12 meters, and are modelled with abrupt ends on mine maps. This is probably not the case and therefore the stopes in the model do not contain all ore extracted.

The outline of stopes in Ostmalmen has only been measured each 12, 5 and 25 meter. Consequently the true outline and thereby ore extraction is difficult to remodel.
Like in Vestmalmen, strings defining stopes from Ostmalmen were also connected to each other across all levels and directions.

Stopes outline were imported as strings. Like in the case of drifts and ramps, stope strings were cleaned for foldbacks, excessive number of points and duplicate points and the direction was turned clockwise. The strings defining stopes at each level were hereafter copied to a new layer in Surpac and triangulated using triangulation inside segments and triangulate end segments.
The solids created were validated and checked for duplicate triangles, invalid trisolation edges and self intersecting triangles (fig. 5).

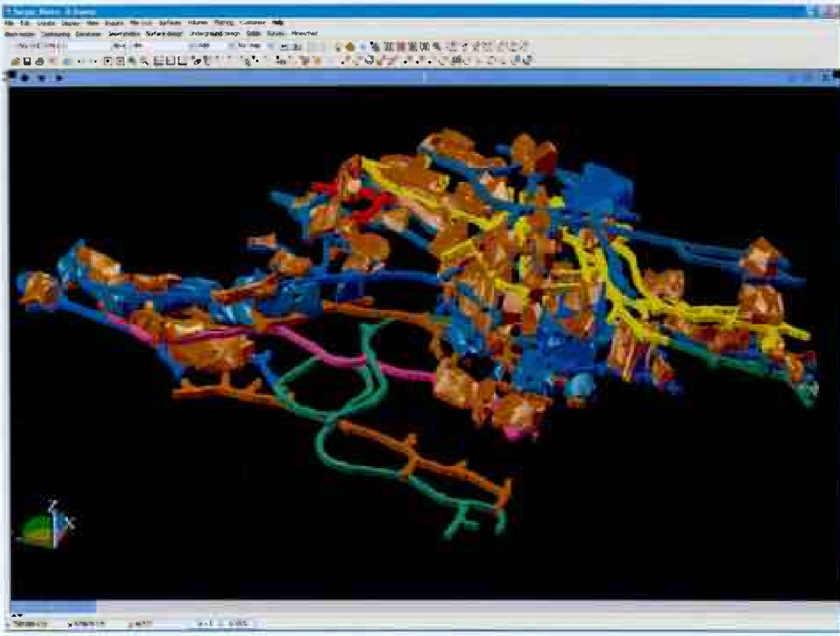


Figure 5: 3D model of drift, ramps and stopes in Vestmalmen.

Resource calculation

As mentioned, NGU (The Norwegian geological survey) made a statistical calculation of the Bruvann Ni deposit showing 43.6Mt, 0.33% Ni, 0.08% Cu and 0.015% Co with a cut off on 0.15%. Of this, 24 Mt is found in Vestmalmen and 19,6Mt in Ostmalmen (Sandvik et. al., 1981).

Falconbridge has validated this calculation and made an additional model with cut-off 0.3% Ni giving resource estimation on 26,6Mt with average 0, 42% Ni (Sandvik et. al. 1981). Comparison with the 8.537Mt, 0.52% Ni mined during mine production, one would expect there to be ore left.

The calculation method used in the mineral resource estimation by Nikkel og Olivin a/s made when the mine was in production, was the conventional section method.

The estimate for Vestmalmen was based on 58 sections at 6, 25 and 12 meter intervals. The weighted distance of influence for each section used was 3.125 and 6.25 respectively on both sides. The mineralized area in each section was divided into subpolygones.

The estimation for Ostmalmen was based on 25 sections at 12, 5 and 25 meter intervals. Like in Vestmalmen, the mineralised area in each section was divided into subpolygones (Storhaug 2000).

The grade of each subpolygon was the weighted average of all samples inside the subpolygon. The weighting method used was assay length, density was not used. The grade of each section was the weighted average of each subpolygon and the tonnage is the sum of tonnages of the incorporated subpolygones (Storhaug 2000).

Between 1989 and 2002 the production was 8.537Mt ore with an average grade of 0.52% Ni (NGU ore database). This include mixing with low grade rocks and mined ore from the open-pit.

The cut-off value at the Bruvann mine was generally 0.45% Ni. Also cut-off 0.40% Ni was used especially in the open pit. Only minor tonnage has been mined with grades between 0.3 and 0.40.

Total production was 32500 ton nickel, 9140 ton cobber and 1500 ton cobalt (NGU ore database).

Resource calculation in this project

The mineral resources calculation in this project is based on nickel values from diamond drill holes and sludge drill holes. The resource calculation was made using ordinary kriging. One large problem in the resource estimation is limited access to yearly production reports.
Further, they have not been turned in to the Norwegian Directorate of Mining after mine closure. It is therefore difficult to resolve the tonnage mined in different parts of the mine.

The resource estimate is based on a 3-D computer block model with nickel block grade estimated into 3 meter x 3 meter x 3 meter high blocks using 1-meter-long drill hole composites. Minimum sample to be included was selected to 25%. Individual string files from Ostmalmen and Vestmalmen were made. Models with bigger block sizes are currently being made.

Prior to compositing the drill hole grades in, high-grade outlier values, above 2%, were cut away based on a variogram plot. Values above 2% nickel do not correlate and show no range of influence. As a general rule, if there is no correlation with a zone of higher values, then the high assay should be reduced to the value of the highest adjacent assay.

Basic statistics show a slightly positive skew distribution of Ni values. Further, a variogram map revealed a slightly anisotropic nature of the deposit.
An omnidirectional variogram was used, where the orientation of sample pairs is irrelevant. The variogram is defined by setting the spread angle to 90. Generally, the omnidirectional variogram will be the "best" or least scattered variogram, as it will contain more data points than a directional variogram. Current work, focus on variogram mapping and finding the major, semi-major and minor directions. Thereby, getting a better resource estimate.

The lag was set to 2, which corresponds to the sample length. The maximum distance was set to 40 but in one case the distance was 10.
Further, an exponential model was chosen, where the entire model is curved, and the sill is a value which the model approaches, but never actually attains.

A concern in the ore estimation is that the range of influence is calculated across fault zones and geological lithologies. Though, the reason for doing so is the very uniform variogram. Large difference across fault zones would normally result in a scattered variogram.
To solve this problem there should be made small block models outlined by fault zones together with a 3D geological model.

Individual block models were made of Ostmalmen, Upper Ostmalm and Vestmalmen due to the major fault separating them.

Vestmalmen

Vestmalmen was calculated using a sill of 0.039, nugget of 0 and range of influence of 17.676 (fig. 6). All values above 2% Ni was cut away prior to the calculation. This should not influence the volume calculation since there is not much nickel with a grade higher than 2% in Vestmalmen. Further, nickel above 2% is likely to have been mined. Though, the total grade will become a little less than observed during mining.

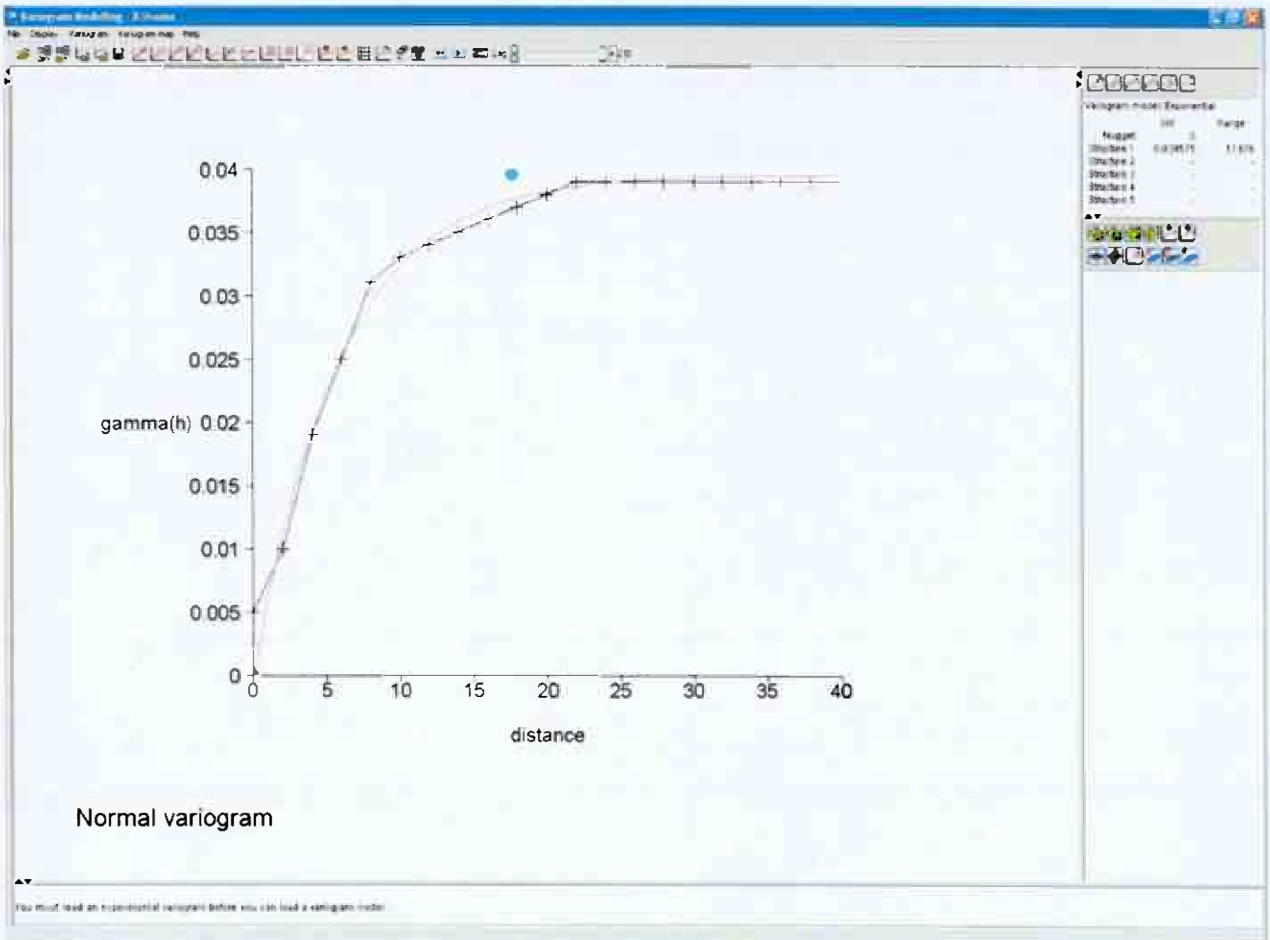


Figure 6: Experimental variogram (black) and modelled variogram (red) used to calculate measured ore in Vestmalmen. Only values below 2% Ni. Lag was set to 2 and distance was 40.

The calculation gave the following measured ore extracting stopes and drifts. Measured ore is inside 2/3 of the range of influence (table 1 + fig. 7).

Cut-off (Ni %)	Measured ore (t)	Grade (Ni %)	2/3 Range of influence
0,3	6174156	0,3869	< 11,784
0,35	3789158	0,4266	< 11,784
0,4	2093931	0,4695	< 11,784
0,45	1030627	0,5185	< 11,784
0,3-0,45	5143528	0,3605	< 11,784

Table 1: Showing the measured resource size at a cut off 0.3%, 0.35%, 0.4% and 0.45% Ni respectively.

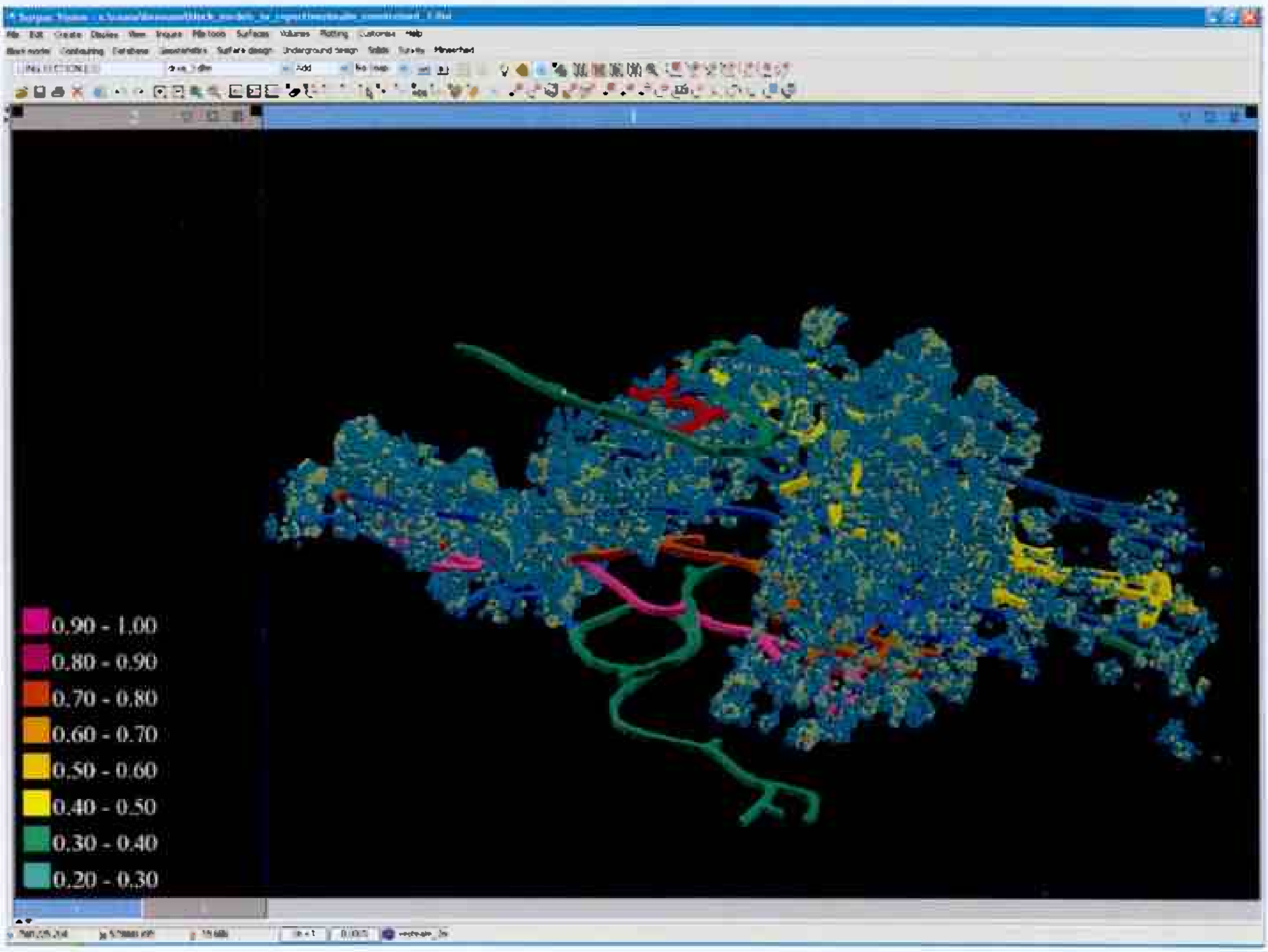


Figure 7: Block model of Vestmalmen showing the ore still in the mine after extracting stopes and drifts. Block size is 3x3x3m. Further, drifts in Vestmalmen can also be seen.

As can be seen in table 1 there is 1.03Mt with cut-off 0.45% Ni left. This is not very likely since this would correspond to the production of about 1½ years (table 2). The production from Vestmalmen is approximately a total of 4Mt including mixing with low grade ore (appendix 2). In this model there are 2,471Mt ore with cut-off 0.45% Ni in the stopes. Further, there are 0.2Mt in stopes at level -20 and -35 (Longhole drilling data). This resource of 2.77Mt together with 1.03 in the ore reserve calculation and mixing with low grade rocks will sum close to 4Mt.

Though, it is a conservative calculation since there would possibly be some ore with 0.45% Ni in the pillars.

The measured ore estimated to be back in the mine is what is left between 0.3% Ni and 0.45% Ni after subtracting ore with this grade in stopes and drifts. This estimate is 5.14Mt (table 1).

But why is it not possible to re-construct the mined material in the stopes. Even though the stopes have been validated by Lisbeth Storhaug they might not outline the whole area mined. As mentioned earlier, stopes have not been surveyed very accurately. Secondly, if not all drill hole data have been received block model values will not become true. These problems will have a high priority in the future work.

The resource calculation does not include level –35 and -20 since they have been filled with waste. Early made block models have shown that this area is not completely mined. This is confirmed by Lisbeth Storhaug (pers. com.). Further, she is of the opinion that these levels should undergo further exploration drilling.

Year	Ore Production (t)	Amount of mixed waste rock (t)	Total Production (t)
1989	Unknown	Unknown	154000
1990	Unknown	Unknown	476000
1991	Unknown	Unknown	649000
1992	Unknown	Unknown	669000
1993	Unknown	Unknown	676000
1994	Unknown	Unknown	663000
1995	538892	144614	683506
1996	577207	155594	732801
1997	506523	102755	609278
1998	540166	148733	688899
1999	Unknown	Unknown	647031
2000	Unknown	Unknown	708296
2001	465379	263023	728402
2002	443382	42260	485642
Total			8570855
Average			612204

Table 2: Production numbers from 1989 (mine opening) to 2002 (mine closure). The table is a resume of appendix 3 and 4.

Ostmalmen

As a first estimate Ostmalmen was calculated using sill of 0.096, nugget of 0.0008 and range of influence on 8.342. Lag is 1 and distance is 10 and all nickel above 2% has been removed (fig. 8).

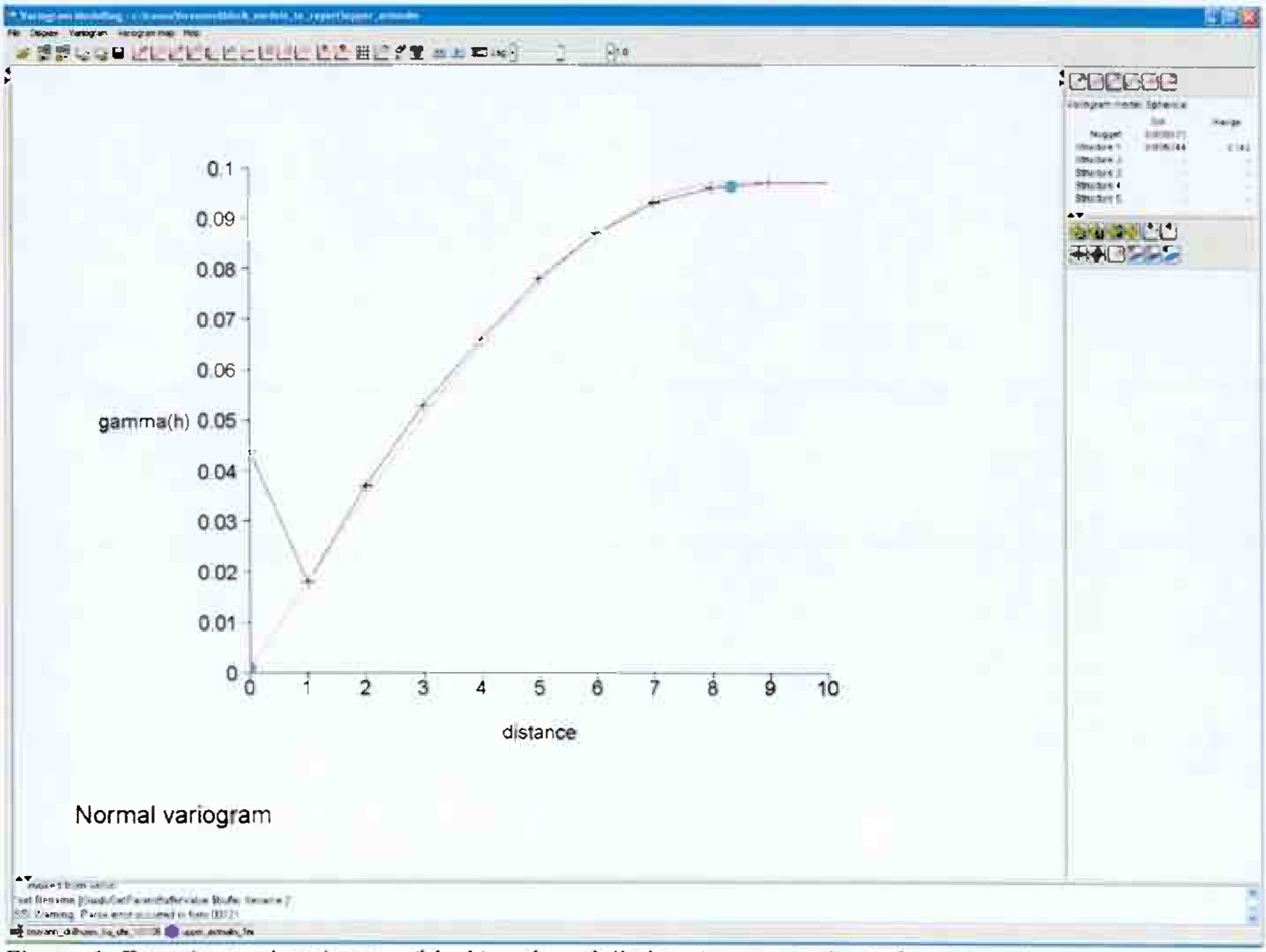


Figure 8: Experimental variogram (black) and modelled variogram (red) used to calculate Ostmalmen. Nickel values used were below 2%. Lag was set to 1 and distance was 10.

This calculation showed ore grade left in the mine of 0.71% Ni at cut-off 0.45%. This is most likely not the case.

A new variogram model was then made with Ni values below 1%, sill of 0.033, nugget of 0.001 and range of influence of 18.358 (fig. 9).

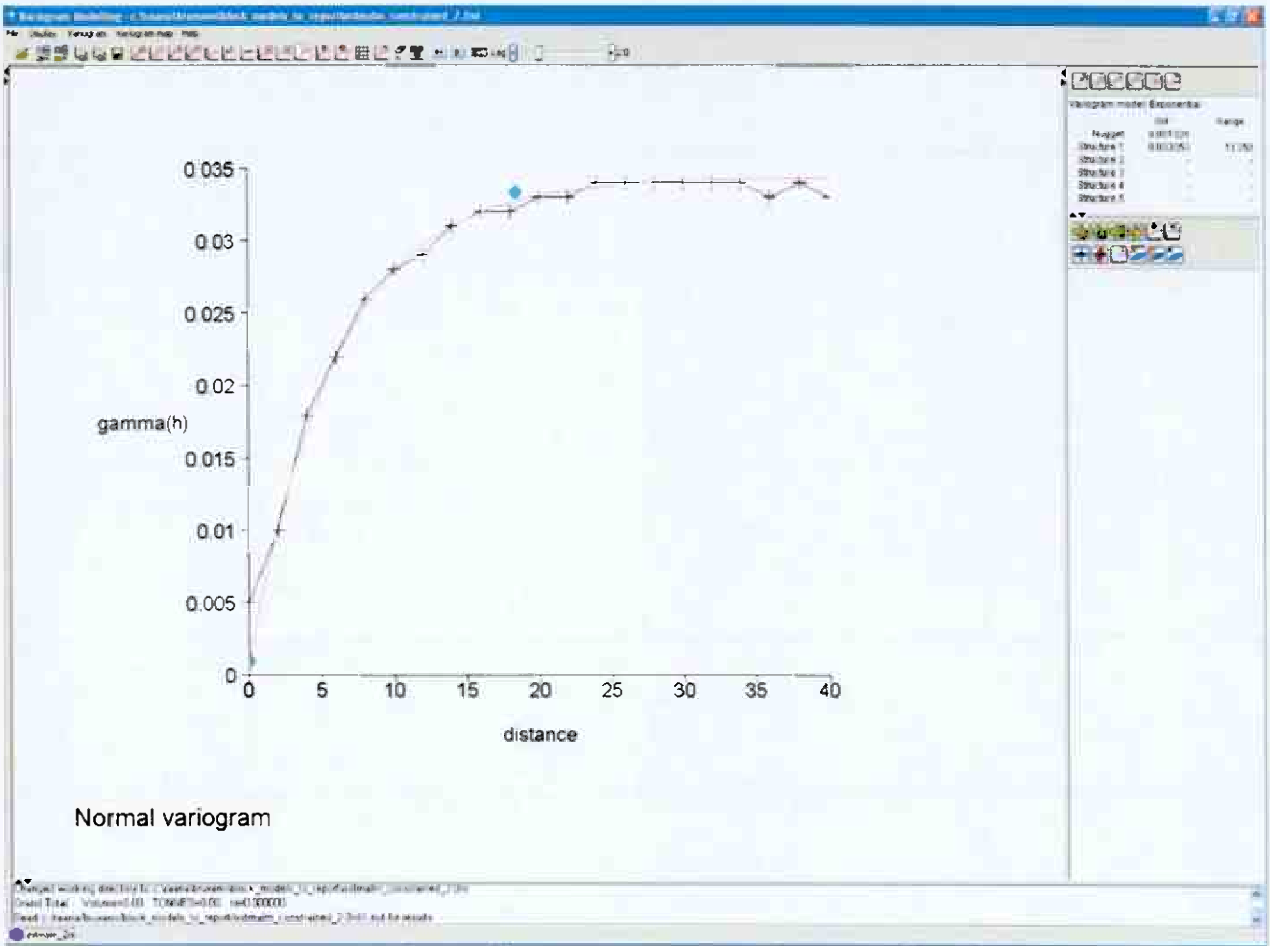


Figure 9: Experimental variogram (black) and modelled variogram (red) used to calculate the measured ore in Ostmalmen. Nickel is below 1%. Lag was set to 2 and distance was 40.

This calculation gave the following result (table 3 + fig. 10).

Cut-off (Ni %)	Measured ore (Mt)	Grade (Ni %)	2/3 range of influence
0.3	7,1	0,44	< 12,238
0.35	4,57	0,48	< 12,238
0.4	3,36	0,52	< 12,238

Table 3: Resource calculation of measured ore at cut-off 0.3, 0.35 and 0.40% Ni.

At the time of mine closure it is highly unlikely that this tonnage should be left in the mine since the cut-off was 0.45. Visual validation of block model and stopes shows that a large amount of blocks with massive ore around level 246, 270 and 300 is not included in the stopes. Looking at mine maps and stope design does not clearly show stopes in this area.

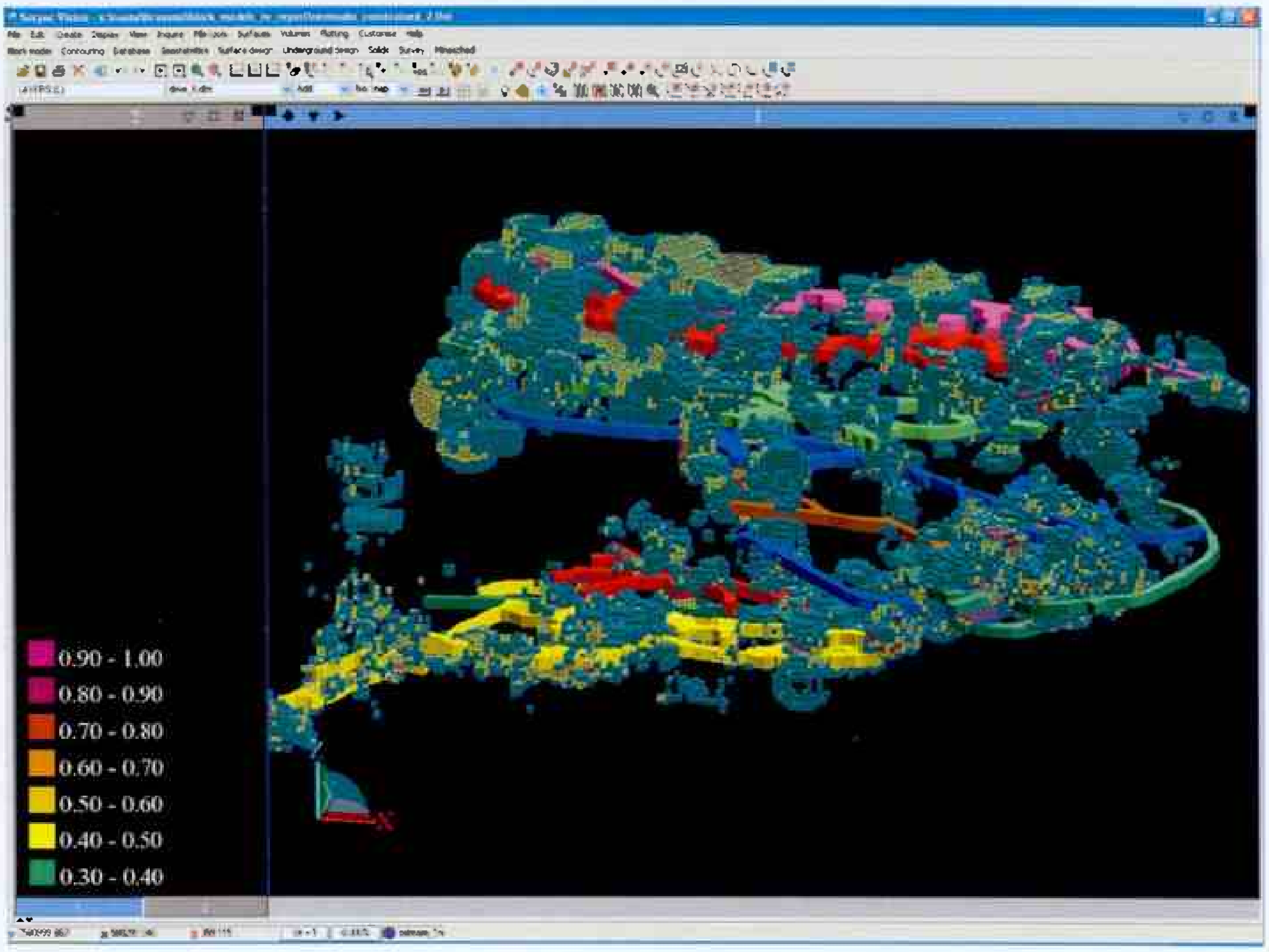


Figure 10: Block model of Ostmalmen showing ore in the mine after extracting stopes. As it can be seen there are high nickel values especially on the lower right side of the model. Block sizw is 3x3x3m. Further, drifts in Ostmalmen are shown.

To test the model, all nickel tonnage was calculated subtracting all nickel with a cut-off above 0.45% (table 4).

	Measured ore (t)	2/3 range of influence
All resources	166344333	< 12,238
All resources below 0,45% Ni	163617380	< 12,238
Resource size above 0,45% Ni	2726953	

Table 4: Measured ore from Ostmalmen.

The value of 2.73Mt ore above 0.45% Ni is probably close to the total mined tonnage. Mixing this with low grade rocks would, raise the mined ore to about 3.4Mt (table 2).

Together with the open pit (estimated to be 0.75Mt), Upper Ostmalm (see later) and Vestmalmen the total mined amount in this model would be 8.45Mt. Total mined tonnage during mining was 8.537Mt (table 2 + appendix 2).

Calculating the measured ore left (extracting stopes and drifts together with all nickel above 0.45%) gives the following result (table 5):

	Tonnage(t)	Grade (Ni %)	Measured ore (2/3 of range of influence)
Ore between 0.30 and 0.45 % Ni	3692777	0,3675	< 12,238

Table 5: Measured ore in Ostmalmen with grade between 0.3 and 0.45% Ni.

Upper Ostmalm

A few stopes are placed in the most eastern part of Ostmalmen, the 420 and 440 levels. There has been made a separate block model for this area (fig. 11). Range of influence is 12.11, lag is 2 and distance is 40.

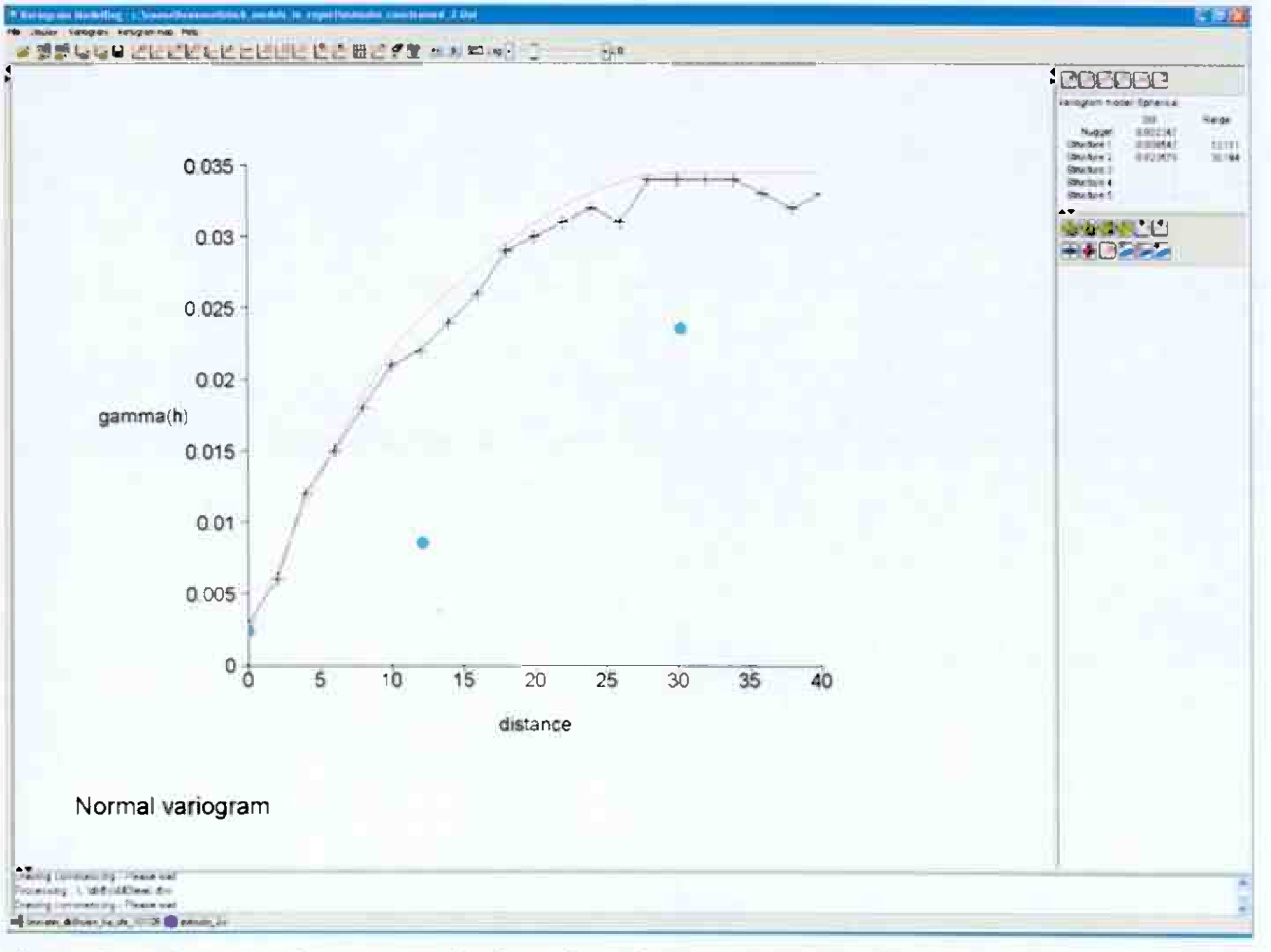


Figure 11:Variogram used to calculate block model at the upper Ostmalm. Experimental variogram is black and modelled variogram is red. Lag was set to 2 and distance was 40.

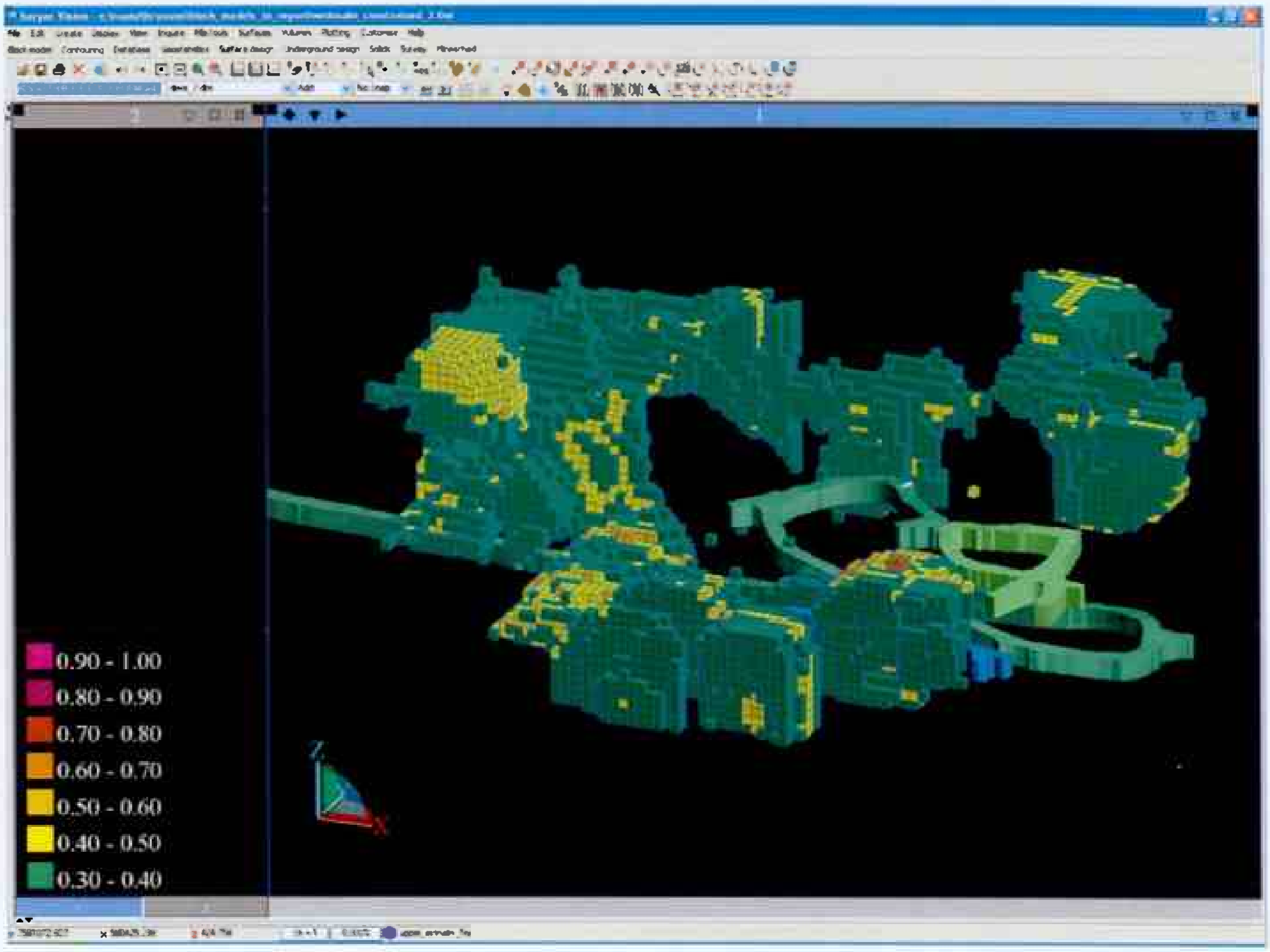


Figure 12:Block model of Upper Ostmalm showing ore still in the mine together with drifts. Block size is 3x3x3m.

The grade has only been calculated in the interval between 0.3 and 0.45 because of the equal problems observed in the Ostmalm block model (table 6 + fig. 12).

	Measured ore (t)	Ni %	2/3 range of influence
Grade between 0.3 and 0.45%	317242	0.3722	< 8

Table 6: Nickel left in Upper Ostmalm between 0.3 and 0.45%.

Validation of block models

The grade models have so far been validated by visual methods. The block model was sliced up into corridors, based on easting and northing values. The grade of the blocks in the model within each corridor was compared to the grade of the composite samples within the corridor, to ensure the model honours the trends in the data.
This process has not shown a particular good correlation between Ni values in drill holes and Ni values in the block model. Further, the block model should be validated geostatistically.

Future work and recommendation

It is suggested that a geostatistical validation of the project should be made. This will be done in connection with participation in geostatistical training held by Snowden, which is one of the world leading consultants in resource evaluation, and Surpac.

A concern in the ore estimation is that the range of influence is calculated across fault zones and geological lithologies. Though, the reason for doing so is the very uniform variogram. To solve this problem there should be made small block models outlined by fault zones and geology.

Further validation of stopes and drill holes will take place.

Levels -20 and -35 should be part of the model because they possible are not mined out.

To get a solid validation of the ore reserve left, it is proposed that a consultant in ore reserve estimation is connected to the project.

Conclusion

Remaining measured ore in the Bruvann mine is 9.15Mt nickel with a grade of 0.364%. The remaining copper tonnage is approximately ¼ of this, resulting in 2.287Mt Cu.

The Bruvann Ni mine is situated only 40 kilometres from Narvik in northern Norway close to a harbour, European interstate road E6, and with all infra structure intact around the mine. This will clearly lower expences if mining is started again. Further, if it is possible to leach the nickel out of the rocks this will lower the expenses even more.

All data have been transformed from coordinate system NGO 1948 (V) to WGS 84, UTN 32.

All drifts, ramps and stopes have been modelled from the data received. They have all been validated in Surpac and show no internal failures. Therefore, they can be used to extract mined ore in the resource model.

Validation of the mine structures (drifts, stopes and ramps) in Vestmalmen has been done analysing mine maps as well as consulting Lisbeth Storhaug, former geologist at the Bruvann Ni mine. Still, they might not have the true outline. Stopes in Ostmalmen have been compared with mine maps but have so far not been validated by Lisbeth Storhaug.

References

NGU-malmdatabasen (deposit no. 1854.008):
http://aps.ngu.no/pls/oradb/!minres_dsp_deposit.link_object?p_sprakobjid=N0000002444

Sandvik, K. L., Brekke, O., Boyd, R. and Mathiesen, C. O. 1981: Rapport fra det forberedende Rånautvalg. Forslag til utredningsplan og budsjett. 23pp.

Storhaug, L. 2000: Ore Reserve Statement of Nikkel og Olivin a/s. pp13.

Appendix 1

Density of the samples, Western ore body

Nikkel og Olivin AS
Markus Ekberg

16.1.94

DENSITIES OF THE SAMPLES, WESTERN ORE BODY

Drill hole	Depth	Pol.section	Core sample	Ni HNO3	Density	Sample
R-7-93	142,5	X		0,58	3,41	93-31045
R-7-93	155,0	X		0,68	3,42	93-31052
R-7-93	169,0		X	0,61	3,44	93-31059
R-8-93	137,0	X		0,54	3,39	93-31114
R-8-93	143,2	X		0,54	3,41	93-31118
R-8-93	138,0		X	0,60	3,39	93-31115
R-9-93	95,0	X		0,64	3,40	93-31127
R-9-93	101,5	X		0,67	3,41	93-31131
R-9-93	106,5		X	0,42	err (2.85)	93-31133
R-9-93	117,6	X		0,66	3,38	93-31138
R-10-93	125,0		X	0,50	3,44	93-31176
R-10-93	126,3	X		0,48	3,44	93-31177
R-10-93	141,0		X	0,52	3,41	93-31184
R-10-93	150,5	X		0,62	3,38	93-31189
R-10-93	163,0		X	0,78	3,41	93-31195
R-10-93	164,5	X		0,69	3,43	93-31196
R-11-93	169,0		X	0,56	3,29	93-31259
R-11-93	183,0		X	0,64	err (3.12)	93-31266
R-11-93	207,0		X	0,59	3,38	93-31278
R-12-93	103,0		X	0,55	3,32	93-31300
R-12-93	109,0		X	0,71	3,42	93-31303
R-13-93	105,0		X	0,54	3,31	93-31330
R-13-93	113,0		X	0,58	3,32	93-31334
R-13-93	127,0		X	0,56	3,41	93-31341
R-14-93	57,6		X	0,39	3,44	93-31348
R-14-93	94,0		X	0,45	3,39	93-31360
R-14-93	110,0		X	0,59	3,47	93-31364
R-15-93	112,0		X	0,67	3,41	93-31394
R-15-93	120,0		X	0,38	3,29	93-31398
R-15-93	132,0		X	0,56	3,40	93-31404
R-15-93	142,0		X	0,65	3,43	93-31409
R-16-93	120,0		X	0,44	3,39	93-31433
R-16-93	148,0		X	0,63	3,42	93-31477
R-16-93	157,0		X	0,58	3,40	93-31451
R-18-93	114,0		X	0,55	3,34	93-31493
R-18-93	126,0		X	0,56	3,36	93-31499
R-19-93	106,0		X	0,39	3,37	93-31591
R-19-93	118,0		X	0,54	3,38	93-31597
R-20-93	142,0		X	0,48	3,34	93-31630
R-20-93	151,0		X	0,56	3,37	93-31635
40				0,567	3,390	

Appendix 2

Ore production from the Vestmalm 1994-1999

Nikkel og Olivin AS
M Ekberg

14-Jan-00

Ore production from the Vestmalm 1994-1999

	Longhole	Corr	Drifting in the ore	Decline in the ore	Total	Ni	Mine rec	Mill rec	Ni-tonnes	Prepared by
1994	0	0	0	0	0					
1995	130000	52814	196202	4790	383806	0.52%				
1996	403850	76021	141598	354	621823	0.51%				
1997	367650	57379	110256	0	535285	0.54%				
1998	448213	56023	145575	0	649811	0.58%				
1999	526619	72054	44265		642938	0.54%				
	1876332	314291	637896	5144	2833663	0.54%		74.62%	11420	
Production from the Vestmalm 2000					600000	0.52%		73.00%	2278	Ekberg-Brusila-Storhaug
Total production from the Vestmalm					3433663	0.54%	77.16%	74.34%	**13697**	

Resources and reserves in the Vestmalm

Total In-Situ Mineral Resource 28.7.1992 (undiluted, cut off 0.45%)	3905000	0.58%	75.00%	74.00%	12570	M Ekberg	27NGU surface holes
Total In-Situ Mineral Resource 29.10.1994 (undiluted, cut-off 0.4%)	5767000	0.55%	75.00%	74.00%	17604	M Ekberg	27NGU+72ug holes
Total In-Situ Mineral Resource 29.10.1994 (undiluted, cut-off 0.5%)	3605000	0.61%	75.00%	74.00%	12205	M Ekberg	27NGU+72ug holes
Mineable Mineral Resource 29.10.1994 (75% mine rec, 20%WRD,cut-off 0.5%)	3240000	0.55%		74.00%	**13187**	M Ekberg	27NGU+72ug holes
Mineable Ore Reserves 29.10.1994 Main Ore (75% mine rec, 20% WRD, cut-off 0.5	2860000	0.55%		74.00%	**11640**	M Ekberg	27NGU+72ug holes
Production plan 29.10.1994 (cut off 0.5%, prod 1995-5/2000)	3250000	0.55%		74.00%	**13228**	M Ekberg	27NGU+72ug holes

In-Situ Resource 6.1.1999 incl. mined and abandoned areas + reserves, cut-off 0.45	4450000	0.54%	77.16%	74.62%	**13836**	L Storhaug 2000++	holes

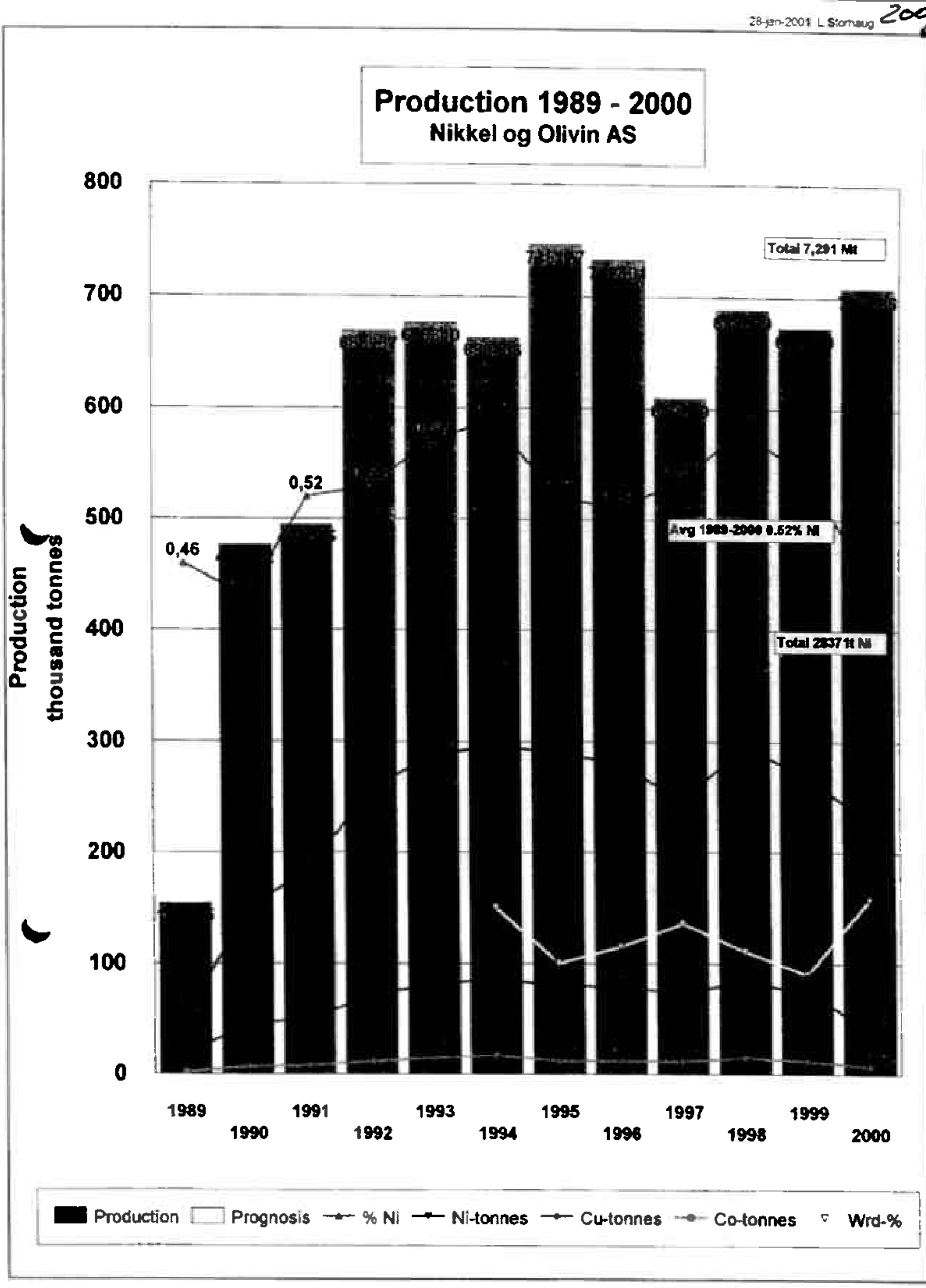
Mine technical recovery until 12/1999 (2.8 Mt/4.45 Mt)	63.68%
Mine technical recovery until 12/2000 (2.8Mt+.6Mt)/4.45Mt)	77.16%

Ni-tonnes for the 1992-1994 resources calculated using planned mine and mill recovery (75% and 74%), Ni-grade is undiluted (Ni-tonnes too high)!!
Copy:VH, KB, JB, LS

Appendix 3

Production 1989-2000

28-jan-2001 L Stornaug 2000 REPORT



file o:\123data\year2000\Ores2000\Produks_Ni_Cu_Co 123

Appendix 4

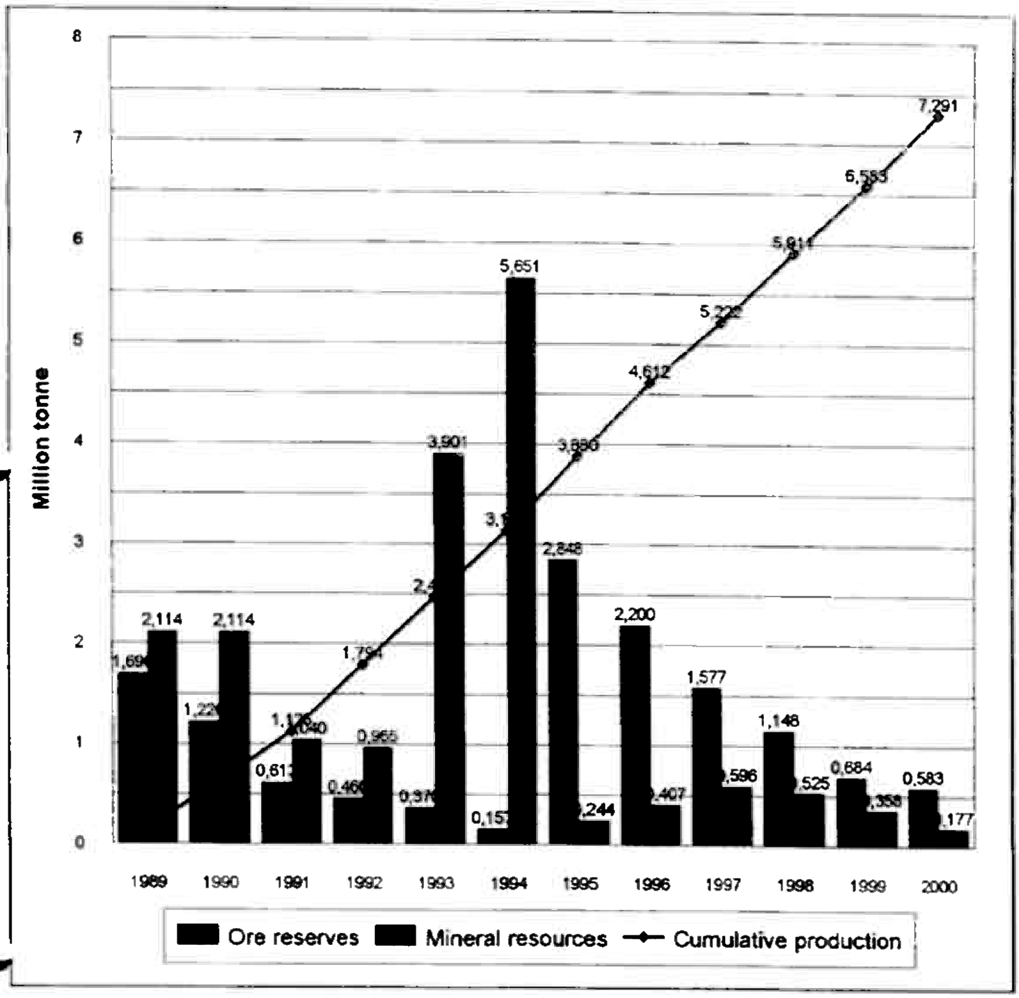
Ore reserves and mineral
resources at the end of the year (2000).

2000 REPORT

Nikkel og Olivin AS
L.Storhaug

28-jan-2001

Ore reserves and mineral resources at the end of the year



	Ore reserves Mt	Mineral resources Mt	Total	Ni %	Prepared by	Cumulative production Mt
1989	1,696	2,114	3,810	0,62	M Motys	0,154
1990	1,220	2,114	3,334	0,50	1989-prod	0,630
1991	0,613	1,040	1,653	0,50	Ø. Pettersen	1,125
1992	0,460	0,965	1,425	0,55	Ø. Pettersen	1,794
1993	0,370	3,901	4,271	0,59	M. Ekberg (incl Vestmalm)	2,470
1994	0,157	5,651	5,808	0,55	M. Ekberg (incl Vestmalm)	3,133
1995	2,848	0,244	3,092	0,52	M.Ekberg/L.Storhaug	3,880
1996	2,200	0,407	2,607	0,55	M.Ekberg/L.Storhaug	4,612
1997	1,577	0,596	2,173	0,54	M.Ekberg/L.Storhaug	5,222
1998	1,148	0,525	1,673	0,51	M.Ekberg/L.Storhaug	5,911
1999	0,684	0,358	1,042	0,51	L Storhaug	6,583
2000	0,583	0,177	0,760	0,50	L Storhaug	7,291

Oreres1989_2000.WK4

Additional notes

Further Ni potential.

Future Potential.

Investigation of Ni values in all drill holes has shown a number of areas with ore potential.

Especially three places should be further investigated. The areas are seen outlined by a green, blue and red string in fig. 1. These three areas either show high Ni values in exploration drill holes or are poorly defined.

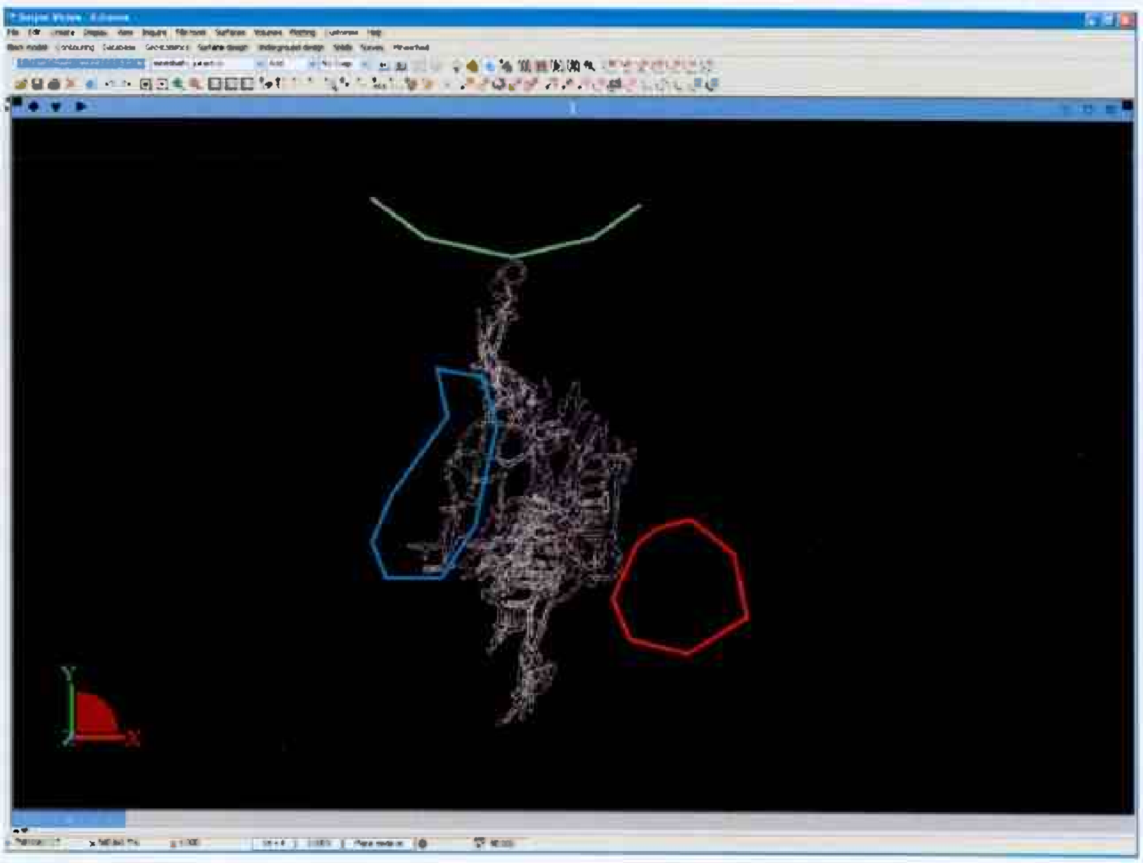


Figure 1: Outline of drifts and ramps in vestmalmen (white) and areas with high Ni potential. Green line is defining the area north of Vestmalmen, which is very poorly defined. Red and blue lines are defining areas where drill hole data show high Ni values.

The first area is the eastern part of the Vestmalm (red area fig. 1). Here, three drill holes (R-57-94, R-66-94 and BH-235-160) show Ni values up to 0.92% Ni (fig. 2). To calculate the volume between these three drill holes a solid was made which outline this area (fig. 3). The volume has been calculated to be 71106m³ which corresponds to an ore tonnage of 241049t (table 1). Further, it is very likely that this area expands beyond the drill holes.

This part of the mine area has not been mined but should be easily accessed from level 0 or 20.

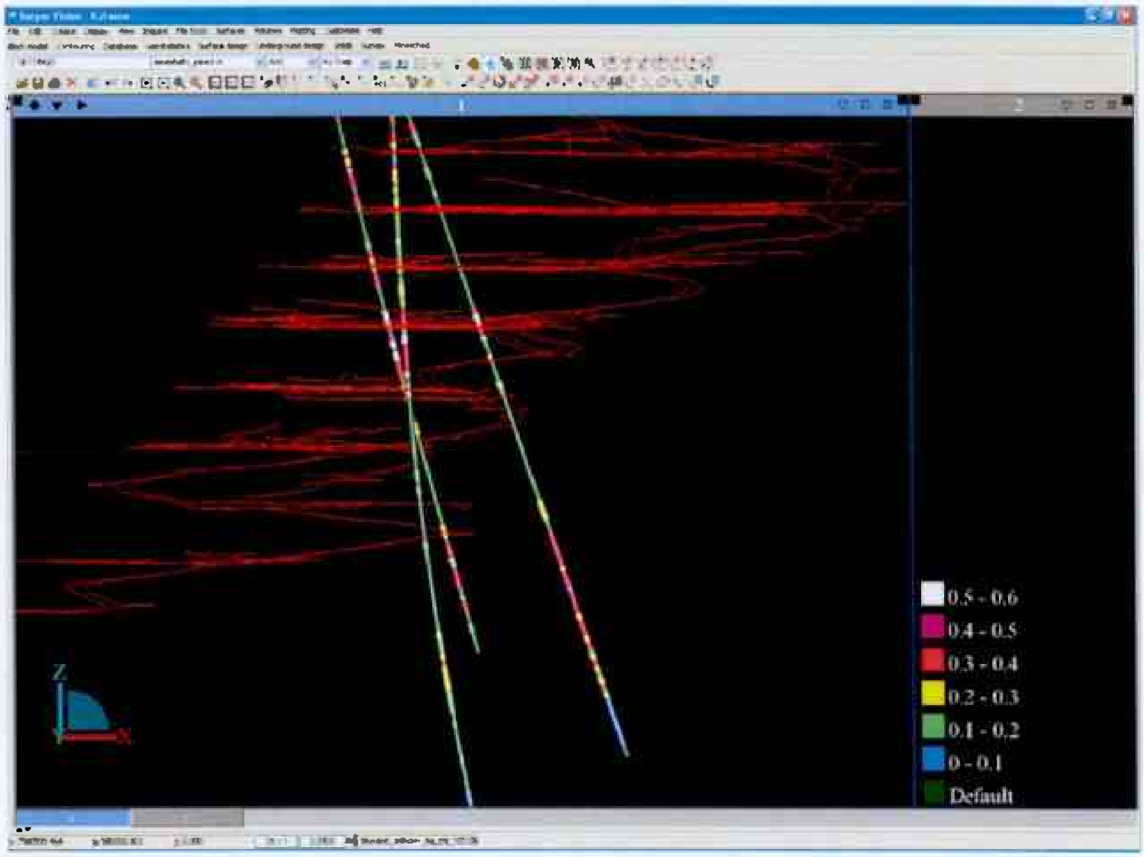


Figure 2: Drill hole R-57-94, R-66-94 and BH-235-160 together with drift outline from Vestmalmen. As can be seen towards the end the three drill holes have values between 0.1 and 0.6% Ni. This area has so far not been mined.

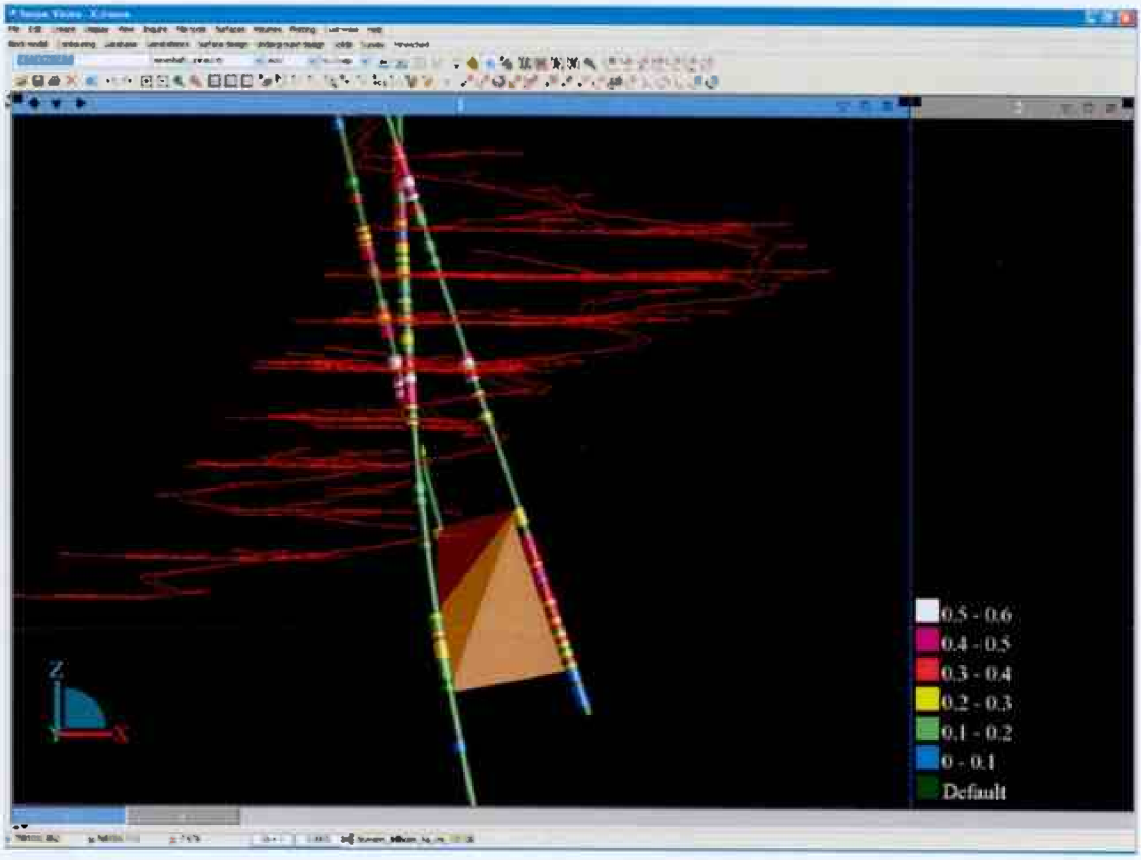
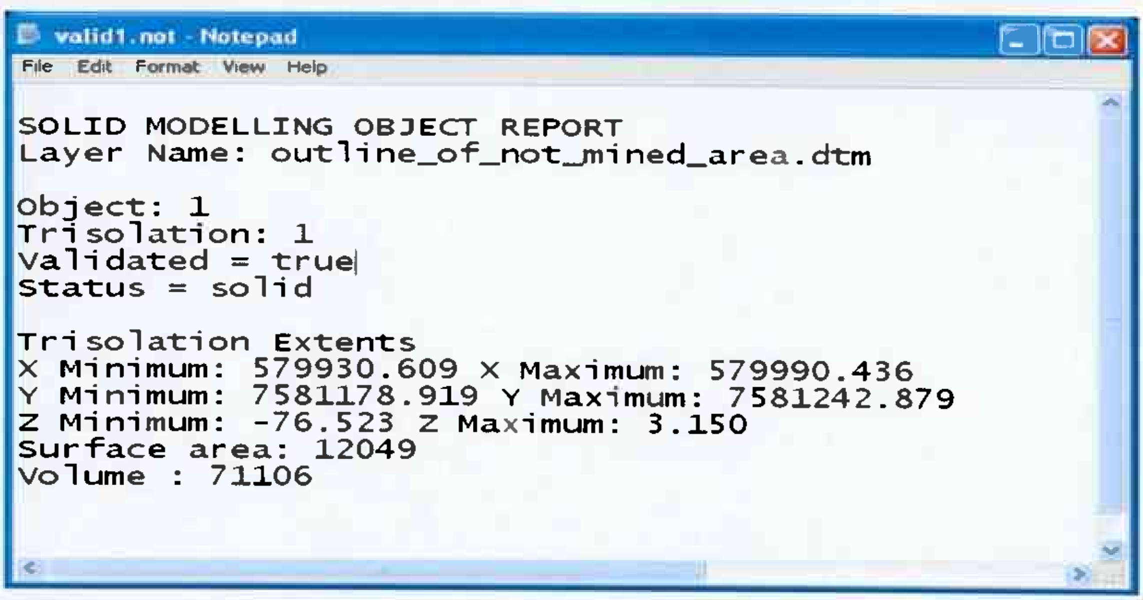


Figure 3: A solid outlining the area between drill hole R-57-94, R-66-94 and BH-235-160 where the high Ni grad is.



valid1.not - Notepad

File Edit Format View Help

```
SOLID MODELLING OBJECT REPORT
Layer Name: outline_of_not_mined_area.dtm

Object: 1
Trisolation: 1
Validated = true
Status = solid

Trisolation Extents
X Minimum: 579930.609 X Maximum: 579990.436
Y Minimum: 7581178.919 Y Maximum: 7581242.879
Z Minimum: -76.523 Z Maximum: 3.150
Surface area: 12049
Volume : 71106
```

Table 1: Volume calculation of the, solid on figure 2. The volume is calculated to be 71106m^3. The tonnage in this area would be 71106m^3 x 3.39g/cm^3 (density) which equals 241049t.

The second area is north of Vestmalmen which is outlined by the green line (fig. 1). The northern border of the Vestmalm is very poorly defined. Both exploration drill holes made from the earth surface and production drill holes made during mining do not give concluding evidence about where the ore ends. This is especially seen at the end of level 20, 40 and 60 (fig. 4 and 5).

All drill holes in this area show good Ni values. The area between the drifts has been mined but there is no indication that the ore should fade out at the end of the drifts.

Since this area is a continuation of the old drifts at level 20, 40 and 60 it would be easy to get access to them by conventional mining methods and expenses would be low. Possibly, closure of the mine did stop this area from further exploration.

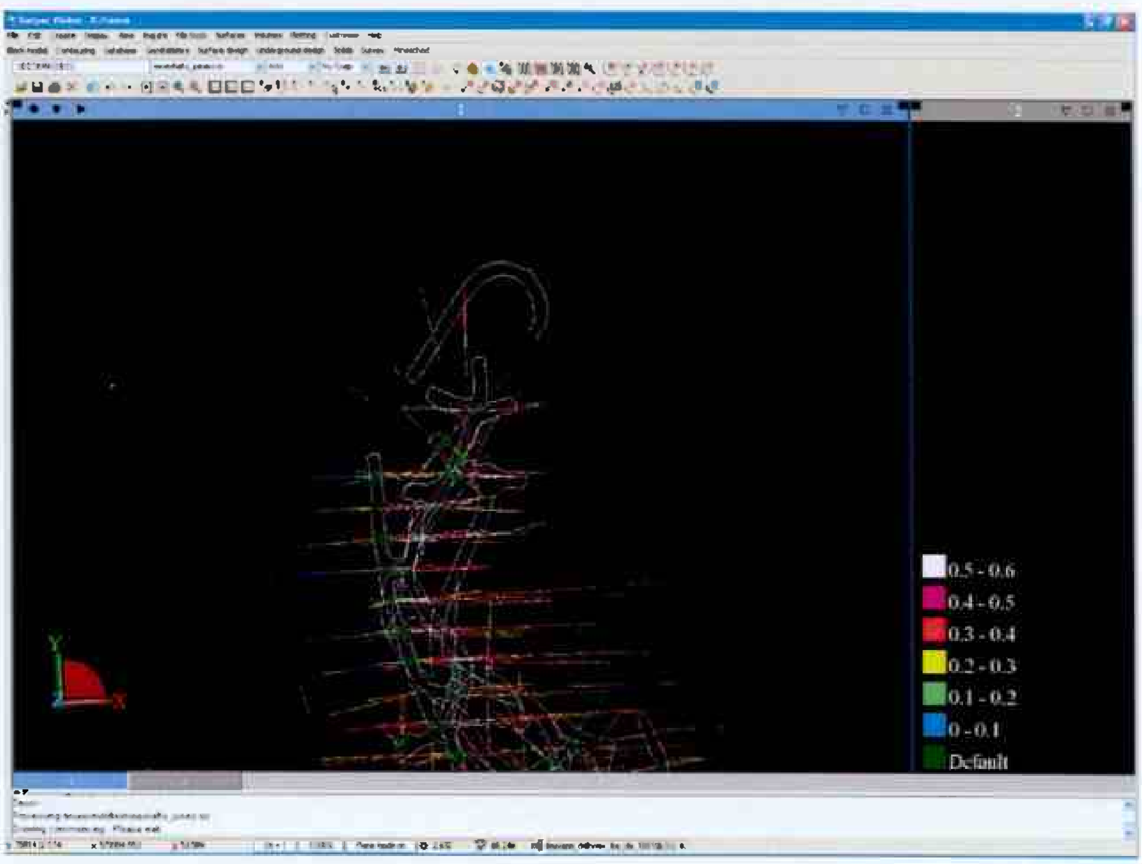


Figure 4: Most northern part of Vestmalmen. This part of the mine is very poorly constrained (blue line) by exploration drilling.

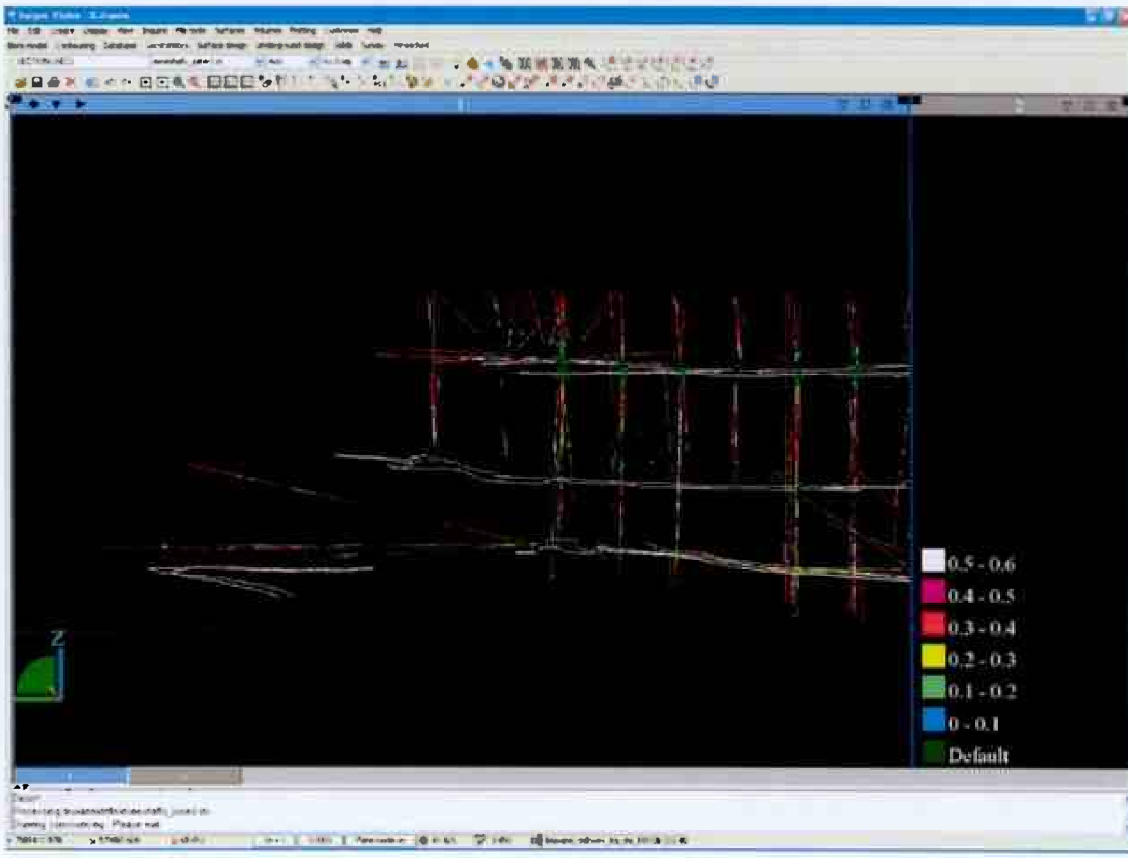


Figure 5: Same area as seen in figure 3, but vertical. Ni values close to the end of drill holes still show high grade (up to 0,5).

Area 3, which is the blue area in figure 1, lies just below level -20 and -35 at the bottom of the Vestmalm. As it can be seen on figure 6, the drill holes posses Ni values up to 0.6%. Especially the three drill holes at the end of level -35 (to the right on fig. 6) have high values. These areas have not been mined and like the case with level 20, 40 and 60 this ore lies as an extension of already existing drifts. Therefore, access to this area should be easy. Further, former geologist at the Bruvann mine Lisbeth Storhaug has confirmed that this area is a possible target for further mining.

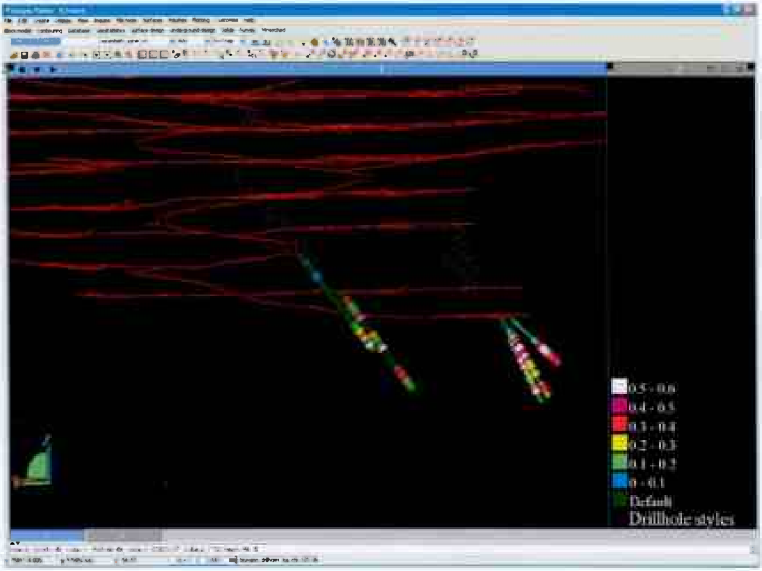


Figure 6: Drill holes in the lower part of Vestmalmen (level -35). Also there is clear evidence of high values up to 0.6% Ni.