# Welcome to Kiruna

Overview of the underground mine in Kiruna

Enrique Povea Gonzalez

# Who we are

- **Enrique Povea Gonzalez,** Mid Term Planner Kiruna mine, LKAB
  - **Mining Engineer**
  - **Worked in mining industry for 9+ years:**
    - Underground Copper Mine, Sublevel Stopping: Drill & Blast Supervisor, ST Planner MOC
    - Underground coach & safety trainer
    - Underground Iron Mine, Sublevel Caving: Mid Term Planner
  - **Companies:** SandFire Matsa - Minas de Aguas Teñidas, IPH Ingenieria y Proyectos Huelva, LKAB
  - Enrique.poveagonzalez@lkab.com

- **Theofanis Apeslidis**, Group manager mine planning Kiruna mine, LKAB
  - **Mining engineer** NTUA, M. engineer
  - **Worked in mining industry for 16+ years** in several roles : safety, production, planning, supervising
  - **Companies**: Hellas Gold, Fhl Kiriakidis, Ariston Melathron, Edilmac, LKAB
  - theofanis.apeslidis@lkab.com
  - Theofanis Apeslidis | LinkedIn

# Summary

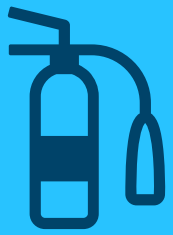
- Safety
- LKAB's Values
- Location - Operations
- Mining Method - SLC
- Machinery
- Design & Planning
- Final Products

LKAB

# Safety First

# Safety first!

Rescue Chamber



Fire extinguisher

Heart defibrillator

Evacuation routes

Reassembly location

# Rescue Chamber

A refuge chamber is a sealed environment built to sustain life during an emergency or hazardous situation.

They provide a secure area with shelter, water, and breathable air, where personnel can remain until rescued, or the hazard subsides.

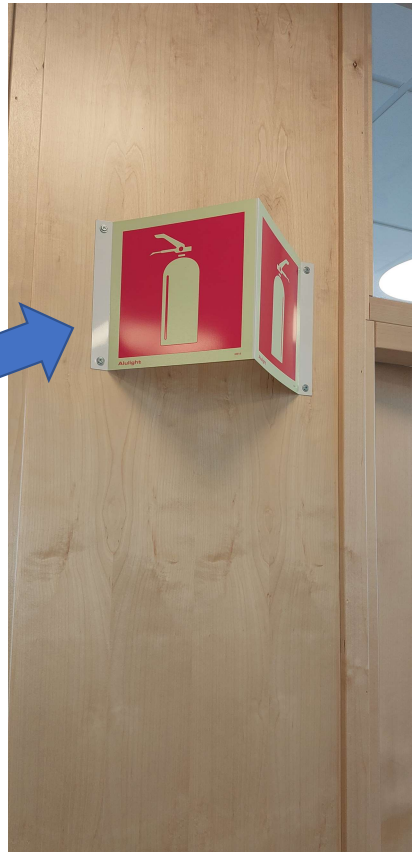
**In case of emergency and not being able to use the escape routes, look for these signs to find the way to the Rescue Chamber**

# Fire extinguisher

A fire extinguisher is a handheld active fire protection device usually filled with a dry or wet chemical used to extinguish or control small fires, often in emergencies.

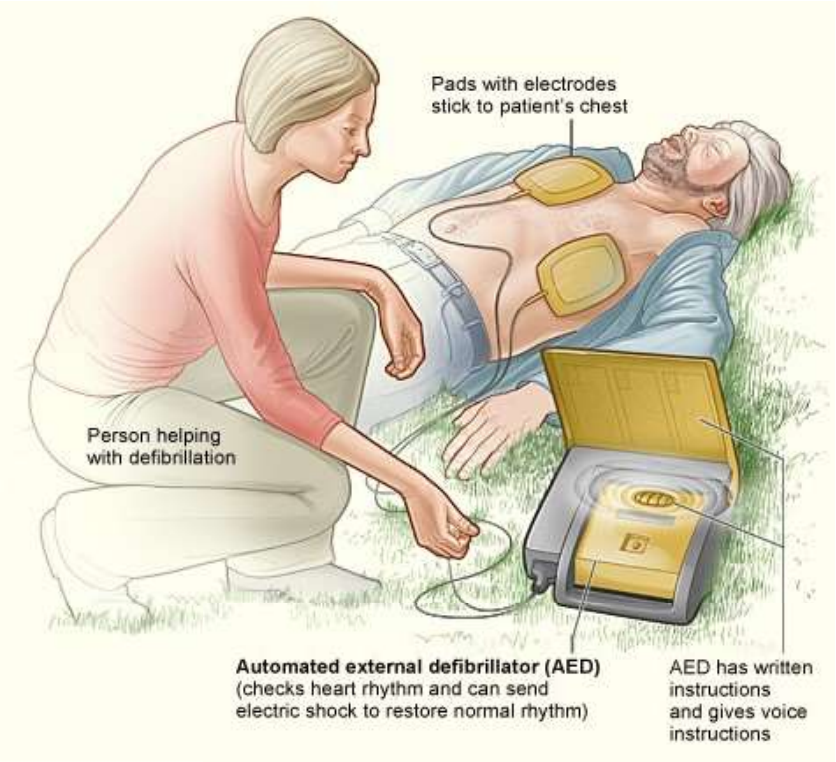
It is not intended for use on an out-of-control fire.

**In case of need, try to look for the signal that indicates that there is a nearby fire extinguisher.**



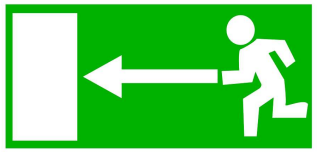
# Heart Defibrillator

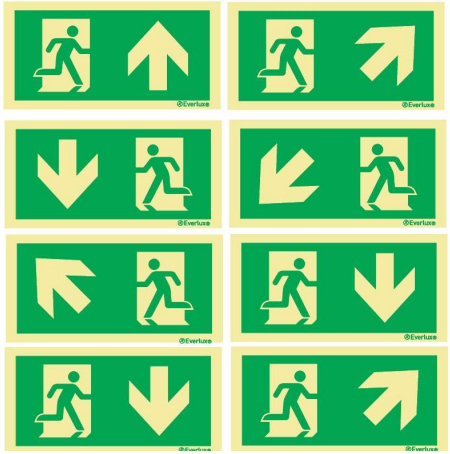
Defibrillators are devices that send an electric pulse or shock to the heart to restore a normal heartbeat.




You can find them either underground and in the LKAB´s offices.

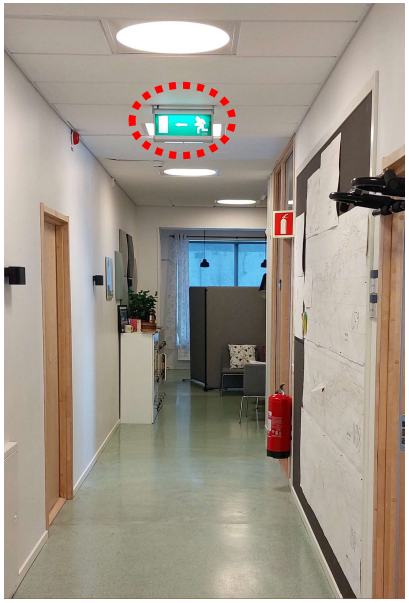
# Evacuation routes





**LOOK FOR THIS SIGNS AND FOLLOW THE INDICATED ROUTE**

# Evacuation routes

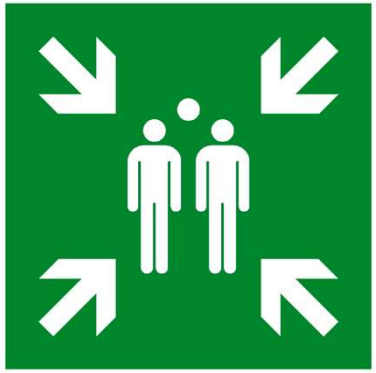


# Evacuation routes

**Also, you can find this maps which indicate where you are and what is the evacuation routes.**

**Get familiar with them at your workplace**

# Emergency assembly location



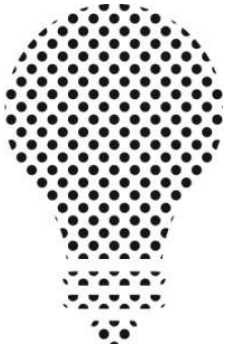
We have a location designated as the place for a group to meet or for people to gather in an emergency.

Ask to know where is it and get familiar with the route from your workplace

# LKAB's Values

# LKAB's Values

**Commitment** means that we focus on our customers' results in everything we do



**Innovation** means that everything can be improved if we dare to think along new lines.

**Responsibility** means that we adopt a long-term approach, show respect and put safety first.

# Location

# Norrbotten, Sweden

# MINING OPERATIONS

## OUR MOST IMPORTANT RESOURCE

The iron ore that LKAB mines in northern Sweden, is among the richest in the world.

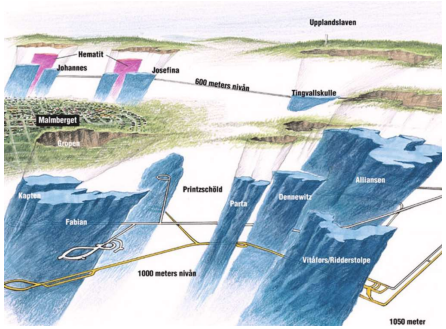
### Kiruna (Underground)

The orebody in the Kiruna mine is:

- ~ 4Km long sheet like intrusion at least 2Km into the ground
- Striking in N-S direction
- In average 80-100m thick
- Dip ~ 65 ° E
- Plunge ~ 45 ° N
- $Fe_3O_4$ (Magnetite)

On surface there is processing plant with enrichment and pellet production. In Kiruna, both blast furnace pellets and pellets for DRI are produced by direct reduction.

### Malmberget (Underground)




In Malmberget, the underground mine consists of about 20 scattered ore bodies of which just over 10 are currently mined.

In the west the field is mined mostly magnetite, but also hematite (pink).
In the eastern field is mined exclusively magnetite.

Above ground, refinement is included enrichment and production of blast furnace pellets and finesse.

### Svappavaara (Open pit)

The three open-pit mines in Svappavaara were Europe's largest iron ore projects. Today, mining is carried out transformation project.

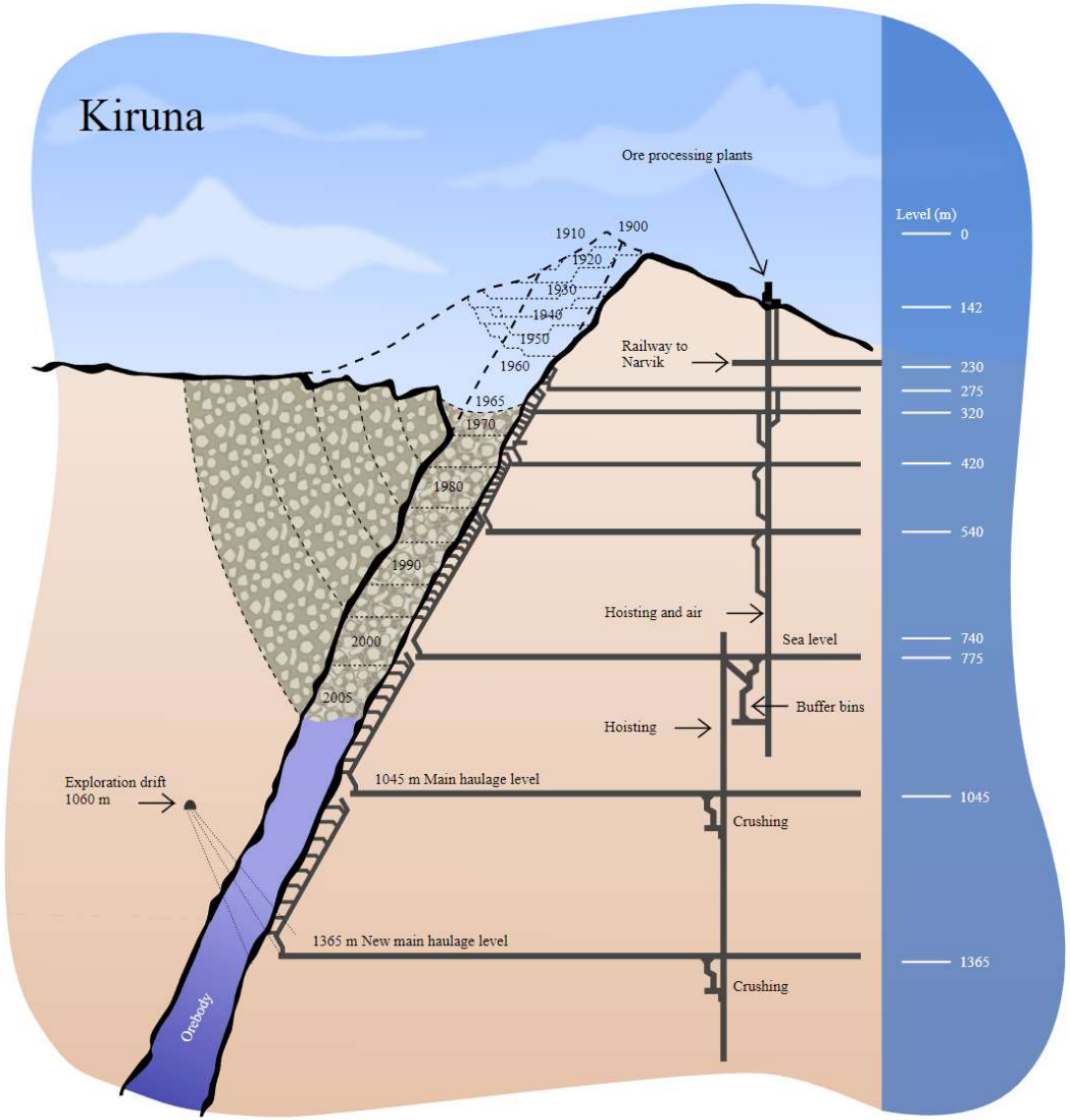
Svappavaara will begin the transformation long before the mines have stopped producing.

We will create added value long after the mining industry has been decommissioned. It's not just about returning; it's about creating added value.

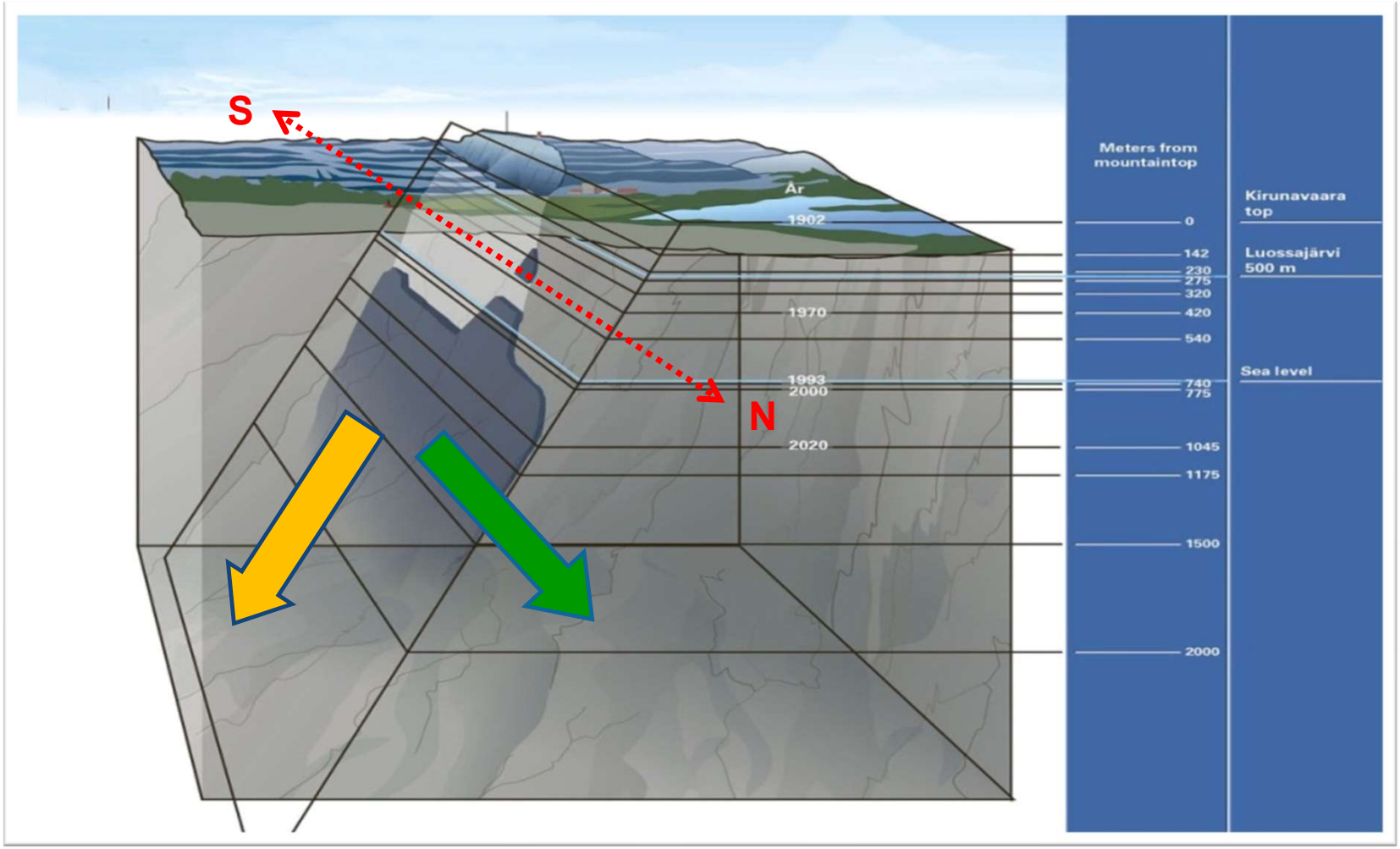
# Underground Mining Method SLC (Sublevel Caving)

# History

- 1696 Iron ore discovered in Kiirunavaara
- 1890 LKAB founded
- 1902 The first ore train to Narvik
- 1950s Underground mining
- 1960s Sublevel caving
- 2013 Present main haulage
  - level at 1365 m
- 2021 24,2 Mt crude ore



# SIMPLIFIED MODEL OF KIIRUNAVAARA IRON ORE DEPOSIT

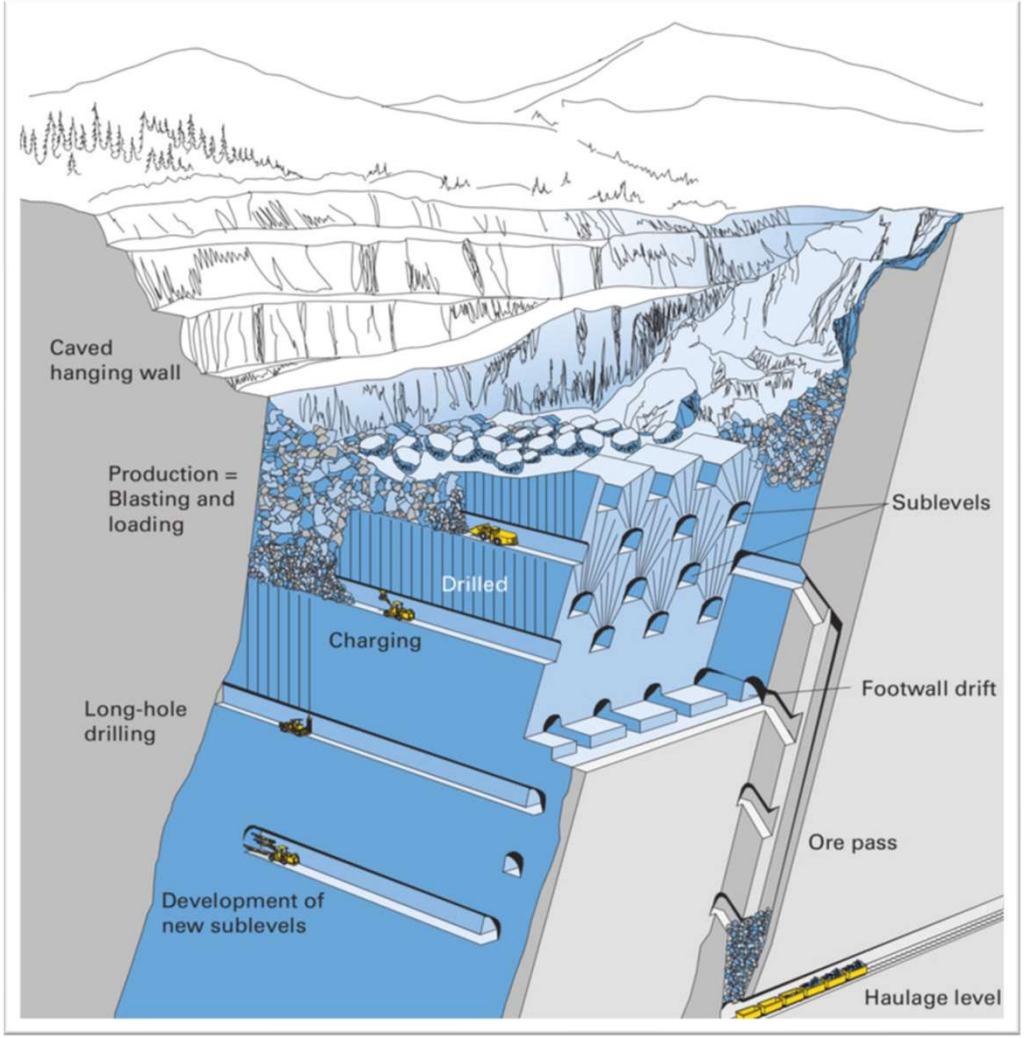



- ~ 4 km long sheet like intrusion
- Striking in N-S direction
- In average 80-100 m thick
- In places in the middle part over 200 m thick
- Dip ~ 65° E
- Plunge ~ 45° N
- $Fe_3O_4$ (magnetite)

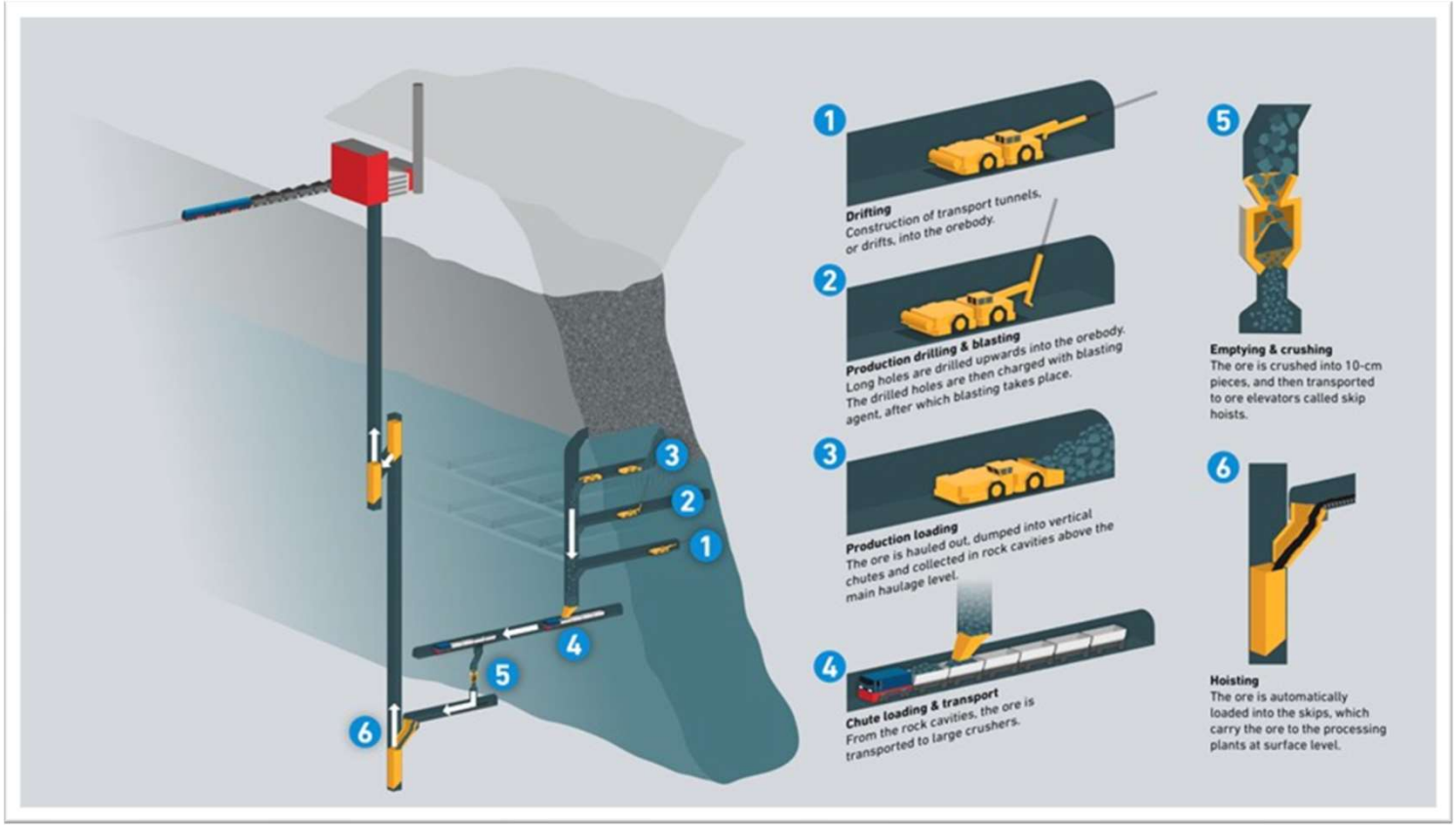
# Sublevel Caving Method

Sublevel caving shares many similarities with block caving, with some exceptions, which are responsible for this method:

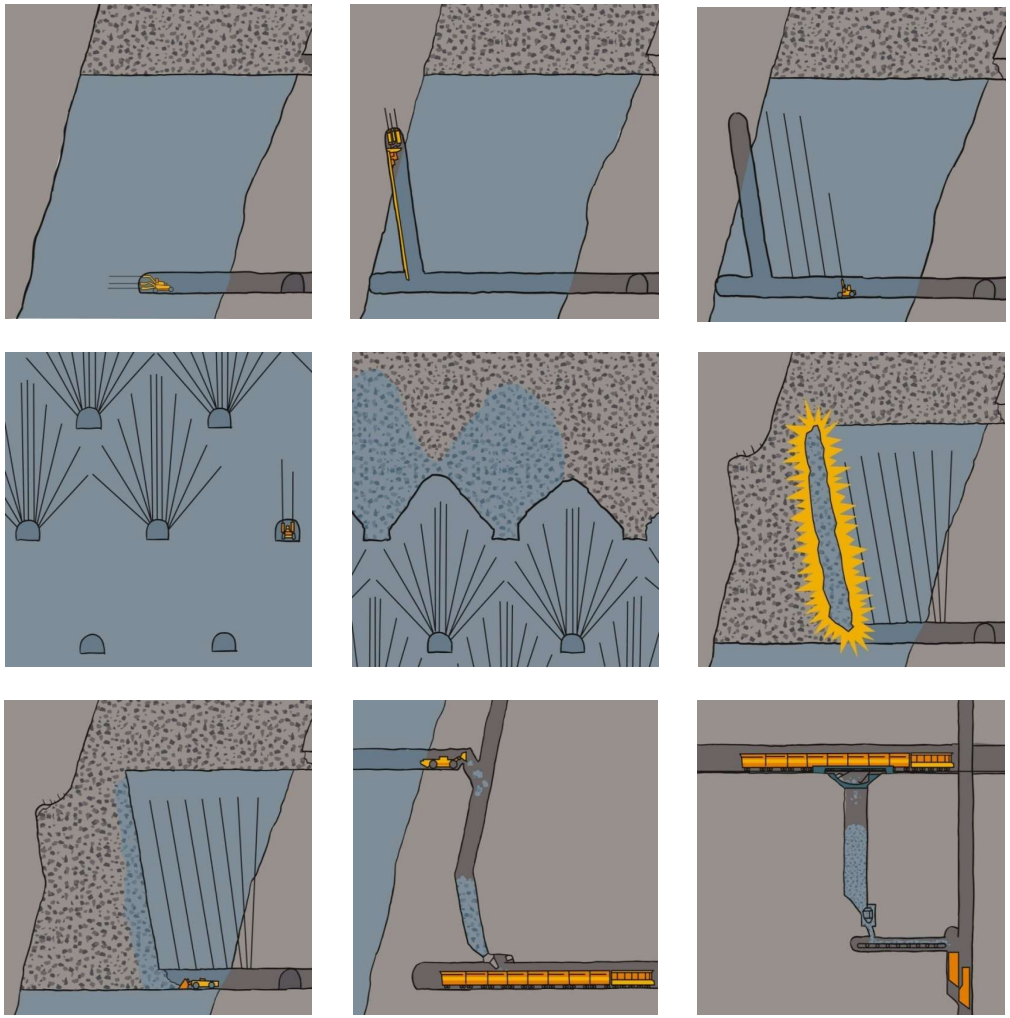
- The orebody is competent and will not cave under its own weight.
- The host rock, on the other hand, is weak and caves behind the ore as it is extracted.
- Consequently, the orebody needs to be drilled and shot to extract the ore.
- Once extracted, the hanging wall caves.



# Mining Cycle



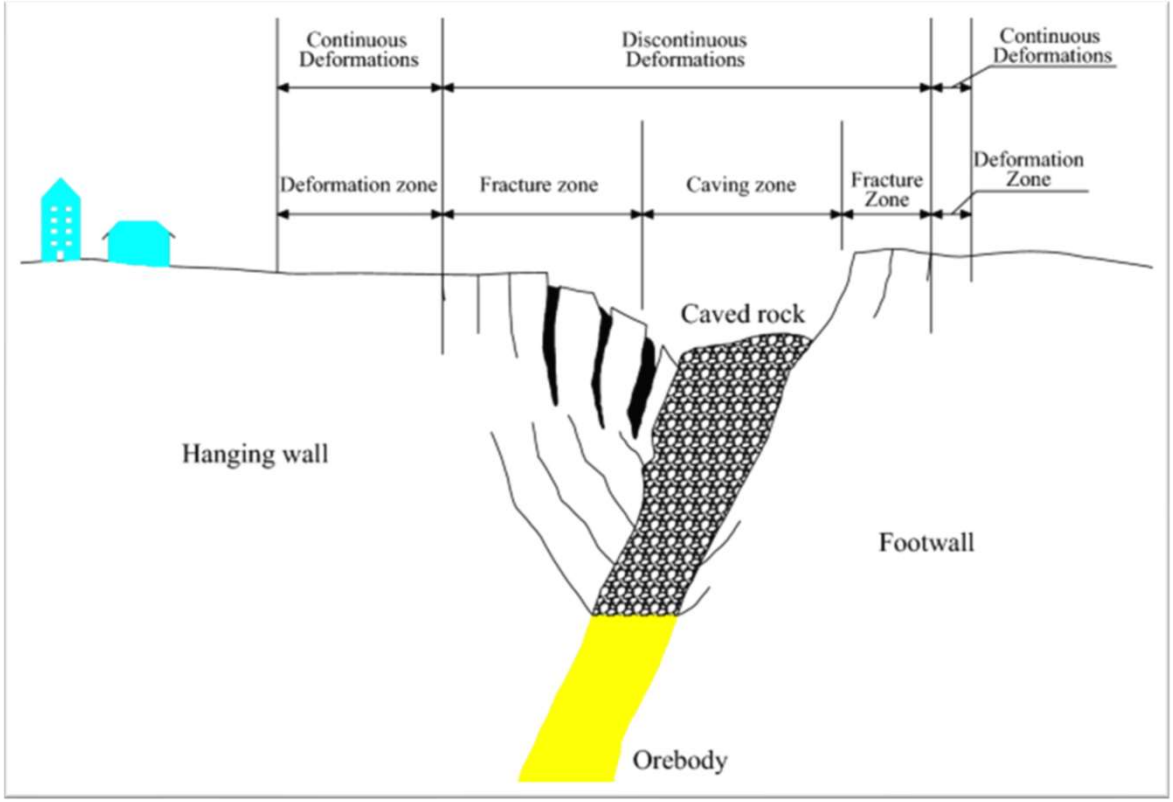
# Production Process



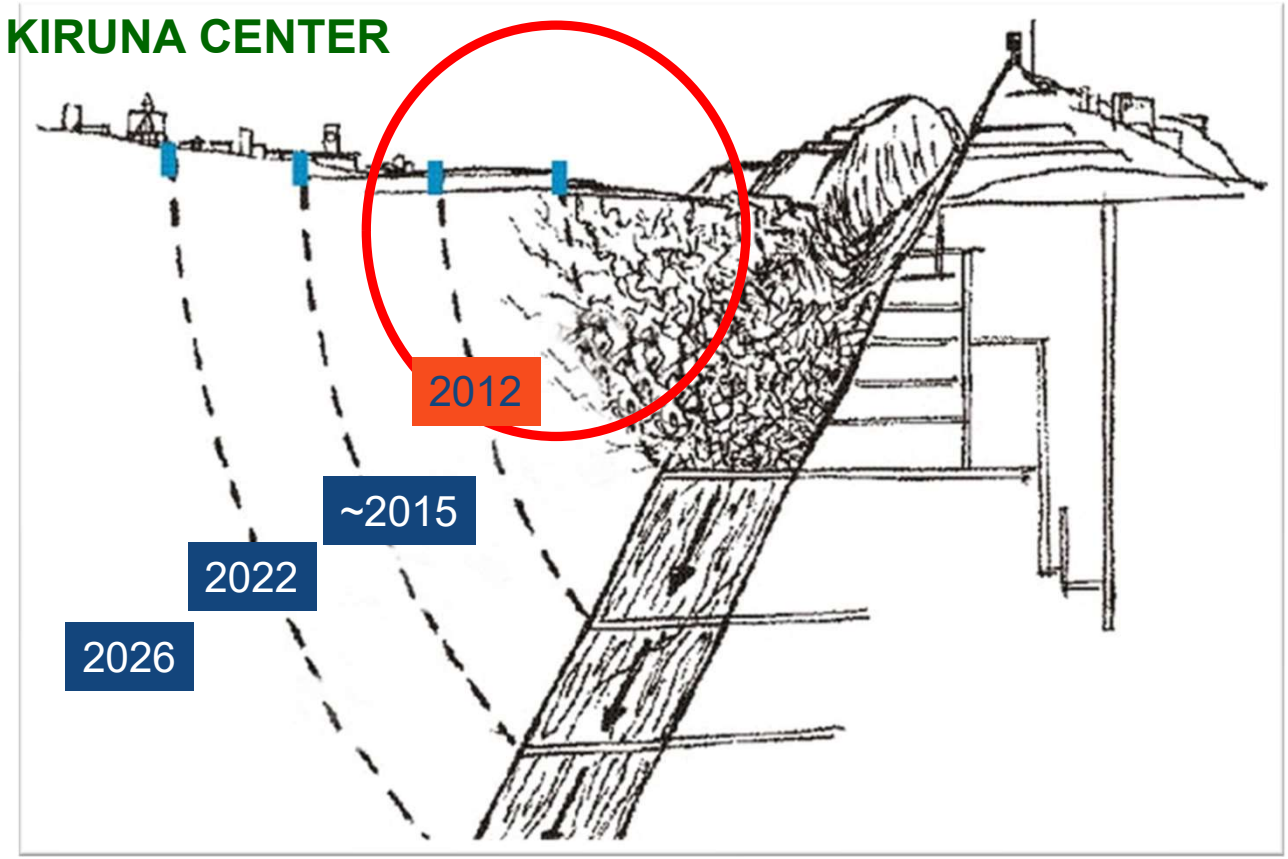
- A set of sublevels are developed.
- Next, the ore above the sublevel is fan or ring drilled.
- The holes are charged and fired.
- The broken ore is then loaded out of the sublevel using an LHD.
- The LHD's travel to ore passes where the ore is dumped and then collected at a lower haulage level.

# Sublevel caving mining method

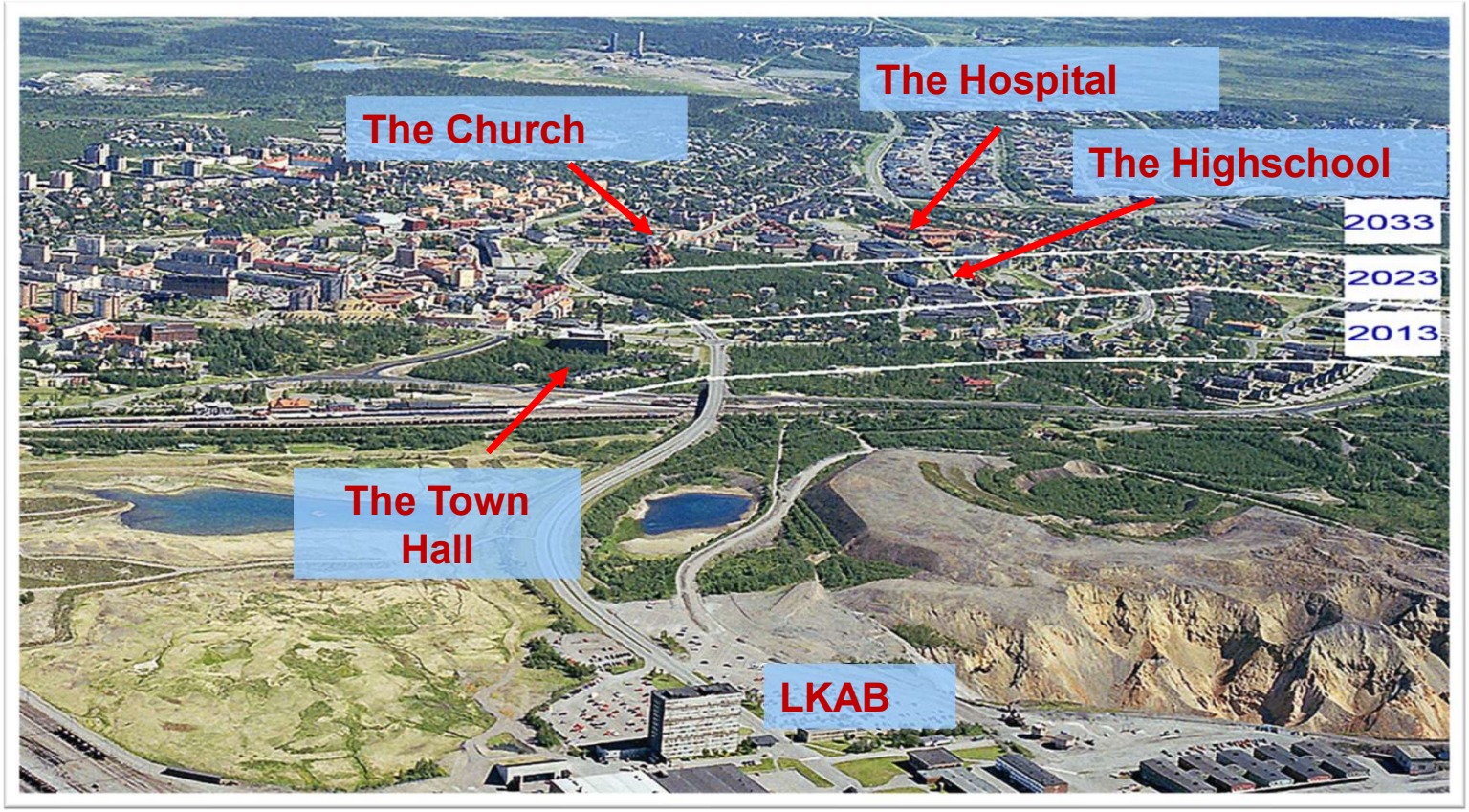
# Consequences of Caving: Subsidence & Seismic Events



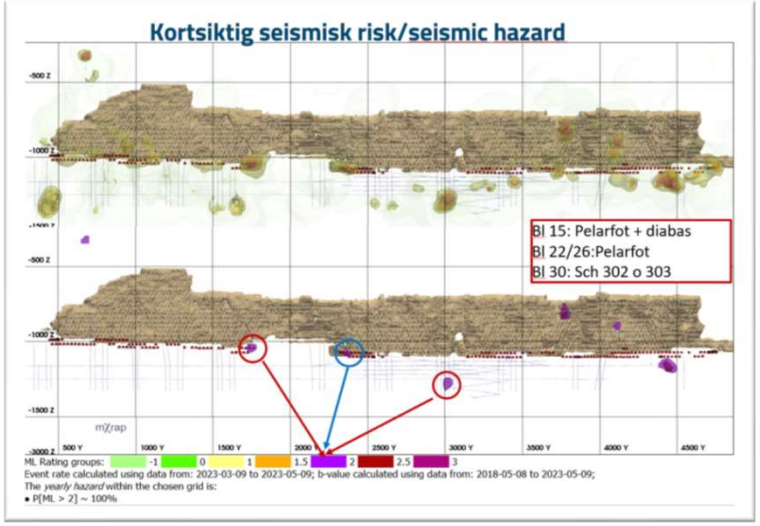
# Subdidence

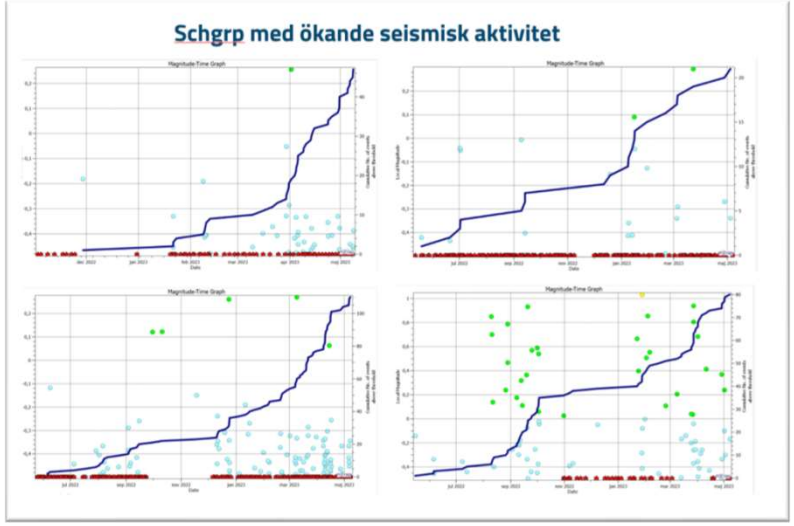


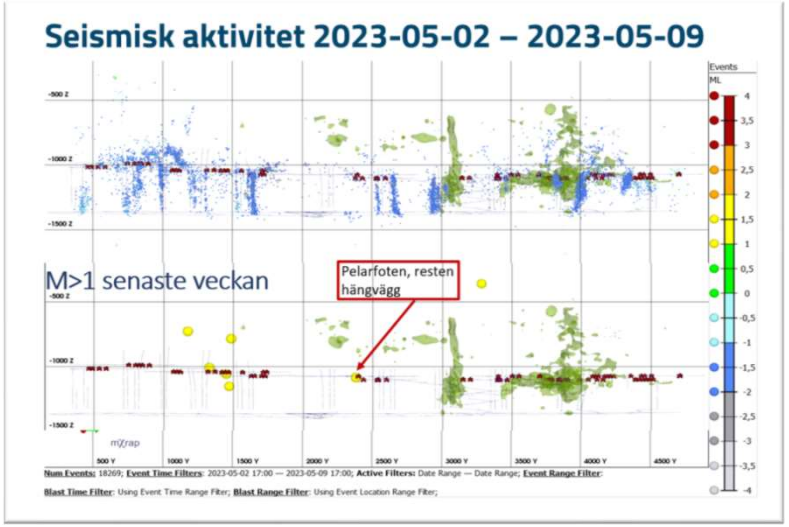
# Subdidence

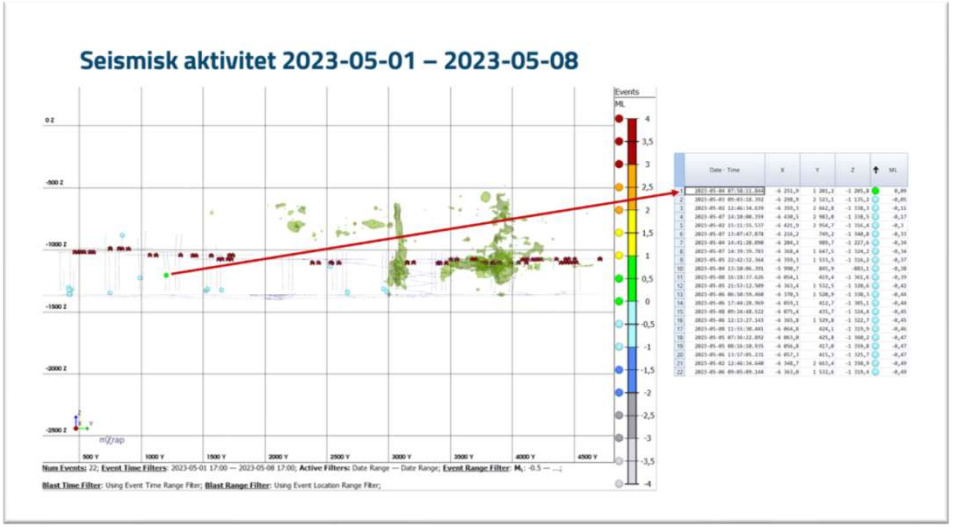

The Hospital
The Church
The Highschool
2033
2023
2013
The Town Hall
LKAB

# Seismic Events

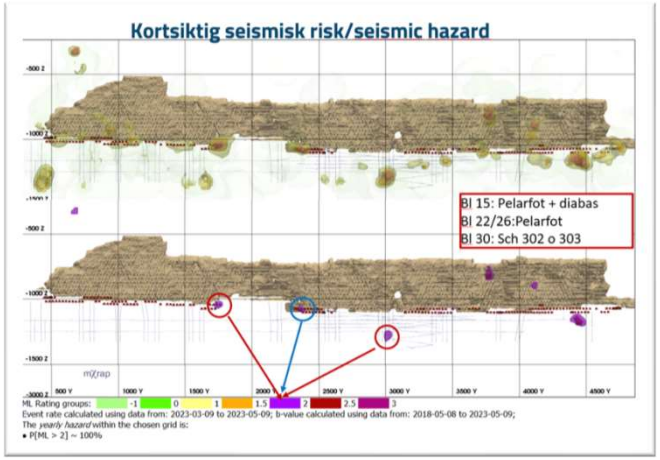


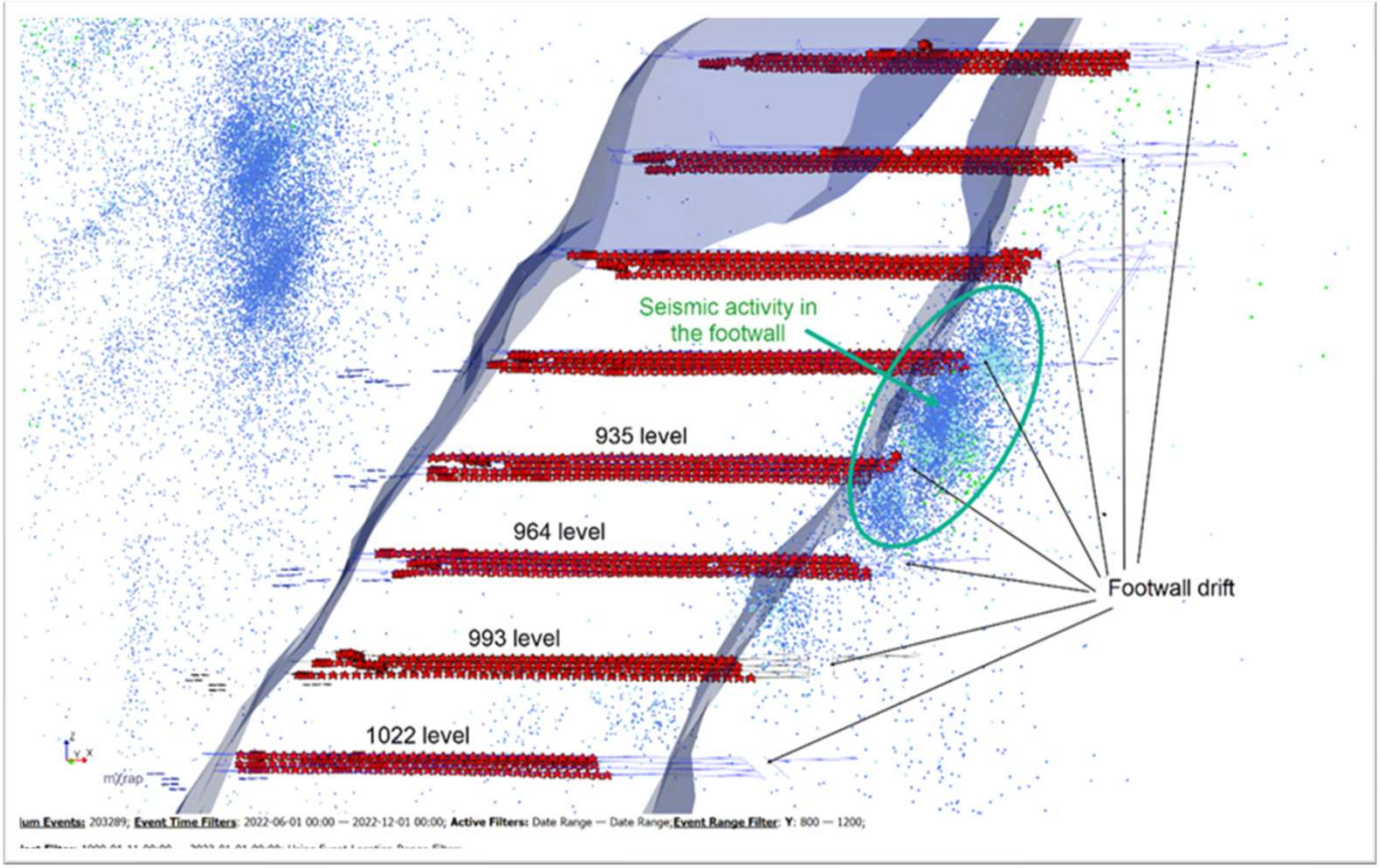



# Seismic Events

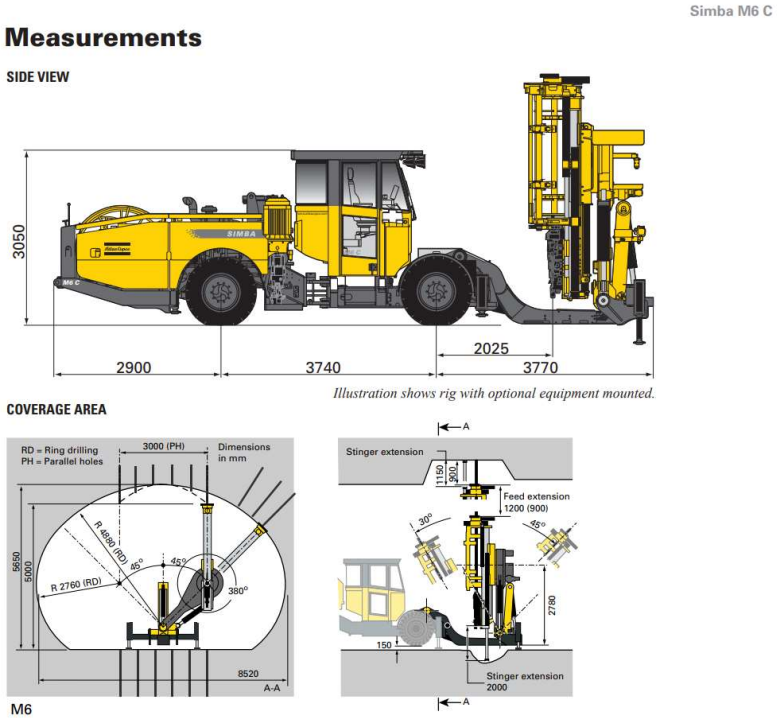


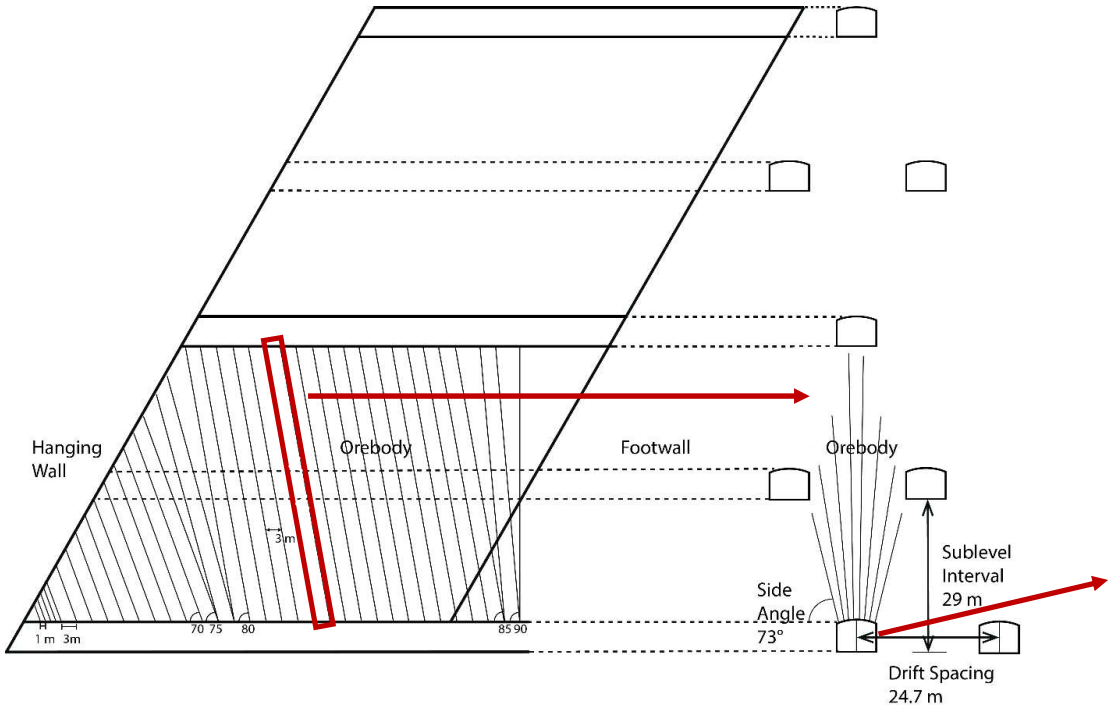
# Machinery

# Machinery – Production Drill Rig

Atlas Copco Simba W6 C-ITH drill rig used in LKAB Atlas Copco



# Machinery – Porduction Drill Rig




Side view

Front view

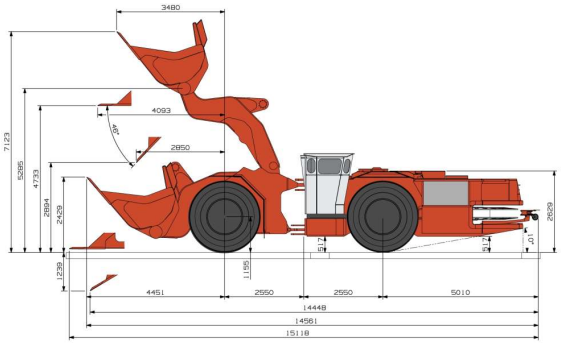
Production drill rig

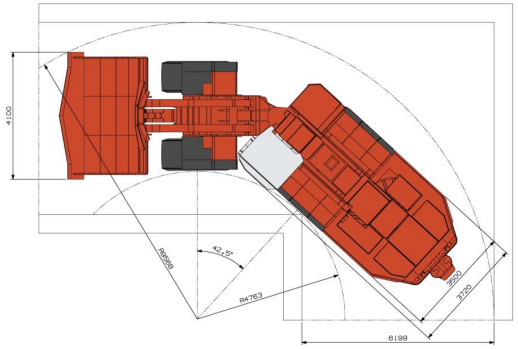
# Machinery – Production LHD

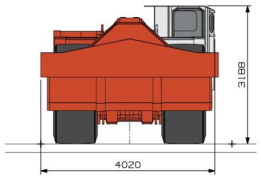
**DIFFERENT MODELS:**

- LHD 621 Manual
- LHD 621 Remote
- LHD 625 Manual
- LHD 625 Remote

TS3-LH625iE-01/ENG/METRIC

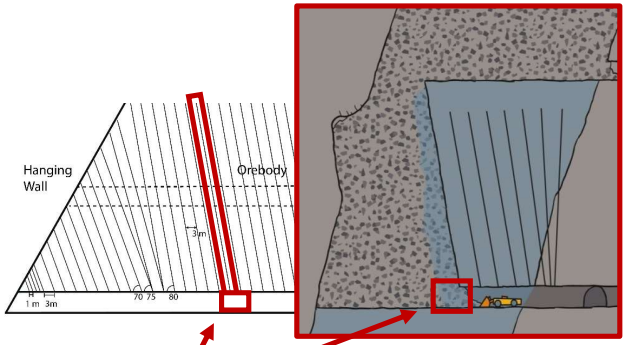


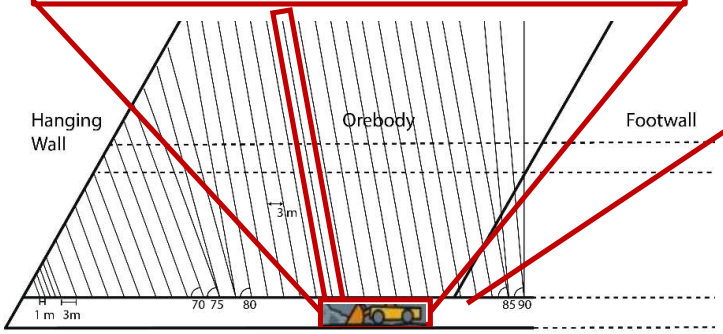



# Machinery

Load Haul Dump (LHD) Machine



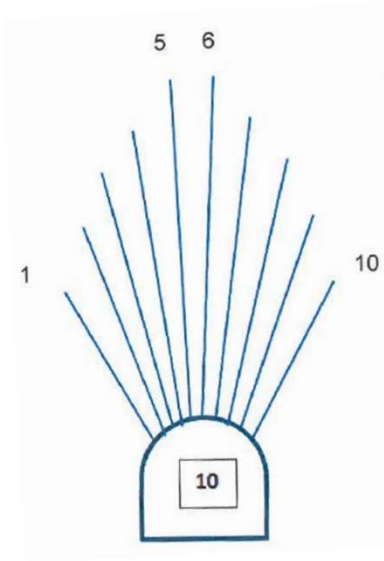
Draw Point



# Charging & Blasting Sequence

Example of a 10-hole standardised blasting and charging plan

| No. of holes | Uncharged length from hole opening [m] | Initiation sequence |
|---|---|---|
| 1 | 0 | 9 |
| 2 | 1 | 7 |
| 3 | 6 | 5 |
| 4 | 3 | 3 |
| 5 | 10 | 1 |
| 6 | 10 | 0 |
| 7 | 3 | 2 |
| 8 | 6 | 4 |
| 9 | 1 | 6 |
| 10 | 0 | 8 |



Charging truck developed by LKAB Kimit (LKAB Kimit, 2015)

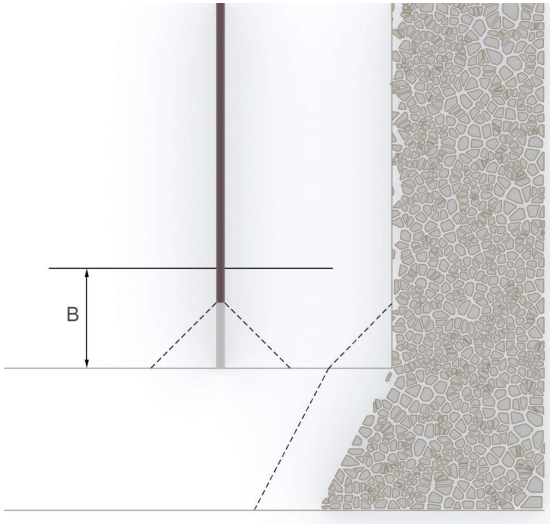
# LKAB Kimit

## Explosive

- The explosive used for production blasting has been developed by LKAB Kimit and is called Kimulux R 0500. It is a sensitized emulsion explosive containing 4% aluminum; it can be used in both underground and surface blasting as long as the blast hole diameter is larger than 48 mm. The specifications of the explosive are presented in the table:

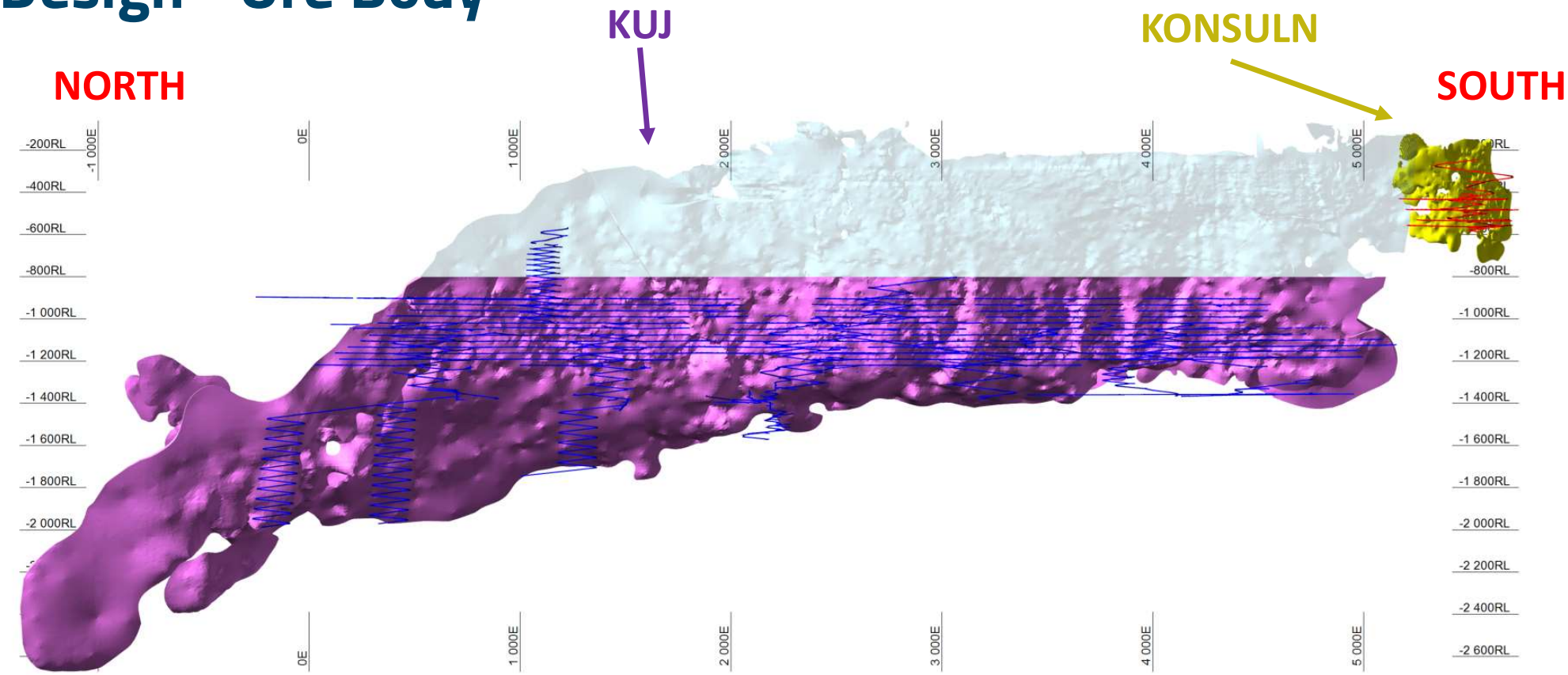
Technical specifications for Kimulux R 0500 (LKAB Kimit, 2015)

| Properties | KR 0500 | Unit |
|---|---|---|
| Density | 1200 | $kg/m^3$ |
| Detonation velocity (VOD) | ≈4800 | m/s (Ø=40 mm) |
| Energy (theoretical) | 3.8 | MJ/kg |
| Gas volume | 930 | l/kg |
| Oxygen balance | –1.43 | % |

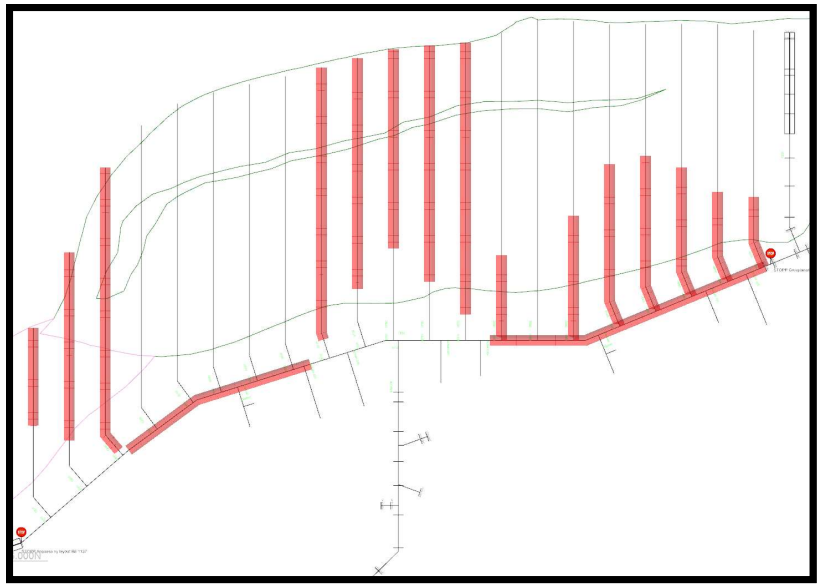


# Design & Planning

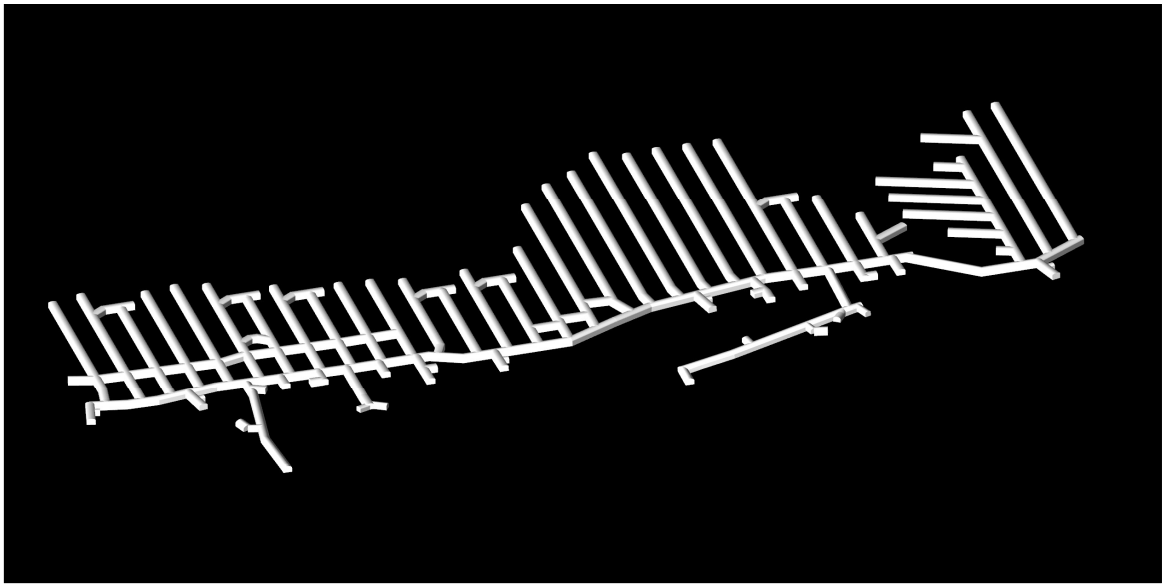
# Design - Ore Body



# Design - Development Layout

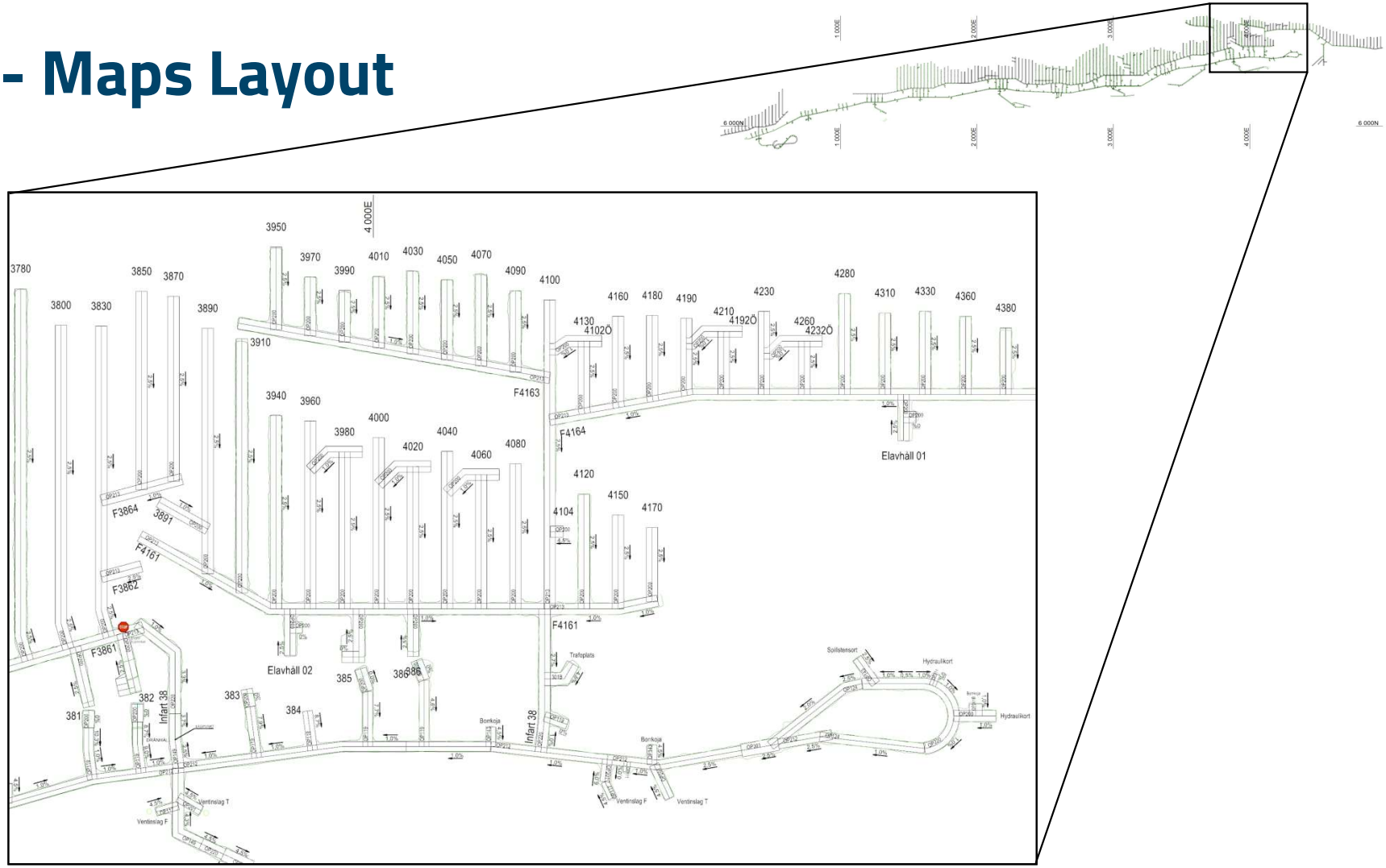


Centre lines

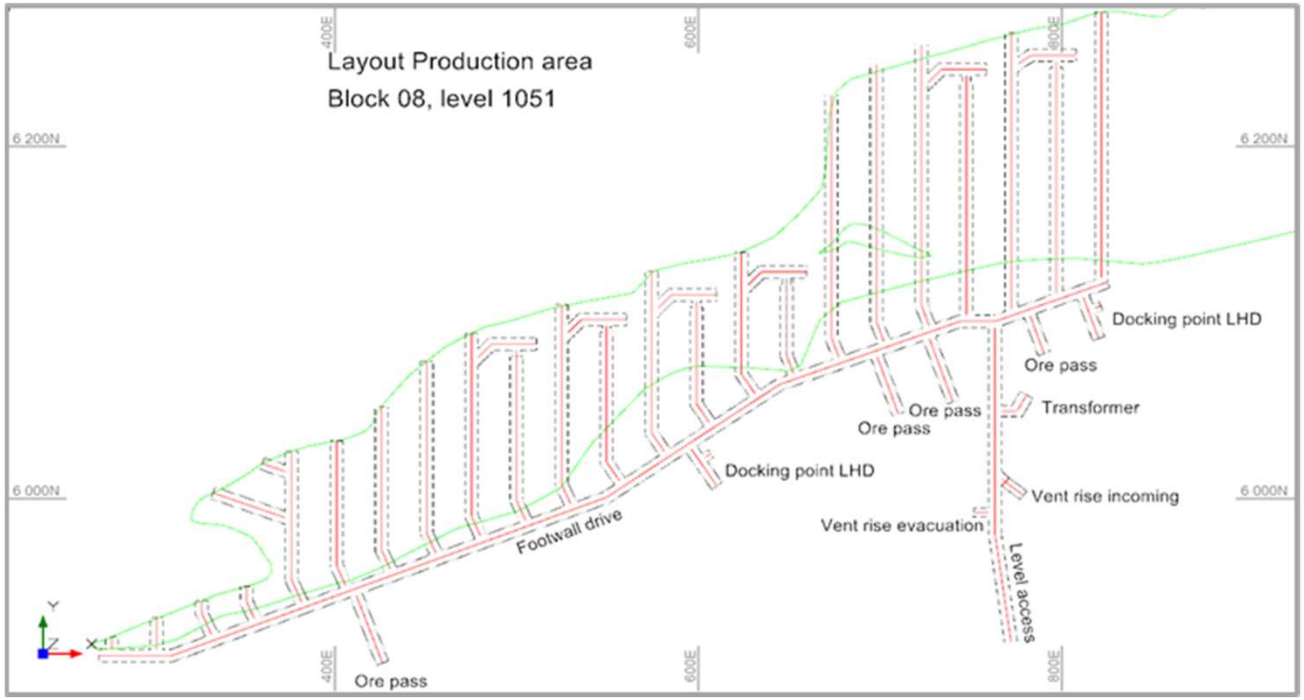


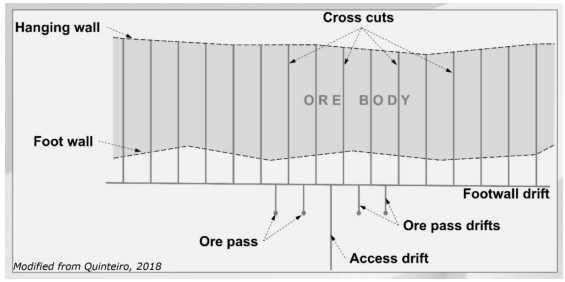
Solids

# Design - Maps Layout



# Design - Drift Profiles

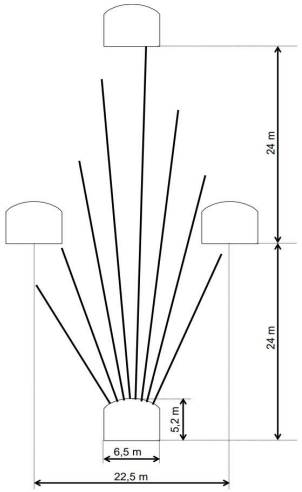


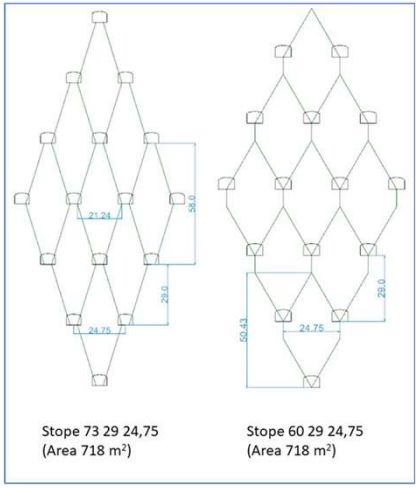



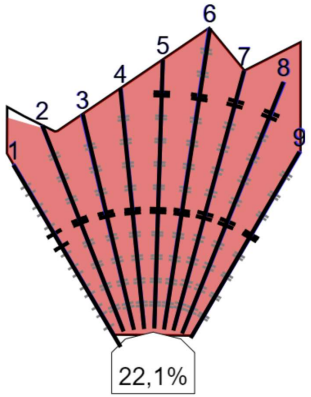

| Drift Profile | W x H (m) | Area (m²) | Perimeter (m) | Type of development |
|---|---|---|---|---|
| 200 | 7,0 x 5,2 | 34,5 | 22,8 | Crosscuts, orepass access, LHD docking |
| 213 | 7,0 x 6,0 | 38,5 | 23,6 | Footwall drive |
| 220 | 7,0 x 5,5 | 34,9 | 22,6 | Straight declines, Level access |
| 301 | 8,0 x 5,5 | 39,9 | 24,5 | Curved declines, Start of level access |

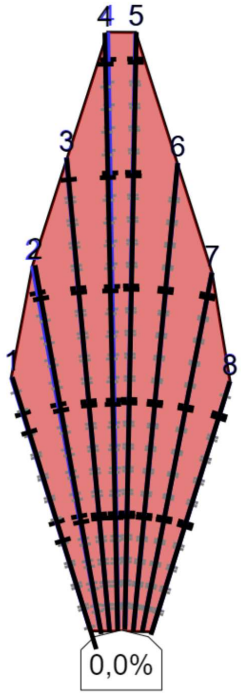
# Design – Production Rings

| Orebody | Ring profile | Stope Section (m2) | Average drill meters (typical ring) | LOMP Assumption (dm/ ring) | Comment |
|---|---|---|---|---|---|
| KUJ | 60 29 24,75 | 717.75 | 276 | 300 | |
| KUJ | 73 29 24,75 | 717.75 | 241 | 250 | |
| KUJ | 77 29 21 | 609.00 | 208 | 200 | |
| KON | 45 40 24,75 | 989.5 | 242 | 250 | To be tried in Konsuln mine on the 436 level |
| KON | 60 25 | 550.0 | 180 | 200 | Used for longitudinal stopes in Konsuln mine on level 371 and 396. |
| KON | 74 25 22 | 550.0 | 188 | 200 | Tested on level 371 and 396 |
| KON | 49 40 22 | 880.0 | 200 | 200 | To be tried on level 436 |
| KON | 49 50 22 | 1100.0 | 250 | 250 | To be tried on levels 486 and 536 |
| KON | 45 50 24,75 | 1237.5 | 302 | 300 | To be tried on levels 486 and 536 |



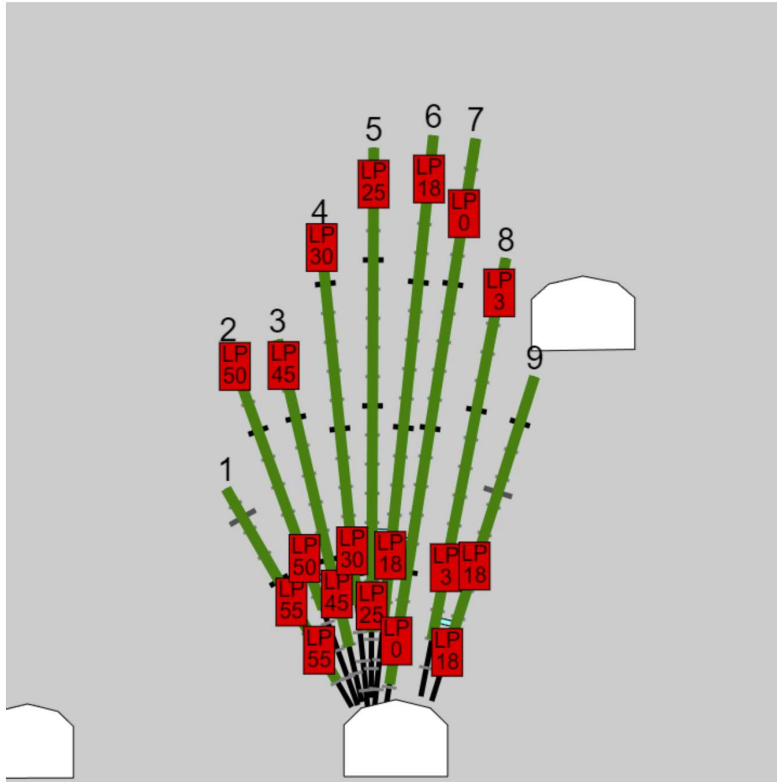


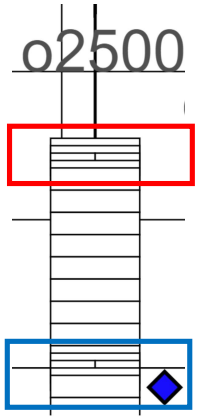
# Design - Rings

Område: 26-1108 Ort: o2500 Krans: 16

**Kranskommentar: Borrningskommentar:** IREDES **Info om valt objekt:** Kransnr: 16

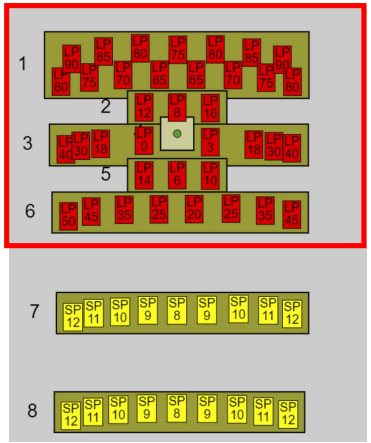



Giron

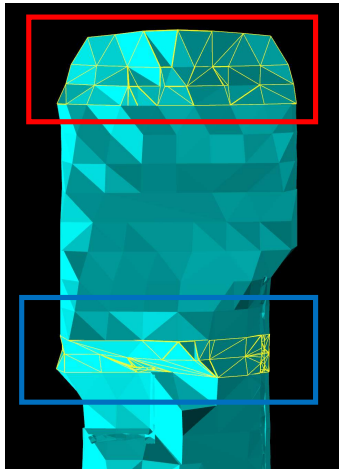



Giron

Opening

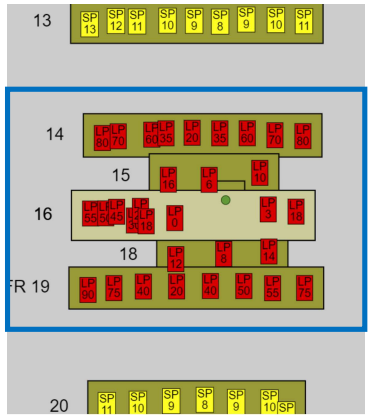


Giron



Deswik

Rasinbrott
+
Opening

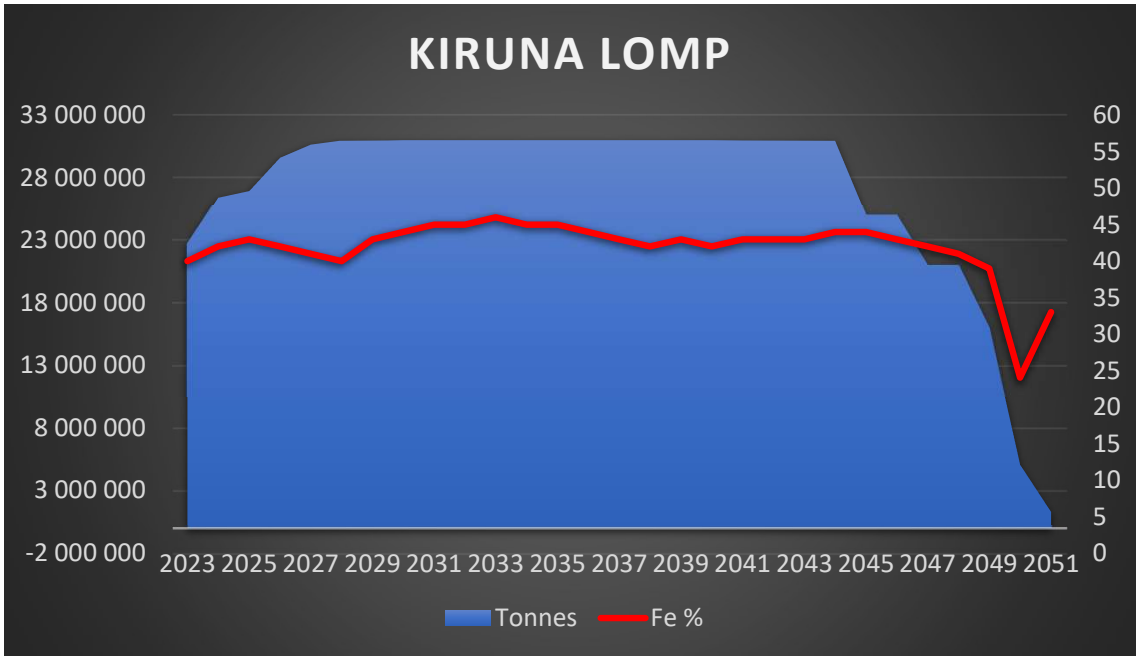


Giron

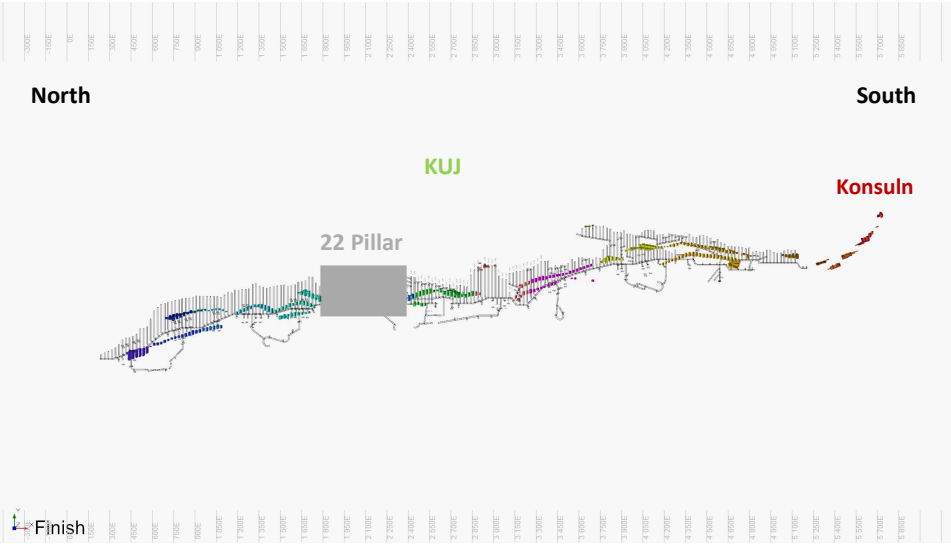
# Planning - Reserves & LOMP

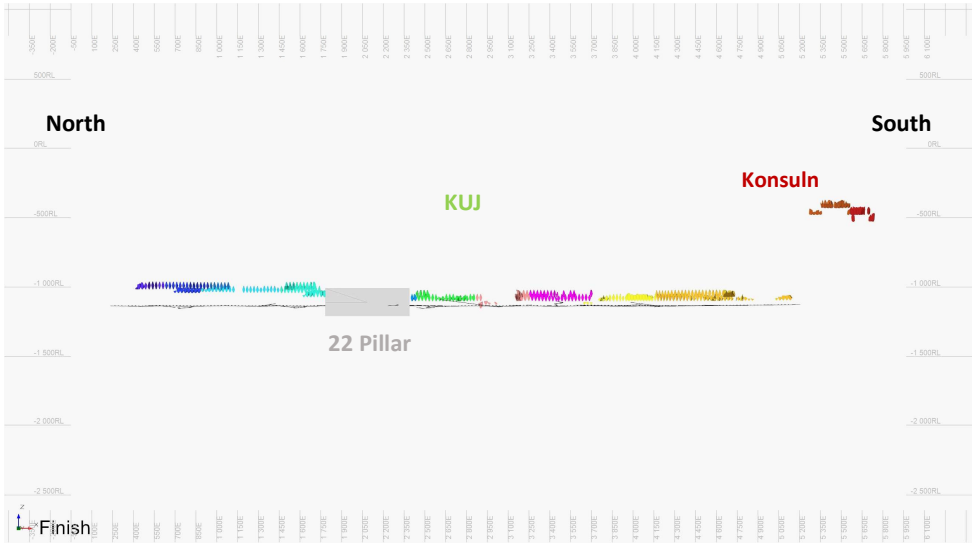
## KIRUNA Reserves

| | | ROM from Development (t) | ROM from Drawpoints (t) | Total ROM (t) | ROM Grade (% Fe) |
|---|---|---|---|---|---|
| Magnetite classified as Measured | (t) | 16 924 097 | 559 942 410 | 576 866 507 | 52,3 |
| Magnetite classified as Indicated | (t) | 1 077 774 | 14 429 101 | 15 506 875 | 39,4 |
| Total Measured and Indicated in ROM | (t) | 18 001 871 | 574 371 511 | 592 373 382 | 51,9 |
| Magnetite classified as Inferred | (t) | 4 525 | 315 098 | 319 623 | 36,7 |
| Magnetite Unclassified | (t) | 0 | 0 | 0 | 0,0 |
| Total Magnetite in ROM | (t) | 18 006 397 | 574 686 609 | 592 693 005 | 51,9 |
| Total Hematite in ROM * | (t) | 26 067 | 534 885 | 560 952 | 0,0 |
| Total Waste in ROM ** | (t) | 10 273 996 | 135 352 048 | 145 626 044 | 10,7 |
| Total ROM | (t) | 28 306 460 | 710 573 541 | 738 880 001 | 43,0 |

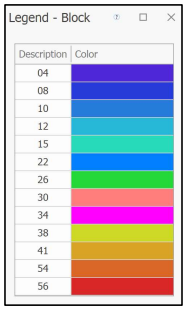


# Planning - 3D Model rings & 5 Years Sequence



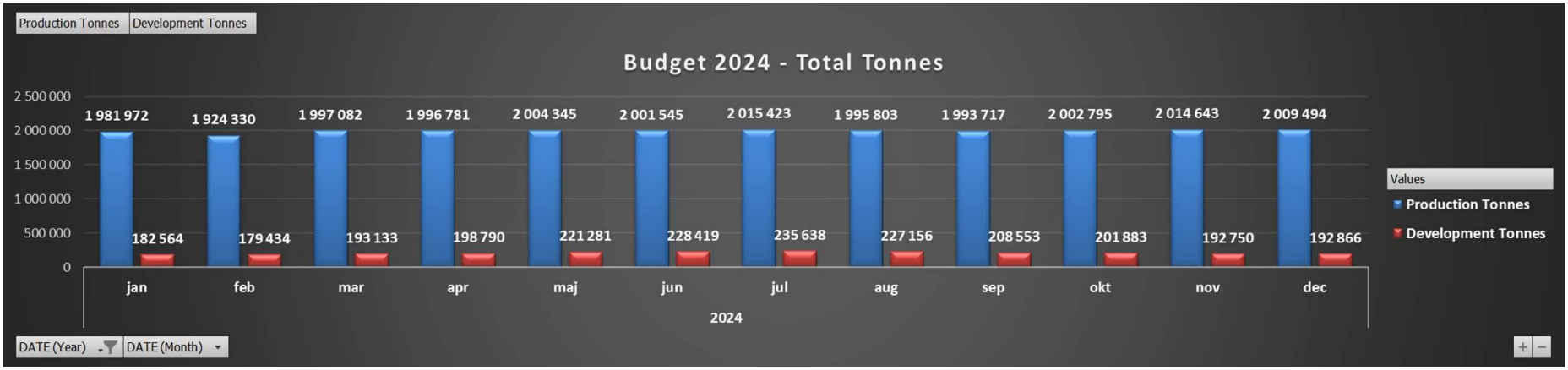

**Top View Rings and Sequence**




**Front View Rings and Sequence**

# Planning - Budget 2024

| Date | 2024 | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | jan | feb | mar | apr | maj | jun | jul | aug | sep | okt | nov | dec | |
| Production Tonnes | 1 981 972 | 1 924 330 | 1 997 082 | 1 996 781 | 2 004 345 | 2 001 545 | 2 015 423 | 1 995 803 | 1 993 717 | 2 002 795 | 2 014 643 | 2 009 494 | 23 937 929 |
| Development Tonnes | 182 564 | 179 434 | 193 133 | 198 790 | 221 281 | 228 419 | 235 638 | 227 156 | 208 553 | 201 883 | 192 750 | 192 866 | 2 462 469 |
| **Total Tonnes** | **2 164 536** | **2 103 764** | **2 190 215** | **2 195 572** | **2 225 626** | **2 229 964** | **2 251 061** | **2 222 959** | **2 202 270** | **2 204 678** | **2 207 393** | **2 202 360** | **26 400 397** |




| | Budget 2024 | |
|---|---|---|
| | Tonnes | Fe % |
| Production | 23 937 929 | 45,5 |
| Development | 2 462 469 | 37,0 |
| Total | **26 400 397** | **44,7** |

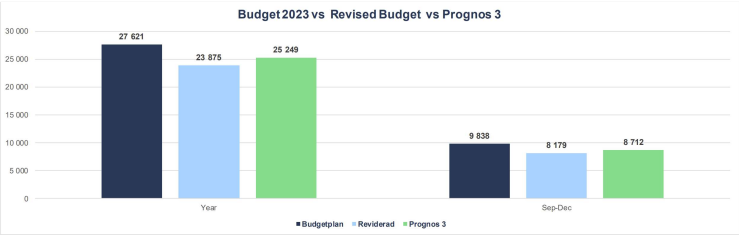
# Planning - Prognos

## Prognos 3 Budgetplan 2023

**Prognos 3 Budgetplan 2023**

| | UTFALL | | | | | | | | Prognos 3 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | jan | feb | mar | apr | maj | jun | jul | aug | sep | okt | nov | dec | Total 2023 | sep-dec |
| Raslasting KUJ | 1 651 | 1 425 | 1 452 | 1 546 | 1 886 | 1 871 | 2 081 | 1 872 | 1 848 | 1 885 | 1 657 | 1 798 | 20 973 | 7 188 |
| Tillredning KUJ | 157 | 136 | 143 | 128 | 159 | 152 | 115 | 97 | 165 | 171 | 165 | 171 | 1 757 | 671 |
| Malm | 94 | 82 | 86 | 77 | 95 | 91 | 69 | 58 | 99 | 102 | 99 | 102 | 1 054 | 403 |
| Gråberg | 63 | 54 | 57 | 51 | 64 | 61 | 46 | 39 | 66 | 68 | 66 | 68 | 703 | 268 |
| Konsuln Ras | 242 | 209 | 235 | 206 | 207 | 184 | 60 | 179 | 221 | 230 | 207 | 182 | 2 362 | 840 |
| Konsuln tillredning | 4 | 4 | 18 | 25 | 28 | 37 | 15 | 15 | 12 | 12 | 12 | 12 | 193 | 48 |
| **Totalt** | **2 054** | **1 774** | **1 848** | **1 905** | **2 280** | **2 244** | **2 271** | **2 162** | **2 247** | **2 298** | **2 041** | **2 162** | **25 284** | **8 747** |

## Budgetplan vs Revised Budget vs Prognos 3




| | Year | Sep-Dec |
|---|---|---|
| Prognos 3 vs Budget | -2,37 mton | -1,13 mton |
| Prognos 3 vs Reviderad | 1,37 mton | 0,53 mton |

# Planning - Quarterly Plan / Månadsplan

## Oct - Dec

**Oktober**

| KUJ | |
|---|---|
| Ras | 1 932 442 |
| Tillredning | 155 000 |
| Totalt | 2 087 442 |
| Per dygn | 67 337 |
| Fe% | 45,8% |

| KONSULN | |
|---|---|
| Ras | 180 027 |
| Per dygn | 5 807 |
| Fe% | 26,1% |

| Totalt | 2 267 469 |
|---|---|
| Per dygn | 73 144 |

**November**

| KUJ | |
|---|---|
| Ras | 1 969 052 |
| Tillredning | 150 000 |
| Totalt | 2 119 052 |
| Per dygn | 70 635 |
| Fe% | 43,3% |

| KONSULN | |
|---|---|
| Ras | 182 487 |
| Per dygn | 5 887 |
| Fe% | 35,1% |

| Totalt | 2 301 539 |
|---|---|
| Per dygn | 76 718 |

**December**

| KUJ | |
|---|---|
| Ras | 1 980 786 |
| Tillredning | 155 000 |
| Totalt | 2 135 786 |
| Per dygn | 68 896 |
| Fe% | 44,4% |

| KONSULN | |
|---|---|
| Ras | 184 315 |
| Per dygn | 5 945 |
| Fe% | 38,2% |

| Totalt | 2 320 101 |
|---|---|
| Per dygn | 74 842 |

## Nov - Jan

**November**

| KUJ | |
|---|---|
| Ras | 2 046 964 |
| Tillredning | 160 000 |
| Totalt | 2 206 964 |
| Per dygn | 73 565 |
| Fe% | 48,7% |

| KONSULN | |
|---|---|
| Ras | 180 537 |
| Per dygn | 6 018 |
| Fe% | 36,8% |

| Totalt | 2 387 501 |
|---|---|
| Per dygn | 79 583 |

**December**

| KUJ | |
|---|---|
| Ras | 1 933 000 |
| Tillredning | 165 000 |
| Totalt | 2 098 000 |
| Per dygn | 67 677 |
| Fe% | 45,3% |

| KONSULN | |
|---|---|
| Ras | 187 946 |
| Per dygn | 6 265 |
| Fe% | 30,1% |

| Totalt | 2 285 946 |
|---|---|
| Totalt | 76 198 |

**Januari**

| KUJ | |
|---|---|
| Ras | 1 809 047 |
| Tillredning | 165 000 |
| Totalt | 1 974 047 |
| Per dygn | 63 679 |
| Fe% | 46,1% |

| KONSULN | |
|---|---|
| Ras | 179 725 |
| Per dygn | 5 991 |
| Fe% | 42,2% |

| Totalt | 2 153 772 |
|---|---|
| Totalt | 71 792 |

## Dec - Feb

**December**

| KUJ | |
|---|---|
| Ras | 1 973 166 |
| Tillredning | 140 000 |
| Totalt | 2 113 166 |
| Per dygn | 68 167 |
| Fe% | 48,9% |

| KONSULN | |
|---|---|
| Ras | 186 106 |
| Per dygn | 6 003 |
| Fe% | 35,7% |

| KONSULN | |
|---|---|
| Ras | 186 106 |
| Per dygn | 6 003 |
| Fe% | 35,7% |

| Totalt | 2 299 272 |
|---|---|
| Per dygn | 74 170 |

**Januari**

| KUJ | |
|---|---|
| Ras | 1 798 781 |
| Tillredning | 140 000 |
| Totalt | 1 938 781 |
| Per dygn | 62 541 |
| Fe% | 44,8% |

| KONSULN | |
|---|---|
| Ras | 182 026 |
| Per dygn | 5 872 |
| Fe% | 44,1% |

| KONSULN | |
|---|---|
| Ras | 182 026 |
| Per dygn | 5 872 |
| Fe% | 44,1% |

| Totalt | 2 120 807 |
|---|---|
| Per dygn | 68 413 |

**Februari**

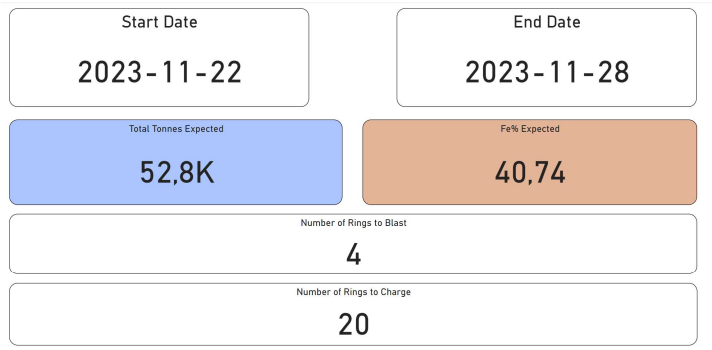
| KUJ | |
|---|---|
| Ras | 1 799 889 |
| Tillredning | 130 000 |
| Totalt | 1 929 889 |
| Per dygn | 66 548 |
| Fe% | 45,4% |

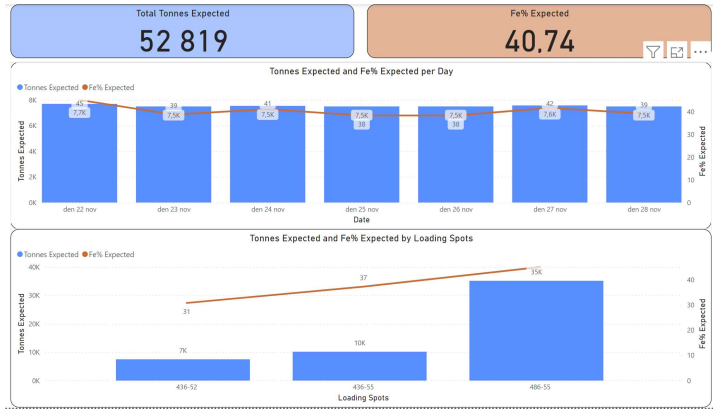
| KONSULN | |
|---|---|
| Ras | 181 215 |
| Per dygn | 6 249 |
| Fe% | 44,7% |

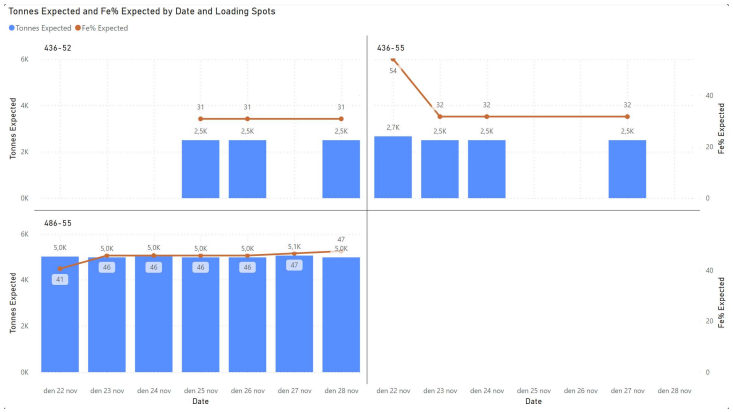
| KONSULN | |
|---|---|
| Ras | 181 215 |
| Per dygn | 6 249 |
| Fe% | 44,7% |

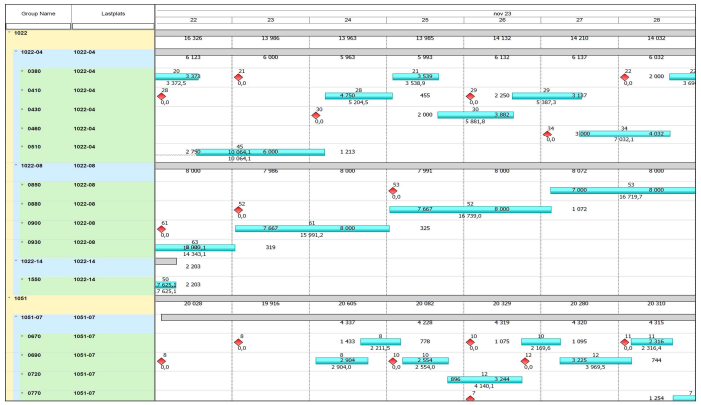
| Totalt | 2 111 104 |
|---|---|
| Per dygn | 72 797 |

# Planning – Weekly Plan



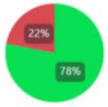



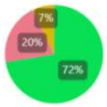
# Planning - Reports

## Budget 2023

| Total Mined | Total Planned | Total Diff |
|---|---|---|
| 22 781 004 | 24 712 843 | -1 931 839 |

- Raslastning total produktion 22,8mt
- Under plan med -1,9mt
- Planuppfyllnad 49% (Produktionsområde)




| Planned And Mined | Not Planned And Mined |
|---|---|
| 19 277 269 | 1 607 948 |

| Planned And Not Mined | Overproduction |
|---|---|
| 5 435 575 | 1 895 787 |

## Budget 2023

**5,5mt Planerat men ej utbrutet**

- 08 +12-1051: (Förändras sekvens p.g.a. B22)
- 15-1079: (Försenad p.g.a. beslut B22 samt seismik)
- 30+34-1079: (Försenad p.g.a. rasinbrott på 1108)
- 41-1079: (Tillredning av ny infart, grov fragmentering)
- 38-1108: (Seismik, lera, grov fragmentering)
- 41-1108: (Försenades p.g.a. 38-1108)
- 38-1137: (Rasborrning försenad)
- 9-993: (Låg produktivitet p.g.a. layout)

**1,6mt Ej planerat och utbrutet**

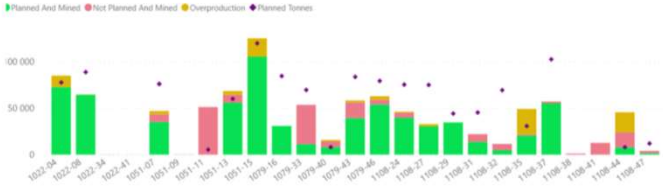
- 26-1079, 22>26-1108: (Ändrad sekvens efter beslut om B22)

**1,9mt Överproduktion**

- 04>15-1022, 38-1079
  - Högre utbyte än förväntat?
  - Fel i blockmodell?
  - Järnhalt/Skopvikt överskattad i Giron p.g.a. fin fragmentering?
- 54>56-436, 486-56
  - Högre utbyte än förväntat?
  - Fel i blockmodell?
  - Kampanj med restmalmslastning
- Så länge inga analyser görs är det svårt att säga vad överproduktionen beror på

## December 2023

**Mined Tonnes In/Outside Of The Plan By Loadingspot**




**527kt Planerat och ej utbrutet**

- 1108-32: Downreaming 341, Häng 344
- 1079-16: Förstärkning efter bergutfall
- 1108-37: Låg tillgänglighet ortar, häng i schakt 344
- 1108-27: 7 dagar stopp i produktionen
- 1108-24: Lägre produktivitet än förväntat 2,5kt/d planerat 4,2kt/d
- 1051-07: Lägre utbyte än förväntat p.g.a. öppningar
- 1079-43: Ej planerade ortar lastade (o430, o427)
- 1022-08: Lägre utbyte än förväntat
- 1108-31: Delar lastplats med 1108-29

- **193kt Ej planerat och utbrutet**
  - 1051-11: Kransar från november
  - 1079-33: Två LHD p.g.a. lastbilskörning (extra kransar tillförda)
  - 1079-43: Kransar skjutna utanför plan (o430 –o427)
  - 1108-41: Kransar skjuta utanför plan (o438)
- **100kt Överproduktion**
  - 1022-04: Kransar kvar från november
  - 1051-15: Kransar skjutna utanför plan
  - 1108-35: Kransar kvar från november, överlastning
  - 1108-44: Kransar kvar från november

# Planning – Reports

## SUMMARY KUJ & KONSULN

| Total Mined | Total Planned | Total Diff |
|---|---|---|
| 500,993 | 633,104 | -132,111 |

- Mucking: 36%
  - KUJ: 36%
  - Konsuln: 37%
- Blasting: 67%
  - KUJ: 68%
  - Konsuln: 57%
- Charging: 38%
  - KUJ: 40%
  - Konsuln: 30,3%

| Planned And Mined | Not Planned And Mined |
|---|---|
| 306,357 | 100,812 |

| Planned And Not Mined | Overproduction |
|---|---|
| 326,747 | 93,824 |

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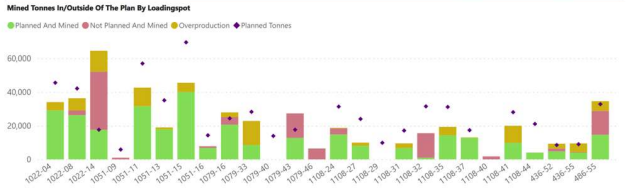
## MUCKING KUJ & KONSULN

WEEK > LOADINGSPOT > COMPLIANCE (CALCUALTED BY RING)

| Fe% Planned | Fe% Giron/Wolis | Fe% Sortingplant |
|---|---|---|
| 47.8 % | 44.7 % | 41.0 % |

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## COMMENTS

- **Resources not in place**: 1051-11; 1079-40; 1079-43; 1079-46; 1108-24; 1108-32; 1108-40; 1108-41
- **Not enough resources**: 1051-13; 1051-15; 1051-16; 1079-33; 1108-27; 1108-29; 1108-35; 1108-44
- **Overproduction of rings**: 1022-14; 1079-33; 1108-31; 1108-41; 436-52; 436-55
- **Constrained by sequence**: 1022-08; 1079-16; 1108-37
- **Low recovery**: 1051-09; 486-55
- **Rings planned wrong**: 1051-09
- **Planned with a higher production rate**: 1022-04

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## 1108-24

- Resources not in place

MONTH > DRIFT > COMPLIANCE (CALCUALTED BY DRIFT)

| Fe% Planned | Fe% Giron/Wolis | Compliance (Ring) |
|---|---|---|
| 38.4 % | 27.3 % | 30 % |

| Total Mined | Total Planned | Total Diff |
|---|---|---|
| 18,730 | 31,359 | -12,629 |

| Planned And Mined | Not Planned And Mined |
|---|---|
| 14,827 | 3,582 |

| Planned And Not Mined | Overproduction |
|---|---|
| 16,533 | 321 |

LKAB

# Final Products

# Final product

**MASUGNSPELLETS / BLAST FURNACE PELLETS**

It is LKAB's largest product group that delivers high customer value in the steel works' blast furnaces with the help of an optimized addition of various minerals such as olivine to improve high-temperature properties

**DR PELLETS / DRI**

DR pellets are reduced with natural gas to DRI, Direct Reduced Iron, which is used to make steel in an electro steel furnace.

LKAB's high pellet quality results in less slag, lower energy consumption, higher productivity, as well as lower maintenance and wear and tear in steel production.

**FINES**

Fines are finely crushed iron ore that is smelted together into cakes (sintered) before use to produce iron in blast furnaces.

The high iron content in LKAB's fines makes it desirable on the market

# Final product

## OTHERS

LKAB also mines and sells minerals and refines and sells iron ore for applications outside the steel industry.

**Magnetite** is used for water purification, sound and vibration damping and as aggregate in heavy concrete.

**Huntite** is used, for example, as a halogen-free, fire retardant additive in plastics and cables.

**Mica** has a very wide range of uses, including as reinforcement and heat protection in plastics and as decorative elements in ceramic materials.

**Mineral sand** is used for the manufacture of welding rods and welding wire.

**Refractory minerals** are used to produce refractory bricks and foundry sand.

LKAB is also an actor in the recycling market of **heat resistant material** such as firebrick and material for lining mas ovens, for example.

One of the most **important innovations** to streamline the mining process in LKAB's underground mines is the drilling technique. **The subsidiary LKAB Wassara has developed a world-patented water-powered drilling system**, which today is also offered for a range of other applications to external customers in the mining and construction industry

# Ενδιαφέρουσα βιβλιογραφία


- SME Mining Engineering handbook
- Subsurface ventilation engineering book, Malcolm J. Mc Pherson
- Στοιχεία προσπέλασης και ανάπτυξης υπογείων εκμεταλλεύσεων, Ζ. Αγιουτάντης

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