Drilling and Blasting practices at Xstrata Nickel – Sudbury Operation

Tuesday, 20 November 2007

Presentation Plan

- **Introduction**
- **Geological Context**
- **Mining Method**
- **Drilling Pattern**
  - Cut and Fill
  - Longhole/Blasthole
    - Narrow Vein <5m
    - Wide Zone >5m
- **Drilling Equipment**
- **Blasting Sequence**
- **Blasting Product**
- **Quality Control**
- **Blasting Performance**
- **Drilling and Blasting Cost**
- **New Project**

Introduction

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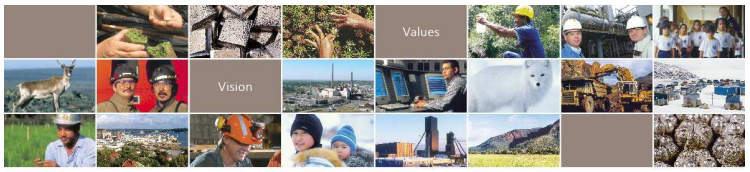
Our Vision and Values



Our Vision

We will **consistently** deliver **superior returns** for **shareholders** by successfully **creating, managing** and **growing** an **industry-leading portfolio** of nickel assets.

We will achieve this in a **safe, transparent, environmentally** and **socially** responsible way together with fellow **employees, communities, governments** and other **stakeholders**.

Our Values

Health and **Safety** above all

Honesty and **Integrity** in our dealings

Accountable for our actions

Entrepreneurial in identifying and pursuing value

Passion to change for the better and **Courage** to pursue that change

Engage with our fellow employees, communities, governments and other stakeholders in building and sustaining mutually beneficial relationships

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Xstrata Nickel – Sudbury Operations

Xstrata Nickel – Sudbury Operations is:

- **3 mines in operations (Craig, Fraser and Thayer-Linsely)**
- **1 Concentrator (10, 000 t/day)**
- **1 Nickel Smelter**
- **1 project in advanced development (Nickel Rim South)**
- **1 project under development (Fraser-Morgan)**
- **1 project in feasibility (Onaping Depth)**

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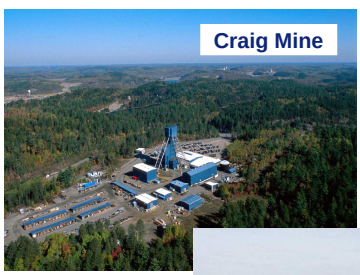
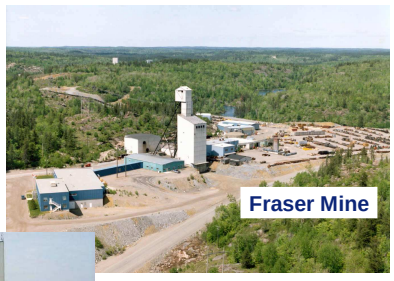
Xstrata Nickel – Sudbury Operations





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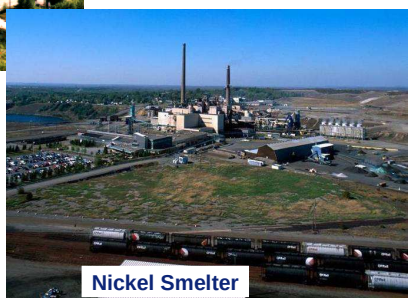
Xstrata Nickel – Sudbury Operations



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Production Statistic

- **Production tonnes (2007):** **1,900,000**
  - Cut & Fill **1,000,000**
  - Longhole/Blasthole **900,000**
- **Tonne/day (2007):** **5,250**
- **Production cost/tonne:** **$126.52**

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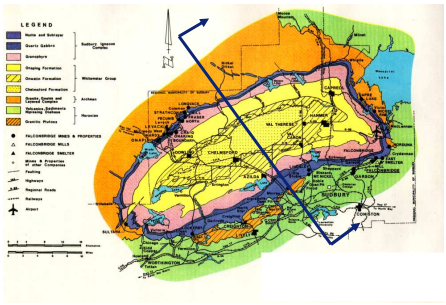
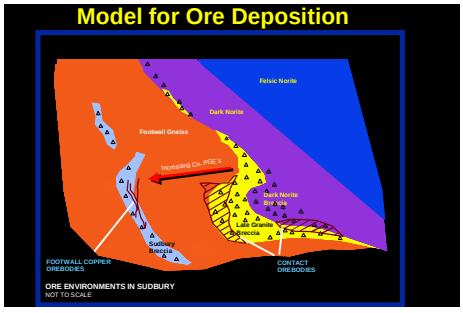
Geological Context

Regional Geology

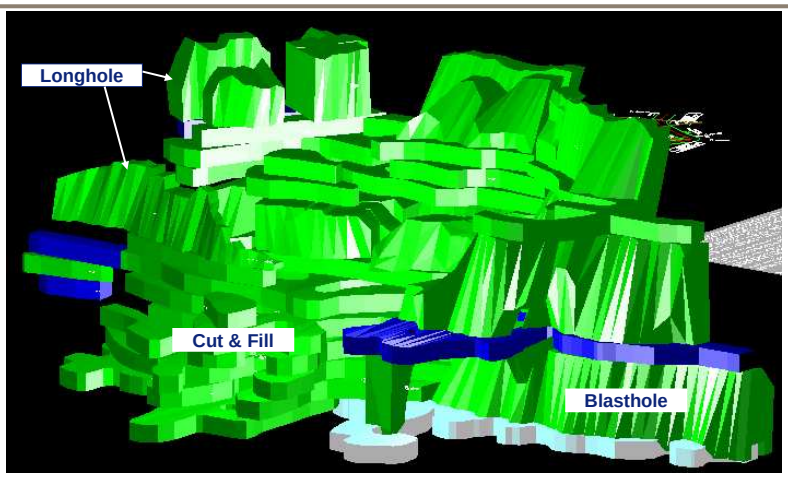
Sudbury Basin



Sudbury Basin – North Range Cross section



Typical Ore zone



Typical ore zone with mixed mining methods, relatively complex geometry
- flatter dipping, more erratic areas mining with post pillar cut & fill, 5m vertical slices
- steeper, more continuous zones mined with blasthole open stoping
- top of ore pods usually extracted with uppers (longhole)

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Mining Method

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Mining Method

Two mining method are used at Strata – Sudbury Operations depending on the spatial orientation of the orebody as well as size and geometries

- **Cut and Fill** mining is used when the orebody is dipping lower than 50° or sub-horizontally

- **Blasthole** and **Longhole** is used when the orebody is above 50°

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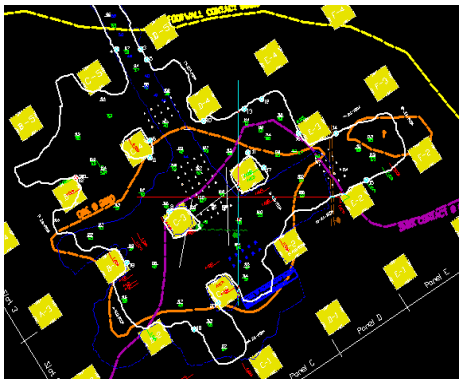
Cut and Fill – Plan view

Cut and Fill – Plan view



Access x-cut are driven from main ramp and drifts to the ore zones. Ore is mined upwards by successive breasting cuts techniques.

When the ore zone exceeds 11 m width post pillar pattern is applied.

Post pillars (5m X 5m) are established between 11m width panels. These post pillars are carried through subsequent cuts.

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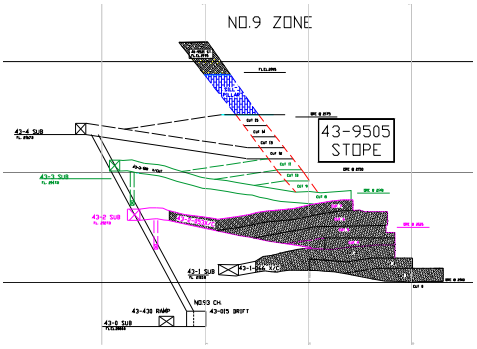
Cut and Fill – Cross section

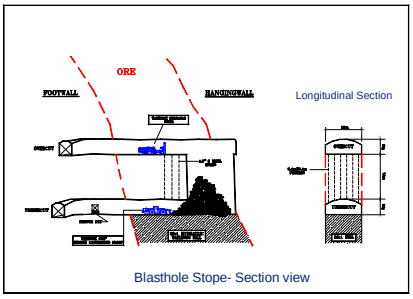


X-Cut distance from the main access permits to mine 5 cuts

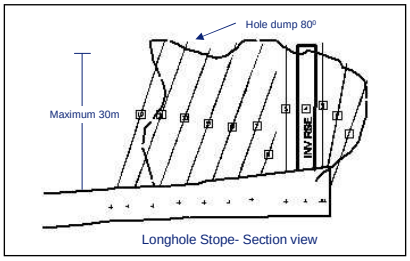
First access is at -15% and other access by increment of 7.5% after to a maximum of +15%

Hydraulic backfill is used to fill finished cut

Blasthole & Longhole Stoping



Blasthole Stope- Section view



Longhole Stope- Section view

Blasthole mining is used where geometry and geologic confidence in the ore outlines are favorable

It is utilized to recover pillars located between areas mined by Cut & Fill or to recovery the top extremity of an ore zone

When ore is mined by blastholes drilled from the undercut with no overcut present (up drilling), the method is locally named Longhole stoping

Typically blasthole are 12 to 15 meters width by 15 to 30 meters height and average of 25 meters long

Slot raise are excavated with conventional method (Machines Roger or raisebore) and in some occasion in form of drop and inverse raises

Holes diameter are 114 mm to a maximum length of 30 meters

Holes are loaded with bulk emulsion explosives and initiated with I-Kon detonators

Drilling Pattern

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Cut and Fill

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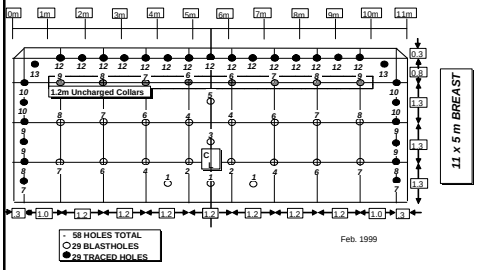
Cut and Fill - Drilling Pattern



- **Drilling is done with twin booms jumbo**
- **Breasts are 4m long with 44 mm diameter holes**
- **Nonel detonators and AnFo are used for blasting**
- **Perimeter drilling and blasting practice are used**

Longhole and Blasthole

Drilling Statistics

- **Meter drilled /year:** **83,300**
- **Tonne/meter drilled:**
  - **Narrow Vein** **2.5 – 3.5**
  - **Wide Zone** **10.5 - 15**
- **Average meter/shift:** **30 - 45**
- **Operating Hour/shift:** **10.5**
- **Shift/week:** **14**

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Narrow Vein (<5m)

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Narrow Vein drilling parameters

- **Sublevel Interval = 12m**
- **Longitudinal stopes developed on the ore veins**
- **Ore Width ≈ 2 – 3m**
- **Stopes length ≈ 10 – 12m**
- **Initial opening – Inverse or Drop raise**
- **Drilling pattern = 3-2-3 (0.9m X 0.9 @ 1.0m)**
- **Hole diameter = 54 mm**

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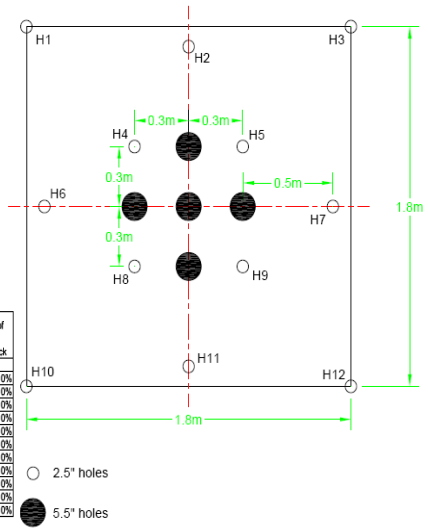
Slot Raise Pattern Narrow vein

- **Drill Pattern for Inverse and Drop Raise**
- **Void Ratio for the First Hole Fire is around 32%**
- **Key Success – Drill holes Accuracy**



General Specs:

Length of raise to blast	10	ft.
Initial void: Diameter of hole(s)	5.5	inches
Number of holes	3	

Initial void area:	0.49	sq.ft.
Initial void area:	0.05	sqr m
Muck movement velocity	90	ft/s

Design calculations:

Firing sequence	Hole #	Top area, sq m	Bottom area,sq m	Average area of rock sq.m	Rock vol, cubic ft	Muck vol, cubic ft	Muck gone in last delay	Muck from last delay	Total muck cubic ft	Void avail(sq.ft	Next delay	Delay time,ms	Void utilization ratio %	% of old muck
1	H4	0.09	0.09	0.09	10	13	0	0	13	5	245	5	98%	
2	H9	0.09	0.09	0.09	10	13	13	0	13	15	250	250	66%	0%
3	H5	0.09	0.09	0.09	10	13	13	0	13	24	200	500	40%	0%
4	H8	0.09	0.09	0.09	10	13	13	0	13	34	200	700	31%	0%
5	H2	0.15	0.15	0.15	16	22	13	0	22	44	150	900	37%	0%
6	H11	0.15	0.15	0.15	16	22	22	0	22	60	150	1050	29%	0%
7	H6	0.15	0.15	0.15	16	22	22	0	22	76	150	1200	24%	0%
8	H7	0.15	0.15	0.15	16	22	22	0	22	92	150	1350	20%	0%
9	H1	0.48	0.48	0.48	52	70	22	0	70	108	150	1500	45%	0%
10	H12	0.48	0.48	0.48	52	70	70	0	70	160	150	1650	34%	0%
12	H3	0.48	0.48	0.48	52	70	70	0	70	212	150	1800	27%	0%
13	H10	0.48	0.48	0.48	52	70	70	0	70	283		1950	23%	0%

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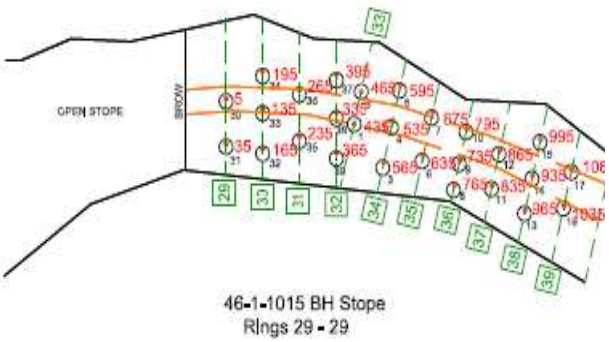
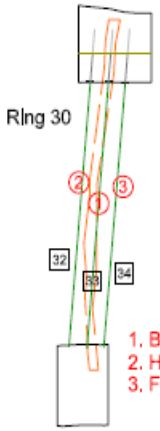
Drilling and Blasting (Narrow Vein (<5m)

Ring Burden = 1.8m (3 hole)
Dice Ring = 0.9m (2 hole)



46-1-1015 BH Stope
Rings 29 - 29



1. Blast center hole first.
2. Hanging wall second.
3. Foot wall third.

Blasting design shown here has 30ms between holes and 100ms between rings.

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Wide Zone (>5m)

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Slot Raise – Design Parameters

Blasthole

Slot Raise Length	Type
Up to 30m	Drop Rse or V-30

Longhole

Slot Raise Length	Type
12-15m	Inverse Raise
15-18m	Single V-30
18-25m	Double V-30
> 25-30m	Alimak Raise

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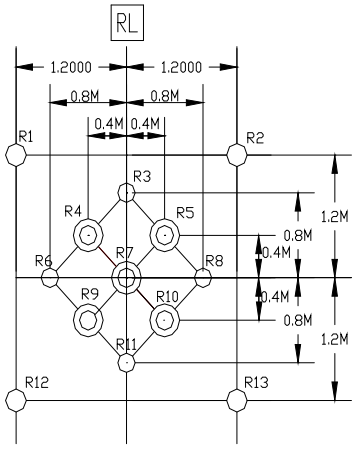
Drop & Inverse Raise – Drilling pattern



- 13 hole slot raise pattern used for lengths up to 15 meters.
- Pattern consists of 5 203mm(8”) reamed holes, and 8 114mm(4.5”) helpers.

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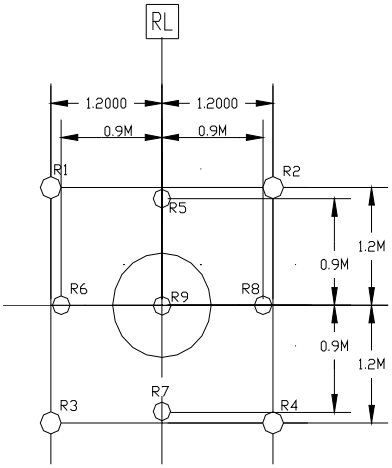
Single V-30 – Drilling Pattern



- **9 hole slot raise pattern used for lengths up to 25 meters.**
- **Consists of 762mm (30”) reamed center hole, and 8 114mm(4.5”) perimeter holes.**

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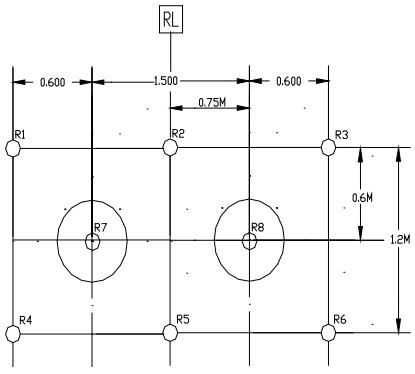
Double V-30 – Drilling Pattern



- **8 hole raise pattern used for length between25 & 30m.**
- **Two 762mm(30”) reamed holes with 6 114 mm (4.5”) perimeter holes.**

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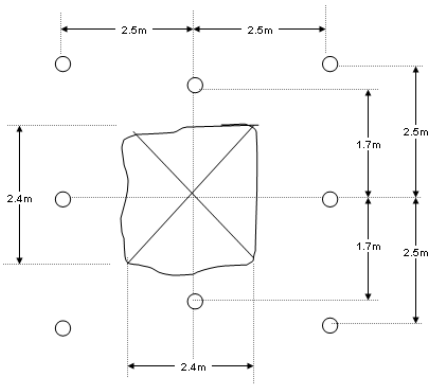
Alimak Raise – Drilling pattern



- **Alimak Raise 2.4m X 2.4m maximum length 30m**
- **8 slashing hole around the raise**

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Blasthole & Longhole-Design Parameters

- **Blasthole**
  - **Fan drilling: 100%**
  - **Burden: 2.5 to 3.0m**
  - **Spacing: 2.5 to 3.0m**
- **Longhole**
  - **Fan drilling: 90%**
  - **Burden: 2.5 to 3.0m**
  - **Spacing: 2.5 to 3.0m**
  - **Dump: 10º**

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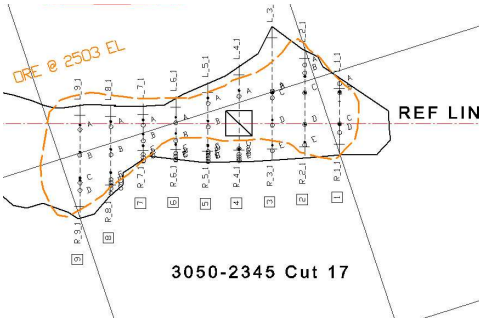
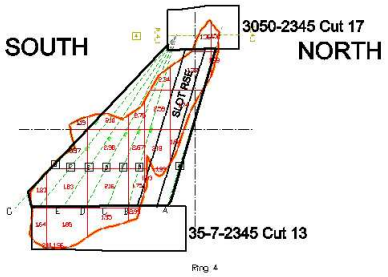
Blasthole Stope Design

xstrata nickel

Plan view



Section view



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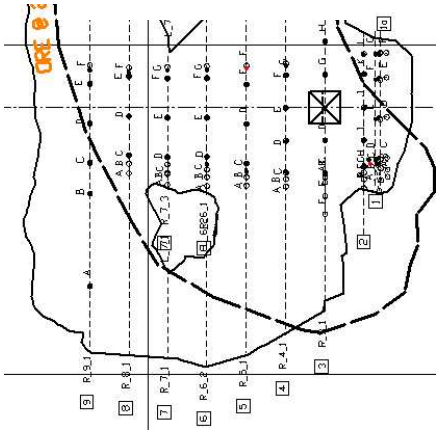
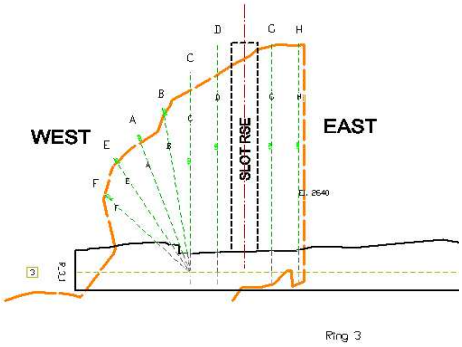
Longhole Stope Design

xstrata nickel

Plan view



Section view



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Drilling Equipment

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Production Drill

- **ITH Production Drill**
  - **2 ITH Cubex on track with carrousel**
  - **2 ITH Cubex on track without carrousel**
  - **1 ITH Cubex "ARIES" trackless**
  - **1 ITH Cubex "Pegasus" trackless**
  - **1 Boart Stopemaster**
  - **1 Boart Stopemate (Narrow Vein Drill)**
- **Contractor (V-30)**
  - **1 ITH Cubex Orion (30" Slot raise)**

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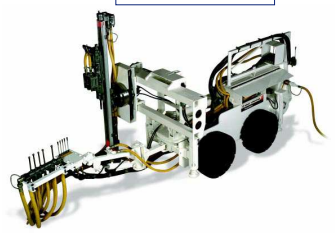
Drilling Equipments

Cubex Aries Drill

Cubex Drill 6200

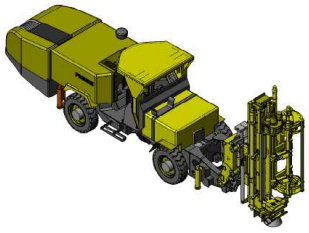
Cubex Drill 5200

Boart Stopemate



Boart Stopemaster

Cubex Pegasus Drill



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Cubex Rubber Tired Vs Cubex Track Mounted

- **Advantage:**
  - **Highly mobile (rubber tired articulated)**
  - **Self contained (booster compressor, power cable reel)**
  - **Lower operating cost**
  - **More productive (operator friendly)**
  - **Easier to set up**
- **Disadvantage:**
  - **Dimension (need larger & straight excavation)**

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Drill Maintenance Cost & Availability

- **Drill availability**
  - **Cubex track mounted 85 to 90%**
  - **Cubex rubber tired 90%**
- **Cubex track Mounted**
  - **Cost/operating hour: $167**
- **Cubex "ARIES"**
  - **Cost/operating hour: $96**

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Blasting Sequence

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Blasting Sequence

Longhole (Machines Roger & Inverse Raise)
- **Stope <10 000 tonnes usually 1 Blast**
- **Stope >10 000 tonnes 2 or 3 Blasts depending on void availability**

Blasthole (Machines Roger raise)
- **Stope <10 000 tonnes usually 2 Blasts**
- **Stope >10 000 tonnes 3 or 4 Blasts depending on void availability**

Blasthole (Drop raise)
- **Stope <10 000 tonnes usually 5 Blasts**
- **Stope >10 000 tonnes 5 or 6 Blasts depending on void availability**

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Blasting Parameters

Blasthole and Longhole Timing

- **Between Holes 25 – 35 ms**
- **Between Rings 100 ms**

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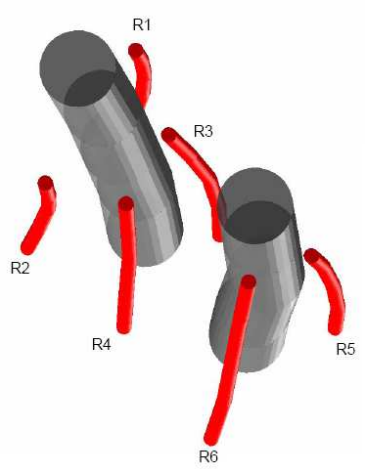
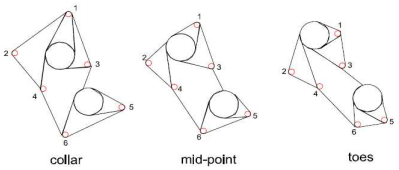
Slot Raise Timing based on Slot Rse Calculator



Raise sections



Input data
Designed delay
Calculated data

28 m

General Specs:														
	Length of raise to blast	92.96	ft					Initial void area:	4.91	sq.ft.				
	Initial void: Diameter of hole(s)	30	inches					Initial void area:	0.46	sqr m				
	Number of holes							Muck movement vel	30	ft/s				

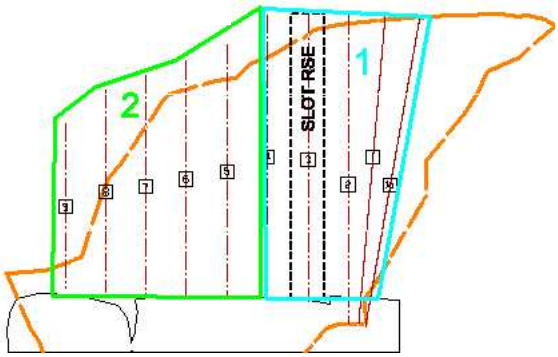
Design calculations:

Firing sequence	Hole #	Top area, sq m	Bottom area,sq m	Average area of rock sq.m	Rock vol, cubic ft	Muck vol, cubic ft	Muck gone in last delay	Muck from last delay	Total muck cubic ft	Void avail sq ft	Next delay	Delay time,ms	Void utilization ratio %	% of void muck
1	5	0.22	0.15	0.19	188	281	0	0	281	456	343	5	44%	
2	6	0.48	0.23	0.36	358	537	94	187	724	644	350	350	64%	67%
3	3	0.33	0.37	0.35	348	521	245	479	1000	1002	350	700	60%	66%
4	1	0.36	0.11	0.23	233	350	339	661	1011	1350	350	1050	56%	66%
5	4	1.34	1.33	1.34	1335	2003	343	669	2672	1583	350	1400	79%	66%
6	2	0.96	0.47	0.72	718	1077	905	1766	2843	2918	350	1750	89%	66%
15														

Longhole Blasting Sequence

Blasting Sequence

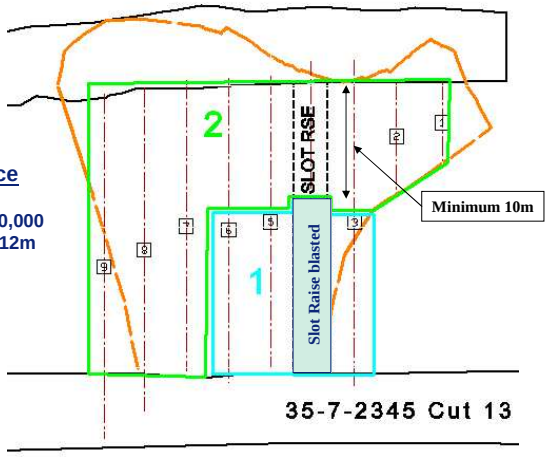
- **Stope tonnage ≈ 15,000 tonnes**
- **Blasted inverse raise with production rings**
- **Final Blast - remnant rings**



Blasthole Blasting Sequence

Blasting Sequence

- Stope tonnage ≈ 20,000
- Blasted slot up to 12m
- Toe Blast to 10m
- Final Blast



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Blasting Product

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Blasting Products

Development

- **AnFo in cut and relive holes**
- **Razor Back or AnFo traced with B-line in perimeter holes**
- **Package emulsion (Magnafrac) in lifters and wetholes**
- **Detonator: Nonel and electric starter**

Production

- **100% bulk emulsion**
- **Detonator: I - Kon**

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I – Kon Benefits

- **Improved recovery**
- **Improved fragmentation**
- **Increased flexibility**
- **Larger blasts**
- **Less Inventory (period, length)**
- **Increased confidence on inverse raises (better timing accuracy)**

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Comparison between I – Kon & Nonel

xstrata nickel

I-Kon vs Nonel

Stope	Detonator	Number of Blasts	Average Blast Size	% Recovery	% Lost	Bucket Factor	Broken Height
4575 N LH	Nonel	2	6500	80%	20%	11.57	13
9505 P1E	Nonel	2	4250	102%	-2%	n/a	
3600 LH	Nonel	2	2850	92%	8%	12.47	10
47-1-017	Nonel	2	2000	89%	11%	n/a	14
47-1-017	Nonel	1	7000	86%	14%	10.40	
40+5-9521	Nonel	3	6367	83%	17%	13.43	17
55-0-929 P3	Nonel	1	4500	82%	18%	11.78	17
53-900-P3	Nonel	2	8750	93%	7%	8.56	18
	AVG	**1.88**	**5277**	**88%**	**12%**	**11.93**	**14.2**
910 P1 LH	I-kon	1	10000	88%	12%	11.68	25
910 P2 LH	I-kon	1	15000	107%	-7%	12.60	
43-3-9505 P5	I-kon	2	13000	99%	1%	12.52	18
43-4-9505 P2 E	I-kon	1	9000	84%	16%	15.02	17
55-0-929 P3	I-kon	1	13500	80%	20%	12.22	
47-1-017	I-Kon	1	22000	91%	9%	10.98	20
1012 L/H	I-kon	1	6800	85%	15%	11.72	14
47-1-017 P3	I-Kon	1	23000	93%	7%	12.42	
	AVG	**1.13**	**14038**	**91%**	**9%**	**12.39**	**18.8**

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Bulk Emulsion Loading System

xstrata nickel

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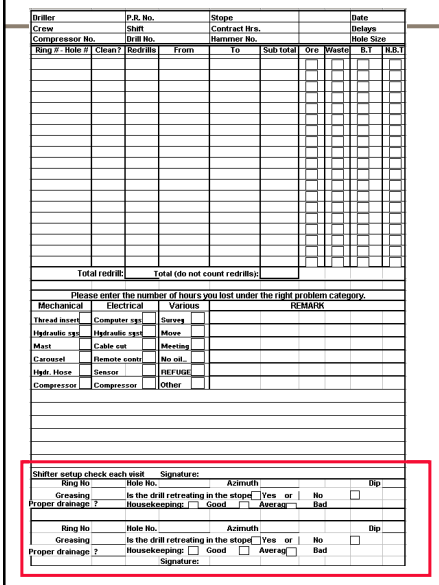
Quality Control

Quality Control Measures

- Drilling tools must be in top condition
- Use stabilizer
- Maintain our drilling equipment in top shape
- Survey slot raise & easy holes
- Check set up & holes degree by the supervisor on each shift
- Cleaning & measuring holes prior loading
- Use a good & precise protractor (digital protractor need to be calibrated periodically)
- Paint adequate lines for drill alignment
- Plug holes not used in blast (Inaccurate holes)

ITH Drilling Report



Driller	P.R. No.	Stope	Date
Crew	Shift	Contract Hrs.	Delays
Compressor No.	Drill No.	Hammer No.	Hole Size

Ring / - Hole #	Clean?	Redrills	From	To	Sub total	Ore	Waste	B.T	N.B.T

Total redrill: ____ Total (do not count redrills): ____

Please enter the number of hours you lost under the right problem category.

Mechanical	Electrical	Various	REMARK
Thread insert	Computer sys	Survey	
Hydraulic sys	Hydraulic sys	Move	
Mast	Cable cut	Meeting	
Carousel	Remote contr	No oil	
Hydr. Hose	Sensor	REFUGE	
Compressor	Compressor	Other	

Shifter setup check each visit Signature:

Ring No	Hole No.	Azimuth	Dip
Greasing	Is the drill retreating in the stope Yes or No		
Proper drainage ?	Housekeeping: Good Averag Bad		

Ring No	Hole No.	Azimuth	Dip
Greasing	Is the drill retreating in the stope Yes or No		
Proper drainage ?	Housekeeping: Good Averag Bad		

Signature:

- **Driller to complete all indicated information.**
- **Shift boss to check accuracy of reporting at end of shift**
- **Shift boss to make on site drill accuracy checks and sign off**

Fill by supervisor every shift

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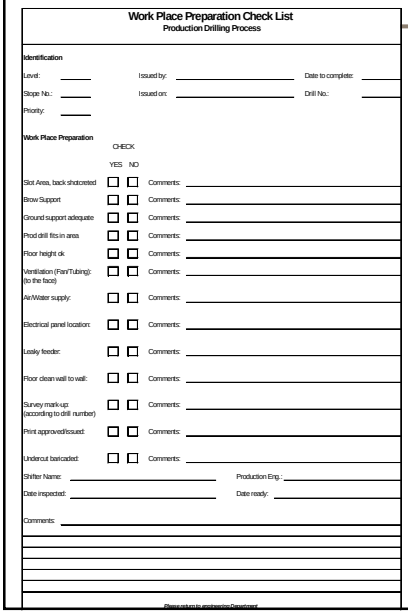
Site Preparation Check List



Work Place Preparation Check List
Production Drilling Process

Identification

Level: ____ Issued by: ____ Date to complete: ____

Slope No.: ____ Issued on: ____ Drill No.: ____

Priority: ____

Work Place Preparation

	CHECK YES	NO	Comments
Slot Area, back shotcreted	☐	☐	Comments:
Brow Support	☐	☐	Comments:
Ground support adequate	☐	☐	Comments:
Prod drill fits in area	☐	☐	Comments:
Floor height ok	☐	☐	Comments:
Ventilation (Fan/Tubing): (to the face)	☐	☐	Comments:
Air/Water supply:	☐	☐	Comments:
Electrical panel location:	☐	☐	Comments:
Leaky feeder:	☐	☐	Comments:
Floor clean wall to wall:	☐	☐	Comments:
Survey mark-up: (according to drill number)	☐	☐	Comments:
Print approved/issued:	☐	☐	Comments:
Undercut barricaded:	☐	☐	Comments:

Shifter Name: ____ Production Eng.: ____

Date inspected: ____ Date ready: ____

Comments: ____

Please return to engineering Department

- **Engineering to initiate sheet based on schedule**
- **Blast hole supervisors to ensure drill locations are ready as defined by the preparation sheet**
- **Drill not allow to move into stope until a completed and signed preparation sheet is received to engineering**

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Consumables quality control
Direct delivery to drill

Material Delivery to Production Drill and Jumbo

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Gyro Smart Survey Instrument

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Stope Performance

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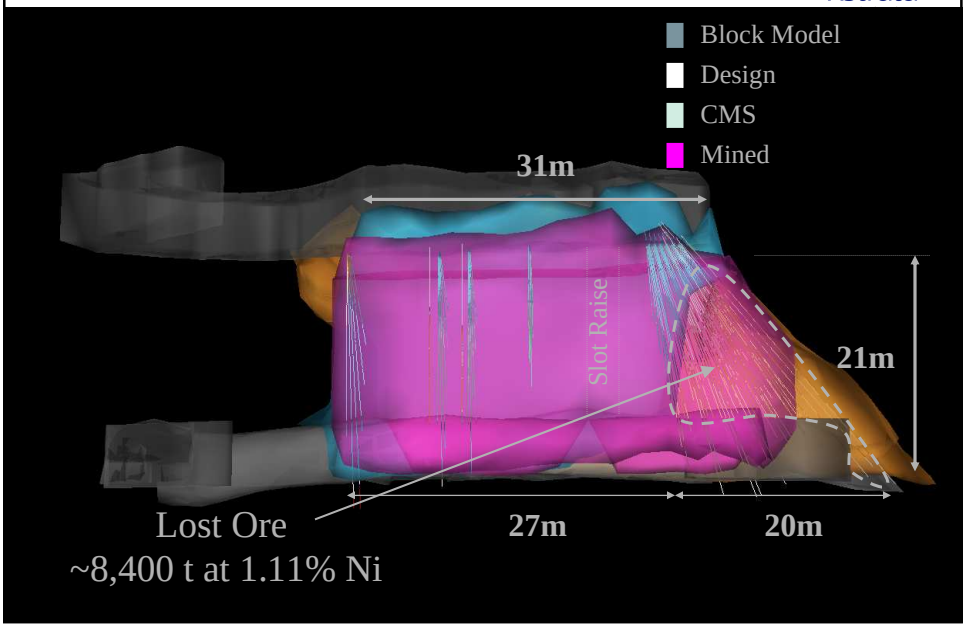
51-3-344 BHP (Looking East)



51-3-344 BHP - Stope Performance Analysis

- **Slot raise and front rings were shot at the same time.**
- **Development at the O/C and U/C were not sufficient**
- **Too many fan rings in front of slot (8 rings)**
- **Tight void at U/C (choked blast)**

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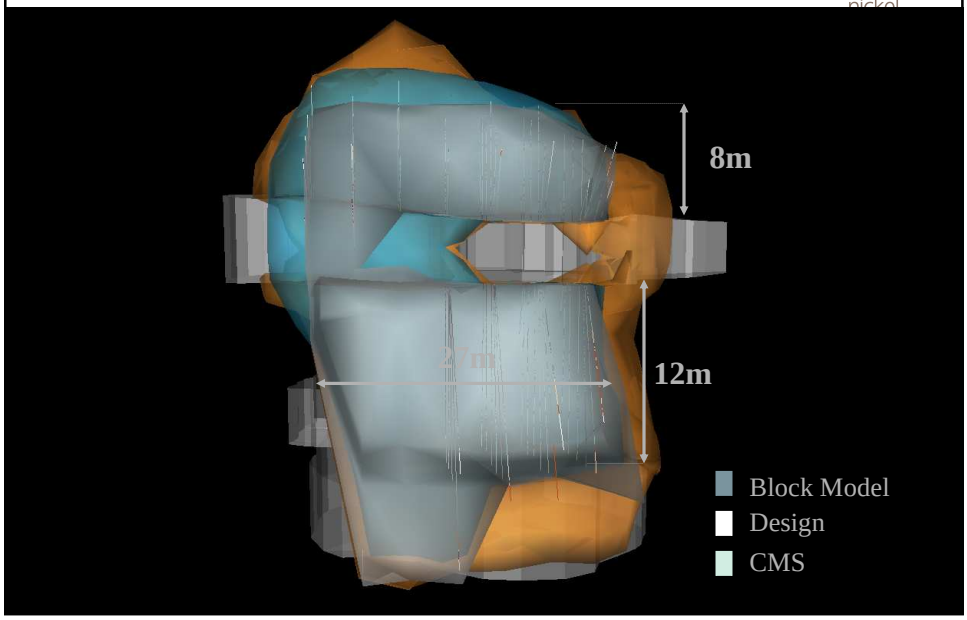
Onaping 56 LH/BHP 7 (Looking East)



56 LH/BHP 7 - Stope Performance Analysis

- **U/C & O/C fully open**
- **Initial opening – Conventional drop raise**
- **Competent ground**
- **3 blast was done in drop raise prior to the final blast**
- **Longhole blasted simultaneously with blasthole**

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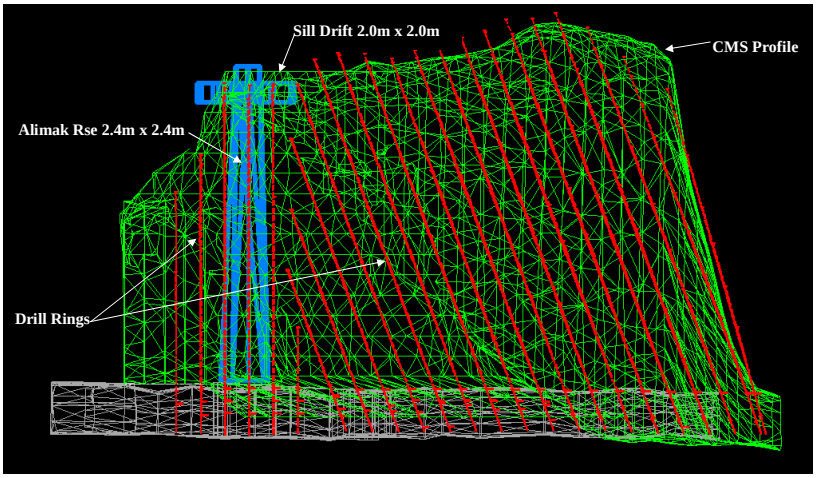
44-0-368 Stope 30-32m Design



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44-0-368 Stope Design

Stope Design

- Stope height between 30 – 35m
- Slot design – Alimak Raise 2.4m X 2.4m
- Slot extremity – Sill Drift 2.0m x 2.0m
- Drill pattern – 2.5m X 2.5m

Quality Control

- All holes around the slot were survey
- Others in the blast randomly survey
- All holes depth before loading
- Inaccurate holes were re-drilled

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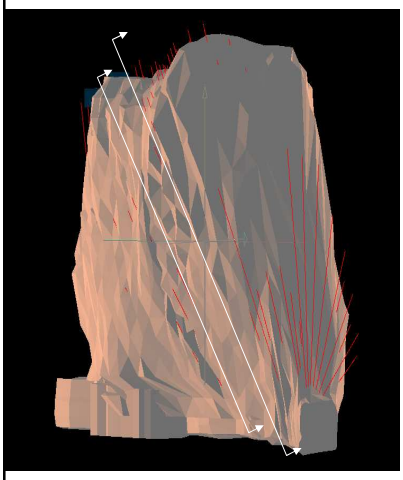
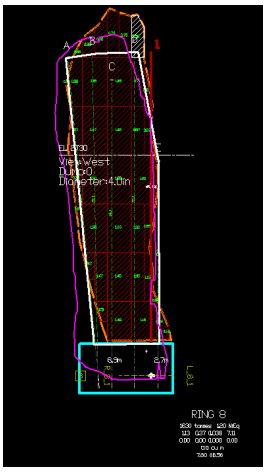
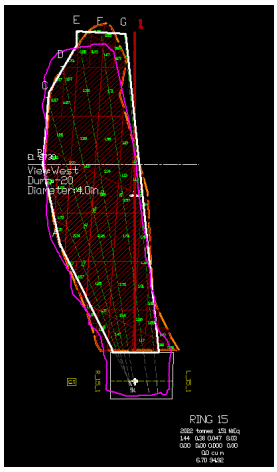
44-0-368 Stope - Blasting Result







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Dilution And Recovery

- **Cut & Fill**

  - Dilution (2007): 2%
  - Recovery (2007): 89%

- **Longhole**

  - Dilution (2007): 5%
  - Recovery (2007): 86%

- **Blasthole**

  - Dilution (2007): 5%
  - Recovery (2007): 89%

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Drilling and Blasting Costs

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Production Drilling Cost

- **Production Drilling Cost**
  - **$/meter drilled (114 mm): 38.28**
  - **$/meter drilled (114 mm) Contractor: 42.50**
- **Slot Raise Cost**
  - **Machines Roger 30” ($/meter): 1150**
  - **Raise Bore**
    - **28.5” down reaming ($/meter): 1400**

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New Projects

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Drilling & Blasting Projects

- **Overbreak reduction program in development from 25% to 15%**
- **Rapid Slot Raising**
- **Larger emulsion bins to avoid manipulation**
- **Continue to test Gyro Smart survey instrument**

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Questions ?

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