Remote Monitoring of Limestone Quarries

Case Studies in Africa, Middle East and India

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Today's Challenges in Mining

Inaccessibility & cost of timely, global expertise

Delayed corrective action

Shrinking material resources

Escalating production costs

Changing quality requirements

Tighter planning schedules

Increasing mining constraints

Why Remote Monitoring ?

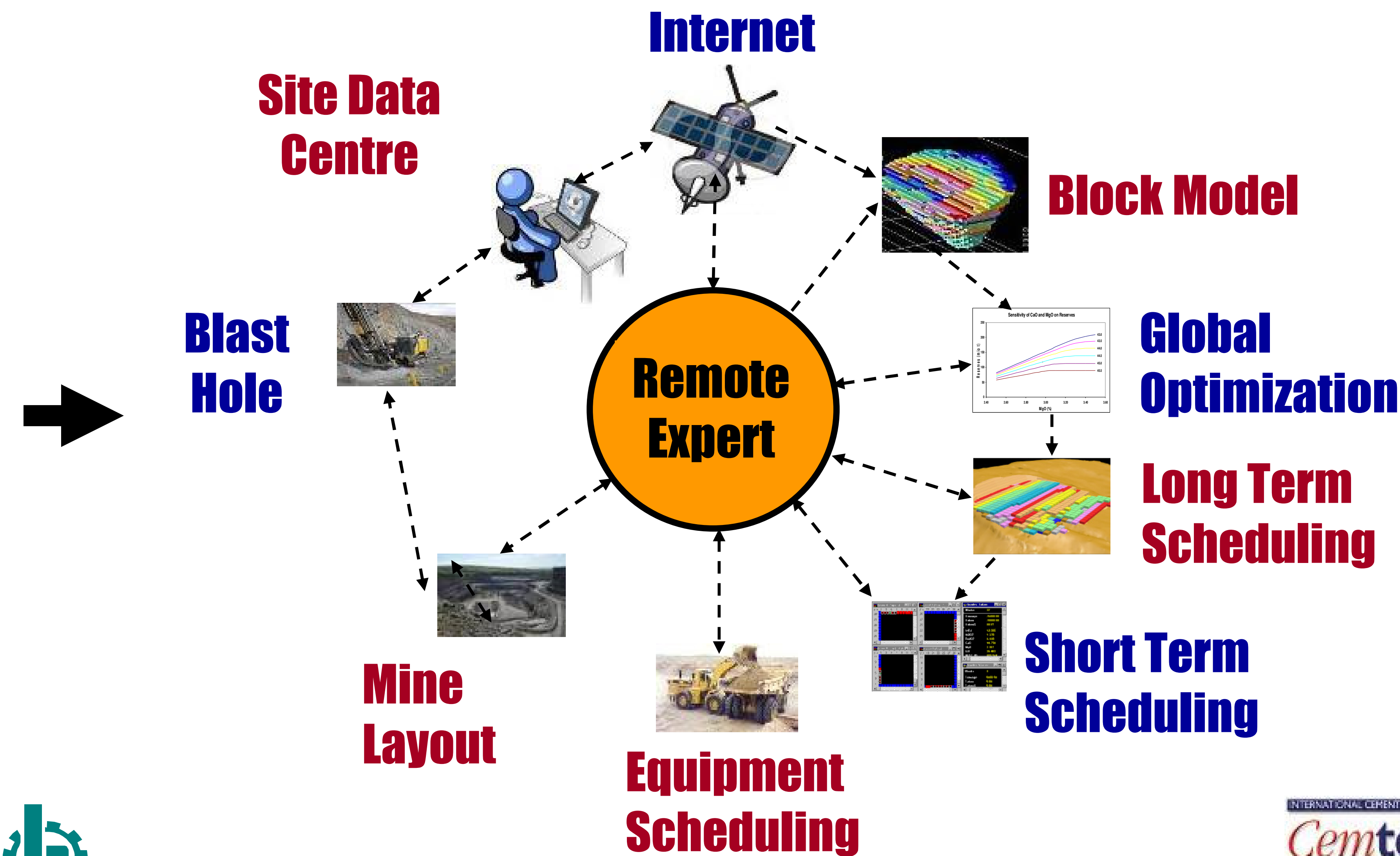
Cost-efficient solution to dynamically optimize mine operations

- Inaccuracies caused by wider grid spacing initially employed
- Unexpected occurrences of deleterious material and land constraints
- Changes in environmental statute and quality variations in input materials and product requirements
- Ease of mining considerations of mines manager
- Inadequacy of local expertise (manpower, analytical tools, etc)
- O&M contracts which ignore resource conservation

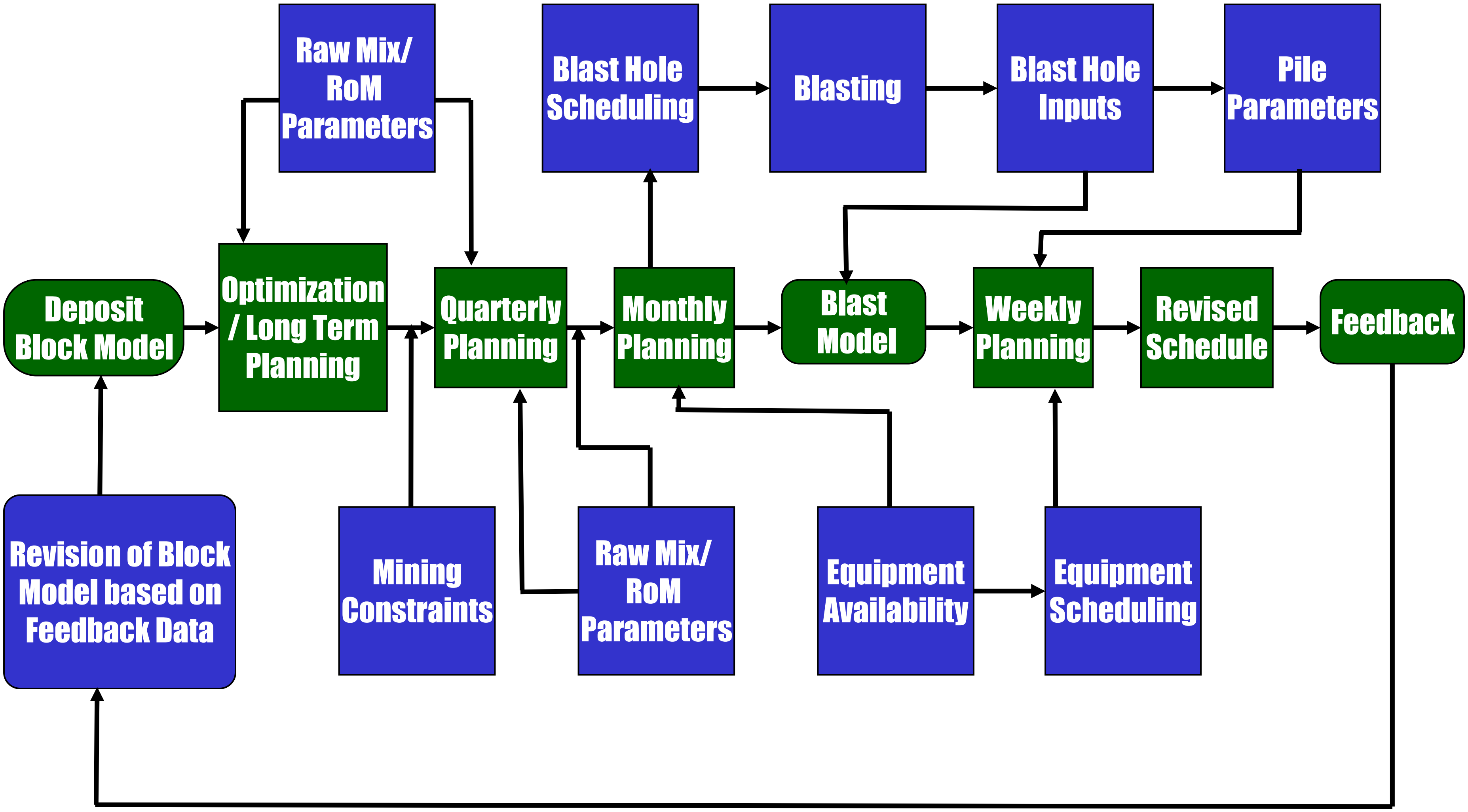
What it achieves

- Permits remote monitoring of mining operations on a dynamic (weekly/ fortnightly/ monthly) basis
- Allows flexibility in mining operations by dynamically optimizing extraction plans
- Assures steady supply of homogenized material to meet changing quality requirements
- Minimizes human dependency and bias
- Guarantees savings in mining costs
- Most importantly, extends deposit life

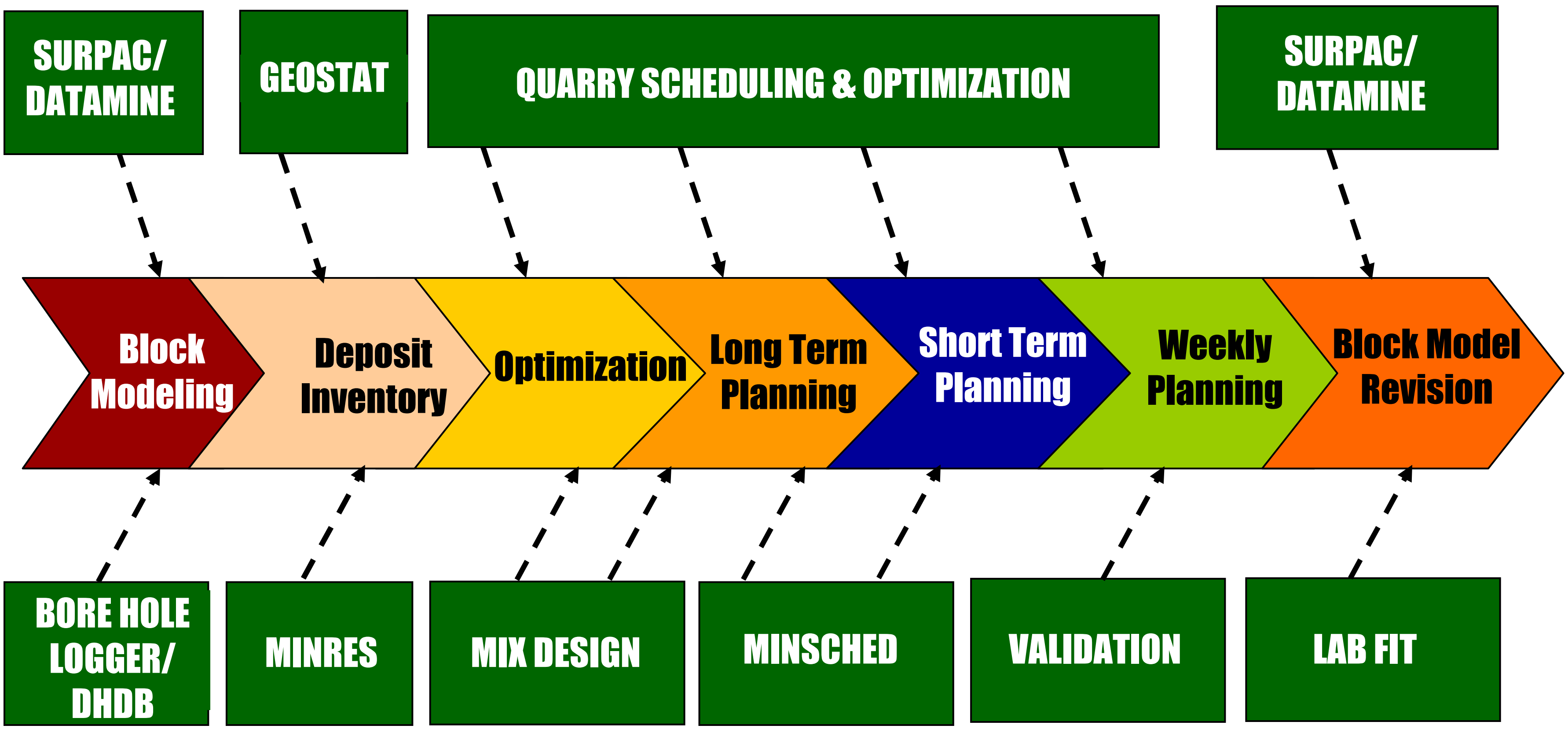
Remote Monitoring System



Methodology

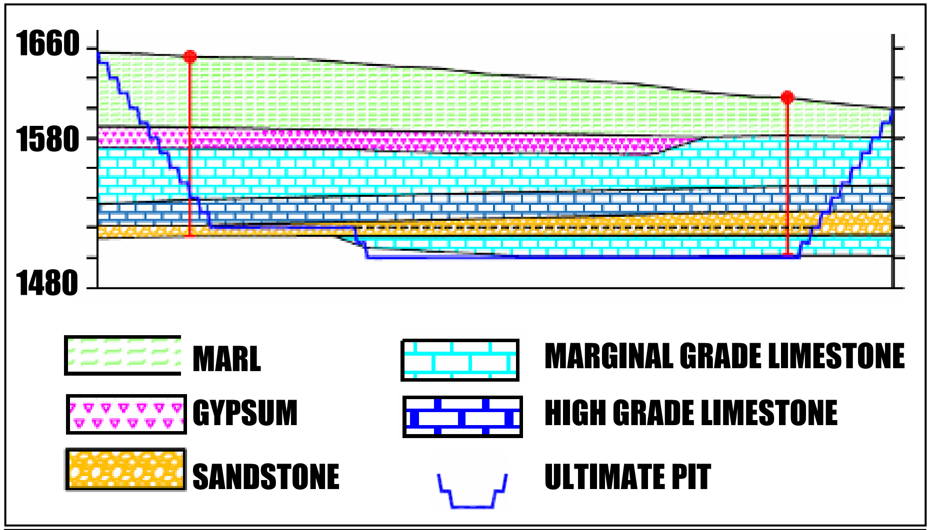


Tools



SURPAC/ DATAMINE
GEOSTAT
QUARRY SCHEDULING & OPTIMIZATION
SURPAC/ DATAMINE
Block Modeling
Deposit Inventory
Optimization
Long Term Planning
Short Term Planning
Weekly Planning
Block Model Revision
BORE HOLE LOGGER/ DHDB
MINRES
MIX DESIGN
MINSCHED
VALIDATION
LAB FIT

Case Study 1 : North Africa



Problems

- Only HG Limestone was being used
- MG Limestone was being dumped as reject over the HG Limestone area
- Mine advancement inhibited due to the OB dump > 30 m height totalling ~ 5 mio t
- High production cost

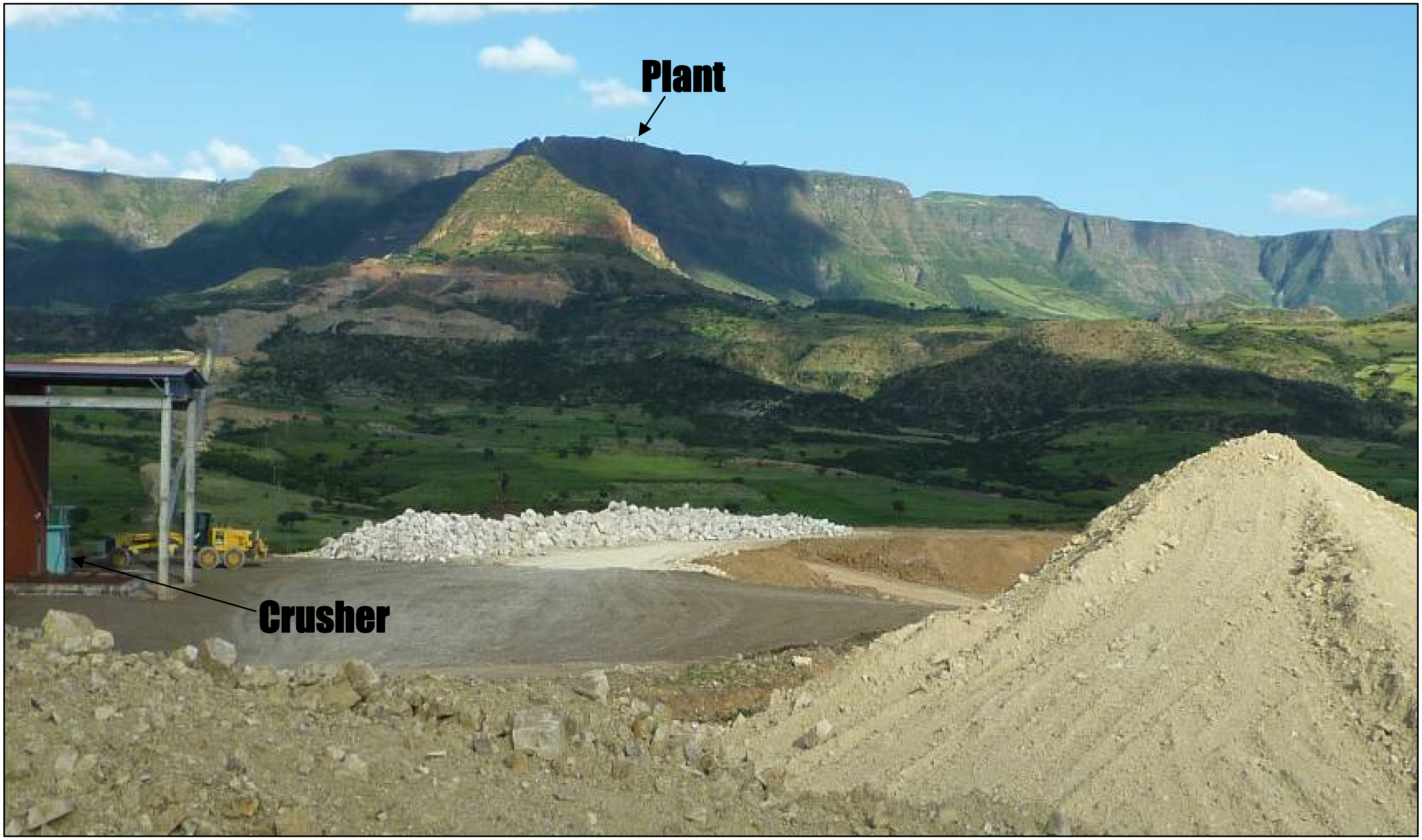
Recommendations

- Blending of MG Limestone dumped as OB with HG Limestone by optimization study
- Systematic sampling & analysis of dump
- Raw-mix study utilizing Marl and MG Limestone in-situ as well as material dumped as OB

Benefits

- Increase in reserves by 29 mio t
- Enhancement of deposit life by 10 years
- Recovery ratio reduced from 1:1 to 1:0.55
- Saving of USD 2.75 mio / annum
- Minimization of equipment and man-power
- Environmentally sustainable operation

Relative Locations



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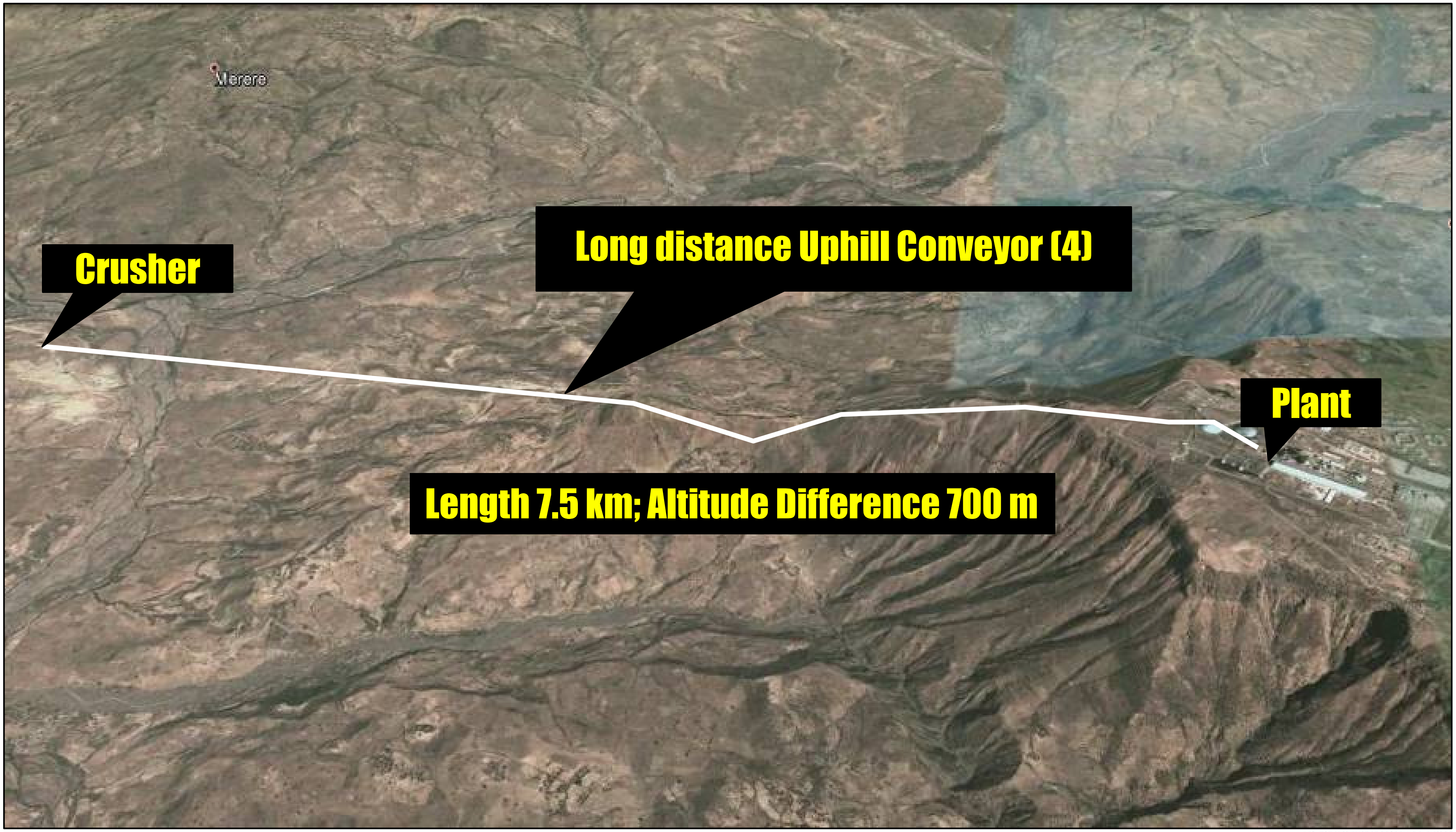
Distances & Logistics



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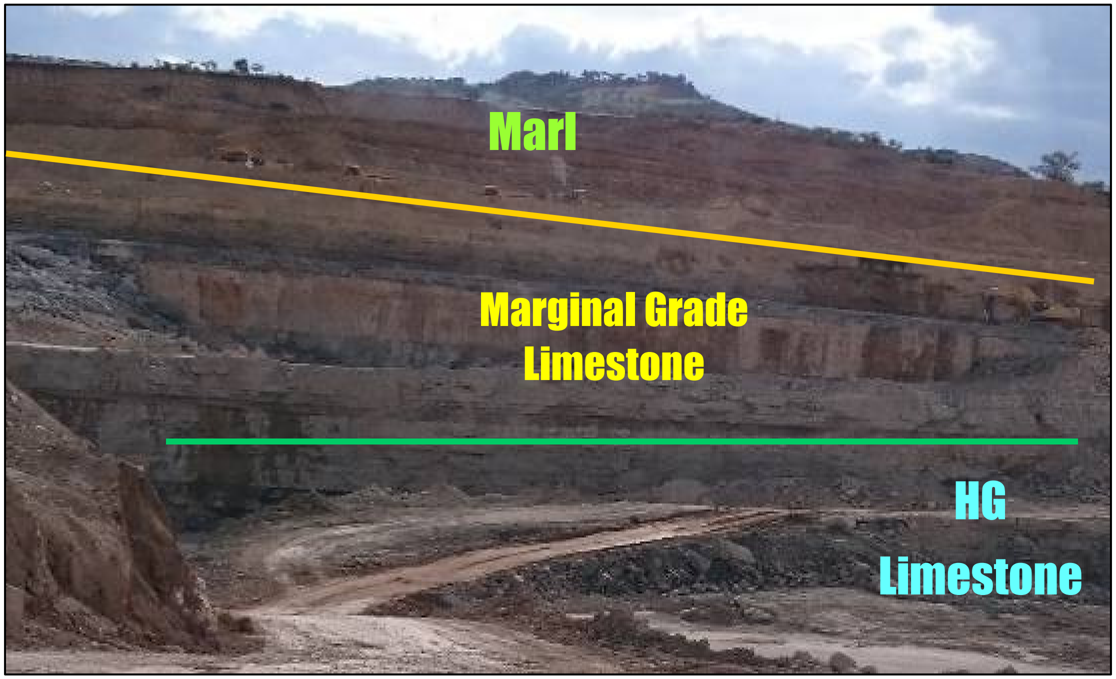
Material Occurrences

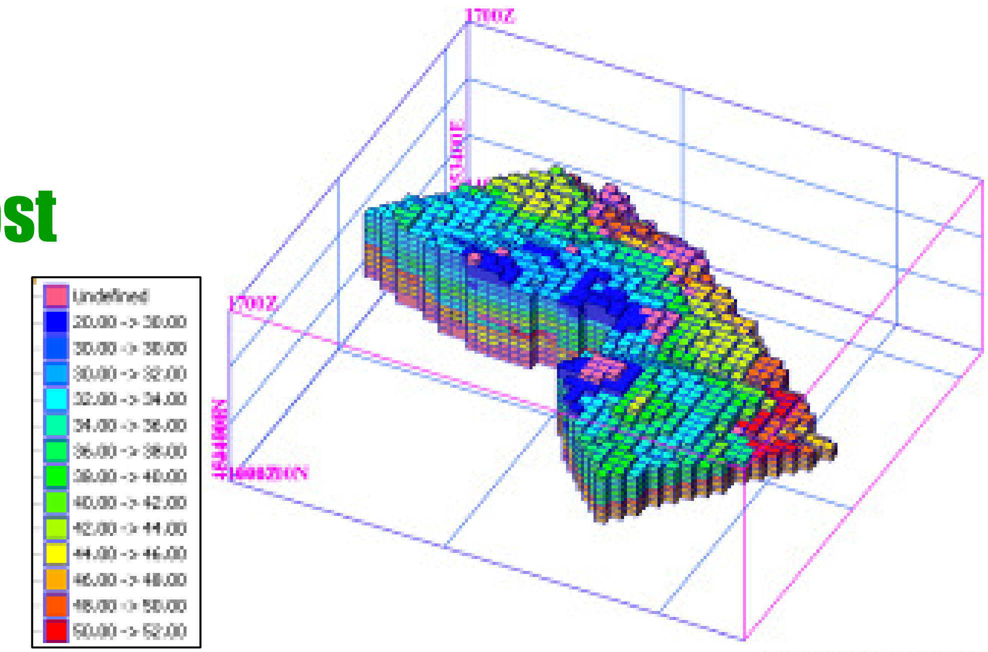


Limestone associated with Marl

High grade Limestone Outcrop

Deposit Evaluation

- Marl: Occurs at top, highly heterogeneous and low grade
- Limestone : Heterogeneous marginal grade of about 50 m thickness overlies 30 m thick bottom high grade
- Use of marl to the extent possible to achieve:
  - Lower Recovery Ratio
  - Reduced Production Cost
  - Enhanced Deposit Life



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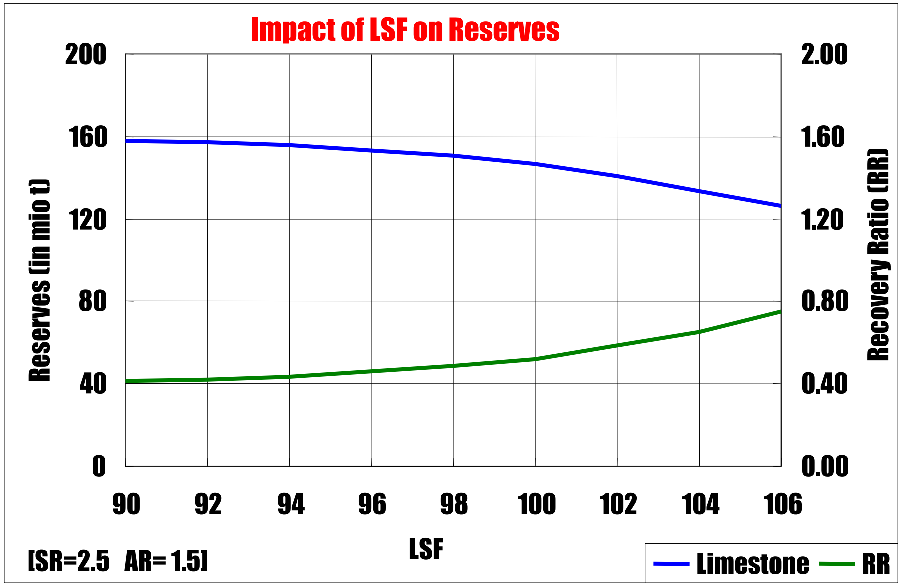
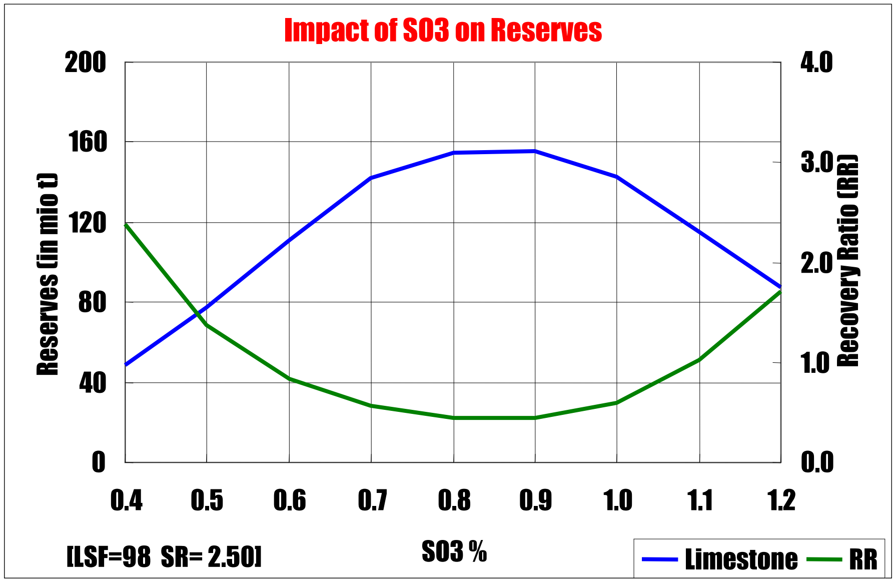
Optimization





The intervention parameters examined to effect optimization included

- LSF
- Alumina Ratio
- Silica Ratio
- SO_3

Outcomes studied were reserves, recovery ratios and mining costs

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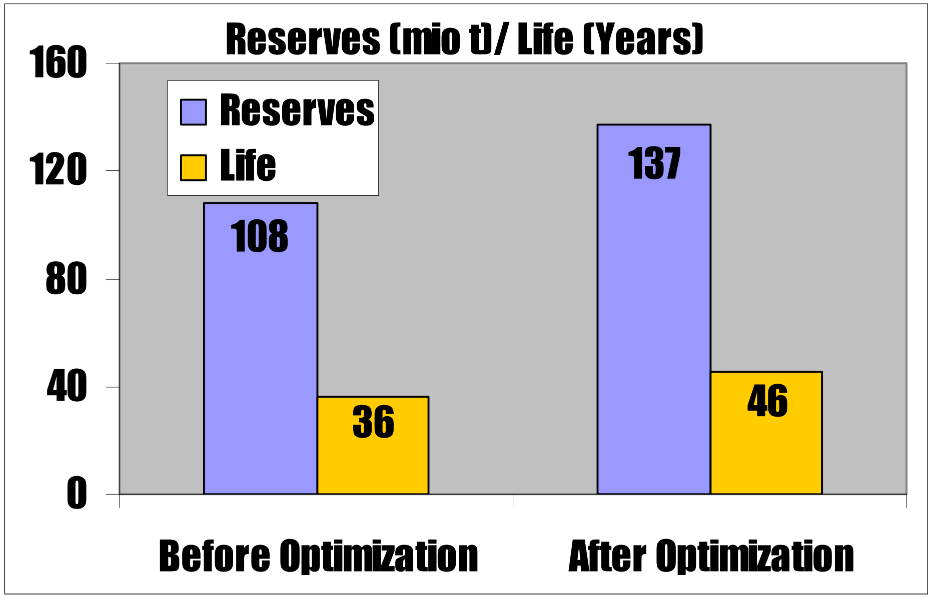
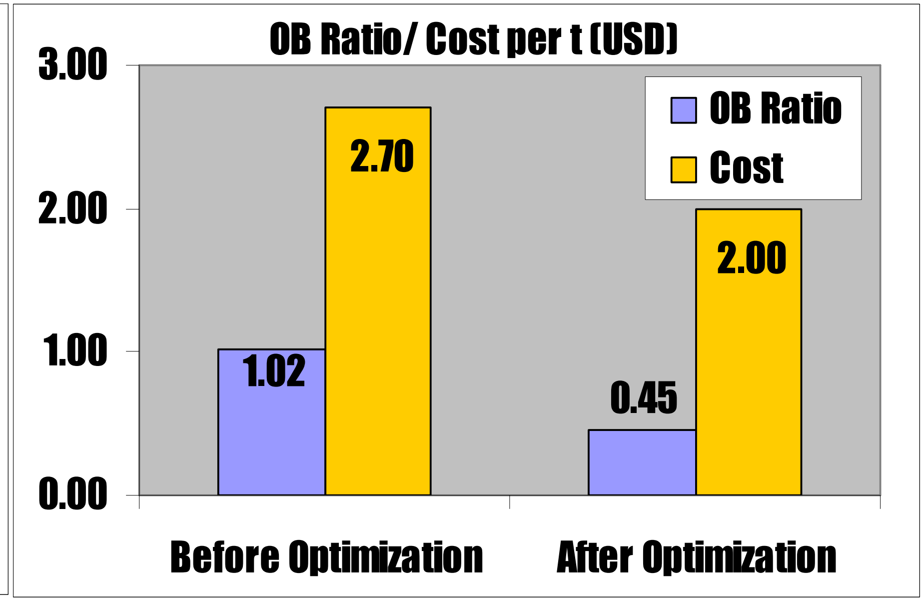
Gain





- Optimization was achieved by enhancing AR to 1.5, keeping SR at 2.5 and limiting LSF to 0.98 and SO_3 to 0.9.
- This resulted in an increase in deposit life by 10 years and a cost saving of approximately 2.75 mio USD per annum

Remote Monitoring

Blast hole sampling with appropriate geo coding is being done regularly and transmitted to Holtec's office in India

	Eastern Block					Western Block				
	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3
Mean	11.39	2.64	1.35	46.94	0.59	12.55	2.75	2.32	43.70	0.56
SD	3.40	1.20	0.94	4.72	0.21	4.70	1.27	1.28	5.04	0.18

Fortnightly Production Scheduling

<table>
<tr><th>Description</th><th>Output</th></tr>
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- Short Term blast modelling based on blast hole data and geo coding of model for interactive use
- Scheduling with revised production plan on fortnightly basis (if necessitated by the fresh data from blast hole samples) for meeting pile requirements
- Equipment placement scheduling with revised production plan and mine development needs
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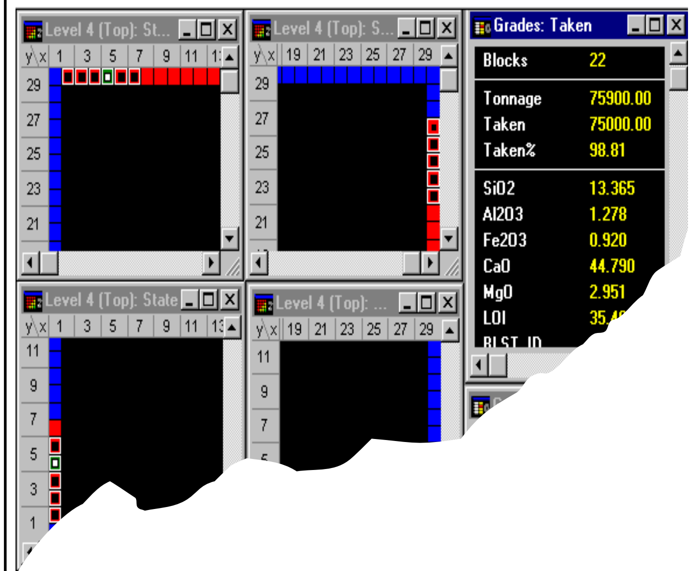

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Information to Site

Fortnightly Production & Equipment Scheduling Report

Location	Blast Nos	Bench	Type of Matl	Qty of RoM (MT)	Quality									Remarks
					SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI	LSF	SR	AR	
B1/NW	554	1	RoM	18,000	9.86	1.85	1.15	45.35	2.20	38.98	148.5	3.29	1.61	Feed to Pile
B3/SE	1002	3	RoM	20,000	13.38	2.25	2.65	43.78	0.75	37.20	104.0	2.73	0.85	Standby

Month	Fortnight	Type of M/c	M/C No	Capacity	Face	Qty to be handled
April	1	Shovel	1	6.0 cum	B1/NW	18,000 T
		Dumper	3,4,5	50 T	B1/NW	18,000 T
		Shovel	3	3.8 cum	B3/SE	Standby

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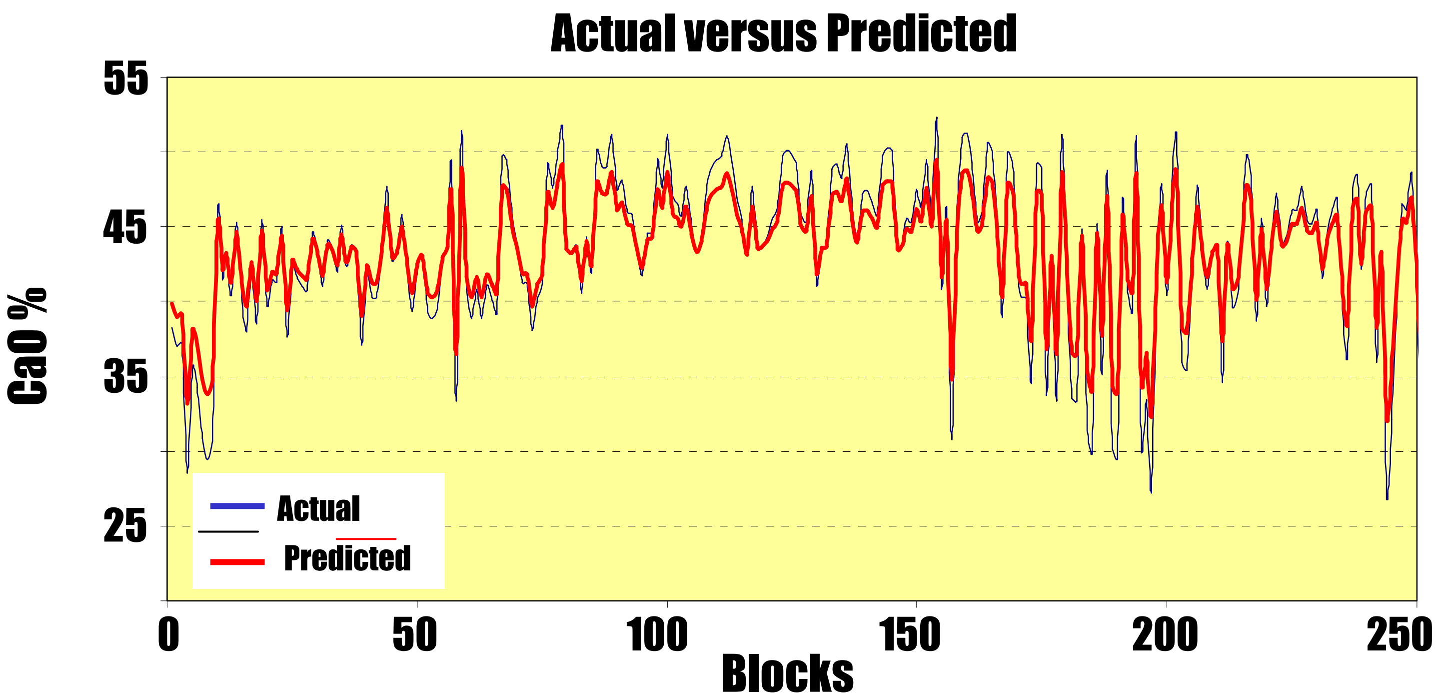
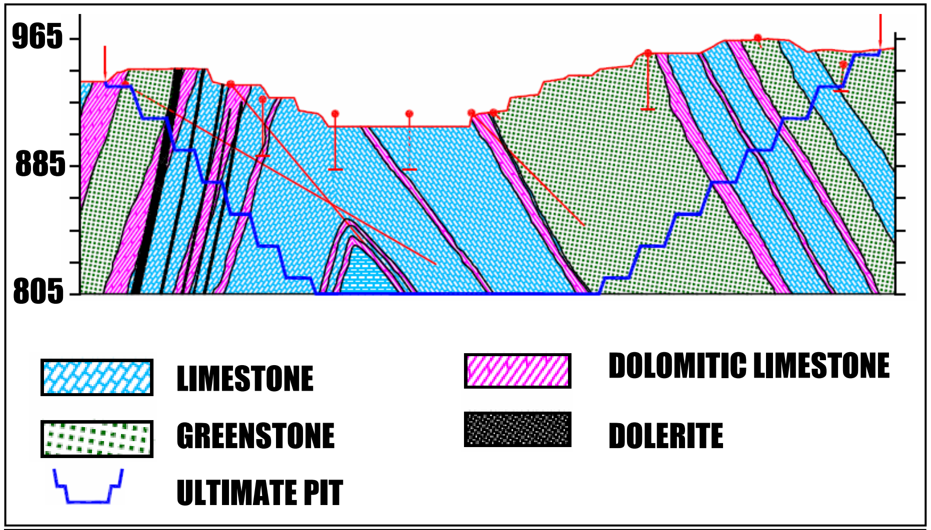
Predicted versus Actual Results



Model Validation for continuous monitoring of predicted versus actual results, based on feedback data from blast holes

Case Study 2 : South Africa



Problems

- Deposit was being exploited at 5% MgO cut off, resulting in unwarranted rejection of usable Limestone
- Deposit was not evaluated scientifically
- High SO_3% content in ROM Limestone reported

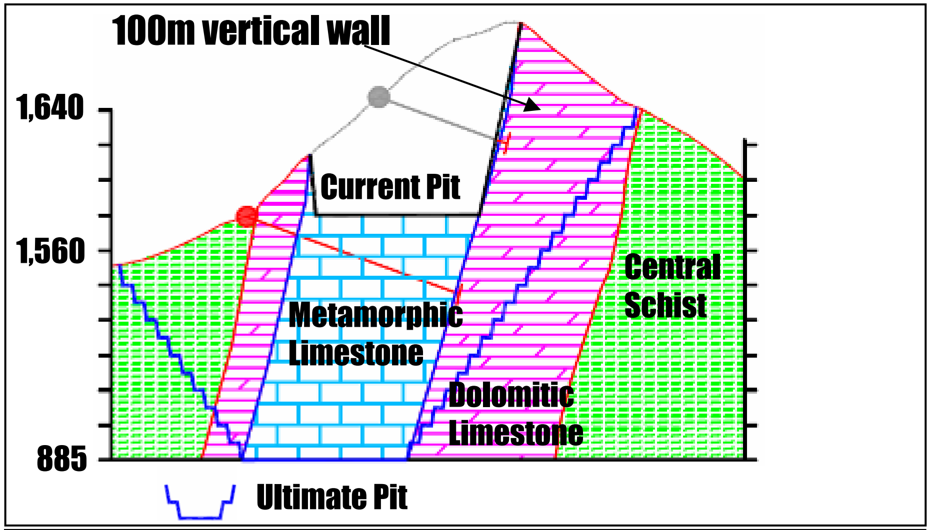
Recommendations

- Deposit was scientifically evaluated by CADE and QSO
- MgO% cut off could be raised to 8% by optimisation of Dolomitic Limestone while maintaining plant process parameters
- Confirmatory boreholes to validate geological model

Benefits

- Increase in reserves by 17 mio t
- Enhancement of deposit life by 10 years
- Saving in costs by USD 0.25 mio / annum
- Recovery ratio reduced from >1:1 to <1:0.6

Case Study 3 : Middle East



Problems

- Steeply dipping Limestone was being mined without forming benches in footwall side
- Side overburden was not being handled
- Slope failure and threat to safety
- Unable to advance to further depth due to space constraints

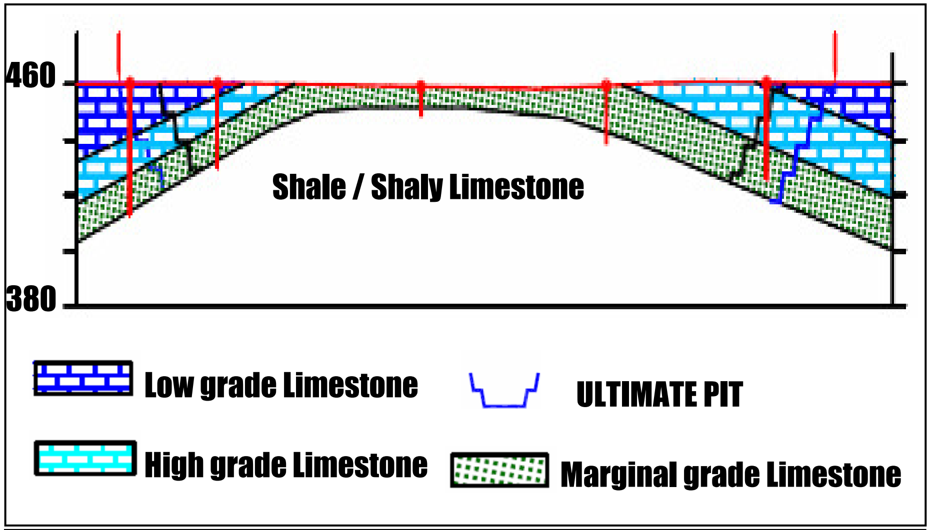
Recommendations

- Confirmatory borehole to establish continuation of limestone at depth
- Re-evaluation of the deposit and development of a new Mine design

Benefits

- Scientific re-design of quarry for full exploitation of mineral resources
- Increased reserves, extending current Plant life and facilitating Plant expansion
- Saving in costs by USD 0.75/t
- Safety for Men and Machinery

Case Study 4 : Central India



Problems

- Only High grade Limestone was being exploited leaving MG and LG Limestone
- High recovery ratio

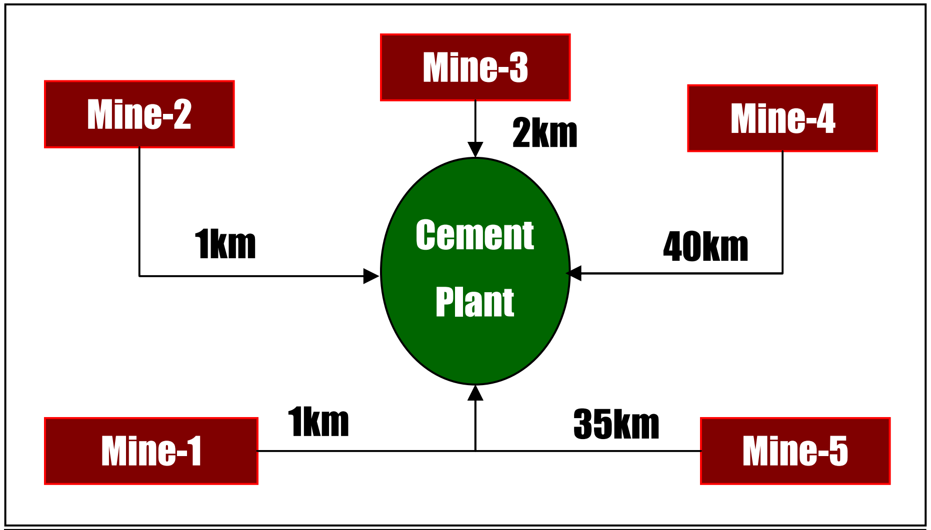
Recommendations

- Deposit was scientifically evaluated by CADE and QSO
- LG and MG Limestone could be utilised along with HG Limestone
- Acquisition of additional adjoining area under mineral concession

Benefits

- Utilization of MG and LG Limestone increasing reserves and enhancing deposit life by 12 years
- Saving in production cost by USD 0.15/t

Case Study 5 : South India



Problems

- Limestone was being fed from 5 distantly located (1 km to 40 km) quarries
- Heterogeneity in quality of limestone

Recommendations

- Blending of high iron containing limestone with low iron containing limestone
- Modified target values for Silica and Alumina Ratios
- High Sulphur limestone optimally blended with low Sulphur limestone
- Block Model validated and mine planning altered based on feedback from blast hole data

Benefits

- Increase in Reserves by 30 mio t
- Enhancement of deposit life by 5 years
- Recovery Ratio reduced to 1:0.11
- Cost saving of USD 0.24 mio/annum

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Thank you

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