MineSight Planning Spiral

- MineSight Economic Planner
- MineSight Strategic Planner
- MineSight Interactive Planner
- MineSight Haulage
- MineSight Schedule Optimizer
- MineSight Axis
TOPICS

What’s it worth?
- Calculating Value in MSEP

Is it worth mining?
- Optimization algorithms and how they are used
- Comparison of Lerchs-Grossmann and Floating Cone

Where should I mine?
- Price Sensitivity Analysis
- Detailed Phase Design

Reporting the results
- Where to look for information
- Generating charts
- How to display resulting surfaces
Calculating Value

Information Needed

- Grade
- Price
- Recovery
- Factor
- Processing Cost
- Mining Cost
Value = Grade x Price x Recovery x Factor – MC – PC
Calculating Value

\[ \text{Factor} = \frac{\text{Grade Unit} \times \text{Revenue Unit}}{\text{Mining Cost Unit}} \]
Calculating Value

Grade Unit

%  Revenue Unit

$/lb  Mining & Processing Cost Units

$/Ton
Calculating Value

\[ CF = \frac{\% \times \left( \frac{\$}{lb} \right)}{\frac{\$}{ton}} = 22.046 \]
Optimization

Lerchs-Grossmann vs Floating Cone

Determining Ultimate Pit Limits

Price Sensitivity Analysis

Phase Development
Determining Pit Limits
Methods

Floating Cone Algorithm (FC)
- Each block pays for the blocks above it
- Runs Quickly
- Can underestimate or overestimate pit limit

Lerchs-Grossmann Algorithm (LG)
- Blocks are examined together
- Gives the Exact Mineable Limits
FC vs. LG – Under Mining

FC (B1) = B1 + A1 + A2 = -5 \rightarrow No Pit
FC (B2) = B1 + A1 + A2 = -5 \rightarrow No Pit
Neither Pit will be mined

LG (B1 & B2) = B1 + B2 + A1 + A2 + A3 = 5
Both blocks will be mined
FC vs. LG – Over Mining

LG = B1+B2+A1+A2+A3 = 5
FC = B1+B2+B3+A1+A2+A3+A4 = 3
Recent LG Improvements

- Multithreading
- LG can even be faster than FC!
- 64-Bit
Ultimate Pit LG - MSOPIT
Basic Requirements

- **Existing Gridded Surface File (GSF)**
  - TOPOG

- **MSEP Gridded Surface File**
  - MSEP Specific Items

- **Block Model**
  - Geologic Items
  - Value Items
Basic Requirements

Important Parameters for Calculation

- Mining cost
- Milling cost
- Mill Recovery
- Pit slope
- Commodity Value
- SG/TF
- Geologic Zone Codes
Getting Started
— Gridded Surface Files —
Initial GSF

- Required for MSEP GSF
- TOPOG Must Be Populated
- Created Through MSCompass Project File Editor
<table>
<thead>
<tr>
<th>Stores MSEP Specific Items</th>
<th>Input Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input items</td>
<td>• Input items</td>
</tr>
<tr>
<td></td>
<td>• Results of Calculation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Items</th>
<th>Calculated Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>• Pits</td>
</tr>
<tr>
<td>Restriction Codes</td>
<td>• Pit Bottoms</td>
</tr>
<tr>
<td>Slope Codes</td>
<td></td>
</tr>
</tbody>
</table>
### 3D Block Model Items

<table>
<thead>
<tr>
<th>TOPO%</th>
<th>Zone Code</th>
<th>Value Per Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Per Ton</td>
<td>Class</td>
<td>Grade Items</td>
</tr>
<tr>
<td>SG/TF</td>
<td>Destination</td>
<td></td>
</tr>
</tbody>
</table>

Software Solutions from Mintec, Inc.  www.minesight.com
MSOPIT Design Options

– Base Case –

Ultimate Pit
- Break even limit
- Pushback size

Price Sensitivity
- Increasing Prices
- Gap in Results
Additional Design Options

**MultP**
- Valuable Blocks First
- Production limits
- Controlled Spacing

**Others**
- MultV
- MultZ
- Resource
- Pit Bottoms
MSOPIT Interface
MSOPIT

– Define 3D Block Model –

Choose file
Name of 3D block model: msop15.opt

3D Block Model Area of Interest

Columns (150)
min: 1 max: 150

Rows (125)
min: 1 max: 125

Levels (64)
min: 1 max: 64
MSOPIT
– Define Surface Topography and Geometric Constraints–
MSOPIT
– Design Variable Definition –

Design variable generation
- Calculate design variable from 3-D block model
- Read design variable from 3-D block model

Design Variable Distribution Interval
Interval: 1500.0
MSOPIT

— 3D Block Model Items —

This information is used to compute a design variable from the block model.

- Take Ore First?
- Use TOPO% from 3D block model?
- Always process all ore% material

Items from file: msop15.opt

Required Items

Topo: TOPO%

Optional Items

Resource Classification Code: CLASS
Limiting Resource Classification Code: 3
Ore Percent:
Density Within Ore %:
Density Outside Ore %:
Mining Cost Within Ore %:
Mining Cost Outside Ore %:
Mined Out Percent:
3D Mining Restriction Code:
MSOPIT

— Value Per Block Limits —

Design Variable Value Range

Minimum Value (Less Than Zero): -100000.0
Maximum Value: 999999.0
Precision: 1.0
Cutoff ($/ton): 0.0

Maximum Number of Blocks in Condensed Model: 15000000
Maximum Number of Blocks in Pit Optimization Model: 15000000
MSOPIT

— Define Economic Parameters for Destinations —
MSOPIT

— Define Economic Parameters for Destinations —
MSOPIT

— Define Economic Parameters for Destinations —
MSOPIT

— Define Economic Parameters for Destinations —

Economics for Value Calculations

<table>
<thead>
<tr>
<th>Material</th>
<th>Grade</th>
<th>Price</th>
<th>Recovery %</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCK1 (1)</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Waste (2)</td>
<td>CUIDW</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

PC ($/ton) 0.0
MC ($/ton) 2.5
SG/TF: 2.7

APPLY
MSOPIT

—— Costs and Discounting ——

- Use variable costs by bench?
- Bench Discounting Option
  - Annual Discount Rate (%): 7.0
- Select Bench Mining Rate
  - Benches per year: 5.0
  - Bench Mining Rate Factor: 0.0
MSOPIT
— Pit Slope Angle Options —

Pit Slope Angle Options
- Constant Slope
- Slope by Azimuth
- Complex Slopes
- Complex Slopes by Azimuth

Slope Parameters
Minimum Slope: 48.0
MSOPIT
— Base —

Number of optimization areas: 1

Add  Remove

Number of Passes (1-3): 1  (If Floating Cone)

Pit Optimization Area 1

Levels (64)  Row (125)  Column (150)

min: 1  max: 64  min: 1  max: 125  min: 1  max: 150

Result (1-50): 1

Limit (0-50): 0
MSOPIT

— Output Instructions —

Net Value per Block
Net Value per Block Item: VALBK
- Only If Bench Discounting Option is Used
- Block is Not Discounted

Net Value per Ton
Net Value per Ton Item: VALPT
- Include Mining Cost
- Do NOT Include Mining Cost
- Includes all Mining Cost (Ore Percents)

Run Definitions
Run ID (0-80): Ultimate Pit Limit Calculation
Run File (RUNOPT): up1
Report File (RPTOPT): Rptopt
Parameters (OPTECN): up1
Resulting Pit

Topography

PIT01
### Pit Summary

<table>
<thead>
<tr>
<th>Summary for area requested</th>
<th>Pit # 1</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of (-) blocks mined</td>
<td>42,821.</td>
<td>42,821.</td>
</tr>
<tr>
<td>Number of (+) blocks mined</td>
<td>47,788.</td>
<td>47,788.</td>
</tr>
<tr>
<td>Number of total blocks mined</td>
<td>90,609.</td>
<td>90,609.</td>
</tr>
<tr>
<td>Sum of Value for (+) blocks</td>
<td>6,927,157,047.</td>
<td>6,927,157,047.</td>
</tr>
<tr>
<td>Sum of Value for (-) blocks</td>
<td>-1,110,868,907.</td>
<td>-1,110,868,907.</td>
</tr>
<tr>
<td>Net revenue = GROSS - costs</td>
<td>5,816,288,139.</td>
<td>5,816,288,139.</td>
</tr>
</tbody>
</table>
MSOPIT

— Phase Development —
Phase Development

Access High Grade Material
Maximize NPV
Minimize Risk
Price Sensitivity

Concept
- Varying Commodity Price
- Low price = smaller Pit
- Examine Price Volatility
- Get direction of mining

Automation
- Easy with Multirun
- Same Setup as Ultimate Pit

Issues
- Gap in Results
- Impractical Spacing
Multirun Setup

Same as Ultimate Pit

Variable Price

10 Prices for 10 Pits

Start = $1.20  Step = $0.20  High = $3.00

<table>
<thead>
<tr>
<th>Grade</th>
<th>Price</th>
<th>Recovery %</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUIDW ?01</td>
<td>87.0</td>
<td>22.046</td>
<td></td>
</tr>
</tbody>
</table>
Tonnages Per Pushback

Cu Price of Pit

<table>
<thead>
<tr>
<th>Cu Price of Pit</th>
<th>kTons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.20</td>
<td></td>
</tr>
<tr>
<td>$1.40</td>
<td></td>
</tr>
<tr>
<td>$1.60</td>
<td></td>
</tr>
<tr>
<td>$1.80</td>
<td></td>
</tr>
<tr>
<td>$2.00</td>
<td></td>
</tr>
<tr>
<td>$2.20</td>
<td></td>
</tr>
<tr>
<td>$2.40</td>
<td></td>
</tr>
<tr>
<td>$2.60</td>
<td></td>
</tr>
<tr>
<td>$2.80</td>
<td></td>
</tr>
<tr>
<td>$3.00</td>
<td></td>
</tr>
</tbody>
</table>

Note: The chart shows the tonnages per pushback at different copper prices.
Mineable Phases

New Layers of Control

- Geometric Constraints
- MultP instead of Base
Multp Process

Sequential Pushbacks

Block Model and Items

Process and Fiscal Constraints

Geometric Constraints
Geometric Constraints

Pushback Width
- Benches
- Meters

Material per Pushback
- Blocks
- Tonnage
Material Per Pushback

10 Pushbacks

Ultimate Pit Report

# Blocks = 90,609

90,609 /10 ≈ 9,000 Blocks
Multp
– Design Strategy –
Multp
— Value Phases by Size —

**Multp configuration**

**Make Pits (1-50)**

From **21** To **30**

Maximum number of pits: **10**
Multp
— Value Phases by Size —
Multp
– Value Phases by Size –
Resulting Pits – 2D
Reporting Mineable Phases

MSBasis procedure PGETRP.DAT
Summarizes multiple MSOPIT “Base” reports

Compare pits created with:
• Varying base options
• Varying pit slope parameters

Compare pit reserves that are:
• Reported using a constant price
• Cumulative or incremental
MSOPIT rptopt.* Assumptions

Each case contains same
- Model items
- Destinations
- Materials

Output files
PGETRP Input

Summarize 50 reports

- MSOPIT Rptopt.* file extensions

Required information

- Report file extension
- Report file name
- Sum file name

A maximum of 50 files can be summarized. The extensions should be in order by GSF file name and pit number. If the number of materials, destinations, or grades change, then new headings will be printed. If there are multiple pits in the report file (MULTP, MULTU etc) each will be as shown:

<table>
<thead>
<tr>
<th></th>
<th>c30</th>
<th>c31</th>
<th>c32</th>
<th>c33</th>
<th>c34</th>
<th>c35</th>
<th>c36</th>
<th>c37</th>
<th>c38</th>
<th>c39</th>
</tr>
</thead>
<tbody>
<tr>
<td>c40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pit comparison
- Pit sum
- Pit graph

Report File name
- Sum File name
- Graph File name
- Ore destinations (control timing)
- Ore production rate per period 000's
- Discount rate %
- Base case file name extension
PGETRP Output

- CSV files
- Sum files (viewed with MSEPc)
- ASCII files
- Graph files
PGETRP Report Type Options

“Various pit material views”

Pgetrp.dat Options

- Increasing price
- Increasing total pits
- Increasing incremental
- Compare to base
Increasing Price

- Provides simple summary
- Variable or constant price economics
- Whole or incremental pits
Increasing Price

Multiple Rptopt.* → Report file

“Summary by Material and Destination”

<table>
<thead>
<tr>
<th>Value</th>
<th>Tons</th>
<th>Grade</th>
<th>$/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>MILL</td>
<td>MILL</td>
<td>MILL</td>
<td>MILL</td>
</tr>
<tr>
<td>ROCK1</td>
<td>ROCK1</td>
<td>ROCK1</td>
<td>ROCK1</td>
</tr>
<tr>
<td>Value</td>
<td>Tons</td>
<td>CUIDW</td>
<td>$/ton</td>
</tr>
<tr>
<td>95599.9</td>
<td>95740.0</td>
<td>0.950</td>
<td>1.00</td>
</tr>
<tr>
<td>224467</td>
<td>164840</td>
<td>0.887</td>
<td>1.36</td>
</tr>
<tr>
<td>454695</td>
<td>313893</td>
<td>0.808</td>
<td>1.45</td>
</tr>
<tr>
<td>765267</td>
<td>413057</td>
<td>0.774</td>
<td>1.85</td>
</tr>
<tr>
<td>1144894</td>
<td>499468</td>
<td>0.748</td>
<td>2.29</td>
</tr>
<tr>
<td>1525766</td>
<td>546906</td>
<td>0.732</td>
<td>2.79</td>
</tr>
<tr>
<td>1936262</td>
<td>585284</td>
<td>0.719</td>
<td>3.31</td>
</tr>
<tr>
<td>2353094</td>
<td>612648</td>
<td>0.709</td>
<td>3.84</td>
</tr>
<tr>
<td>2771836</td>
<td>631142</td>
<td>0.701</td>
<td>4.39</td>
</tr>
<tr>
<td>3196094</td>
<td>642298</td>
<td>0.697</td>
<td>4.98</td>
</tr>
<tr>
<td>3620607</td>
<td>649514</td>
<td>0.693</td>
<td>5.57</td>
</tr>
</tbody>
</table>

Pit   Report file   Name
30    rpto.c30      
31    rpto.c31      
32    rpto.c32      
33    rpto.c33      
34    rpto.c34      
35    rpto.c35      
36    rpto.c36      
37    rpto.c37      
38    rpto.c38      
39    rpto.c39      
40    rpto.c40      

Factor
Increasing Total Pits

“Single phase view - incremental”

Uses:

- Best mining direction
  - $/ton decreasing/phase
  - SR increasing/phase

Incremental pit summary from “whole” pits

Phase selection
Increasing Total Pits

“Pit B – Pit A, Pit C – Pit B+A...”
Increasing Incremental Pits

“Multiple phase material view”

Helps us verify/determine:
- Best mining direction
- $/ton decreasing/phase
- SR increasing
- Phase selection

By reporting:
- Ore tons
- Average grade
- Average $/ton
- Total value
Increasing Incremental Pits

“Pit A + B + C...”
Compare to Base Pit

Base pit vs. pits with:

Various slope designs
- Constant slope
- Slope by azimuth
- Complex slope
- Complex slope by azimuth

Comparison items:
- Ore tonnes
- Average grade
- $/ton
- Total value
Compare to Base Pit

“Pit X - Base pit...”
Compare to Base Pit

$/tonne vs. Pushback

$/tonne

Pushback Number

Economic mining limit
Charting with MSEPt

- Report Templates
- Detailed Reports
- Export Data
MSEPc: Report Templates

Period vs Cashflow, Cum Present Value, Cum Profit

- Templates
  - Standard: msvalp_summary_CashflowCpvProfit.srs
  - User Standard:

- Tools
  - Add New Series...
  - Load Templates...
  - Save Templates...
  - Summary Report
MSEPc : Detailed Reports

```
<table>
<thead>
<tr>
<th>Period</th>
<th>Cum Present Value</th>
<th>Adj Total Waste Tons</th>
<th>Total Adj Tons Mined</th>
<th>Ore Mined Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17,965,248.00</td>
<td>23,519,036.00</td>
<td>38,995,312.00</td>
<td>15,476,274.00</td>
</tr>
<tr>
<td>2</td>
<td>154,610,832.00</td>
<td>4,151,106.00</td>
<td>19,093,140.00</td>
<td>14,942,034.00</td>
</tr>
<tr>
<td>3</td>
<td>292,922,304.00</td>
<td>437,400.00</td>
<td>15,036,570.00</td>
<td>14,599,170.00</td>
</tr>
<tr>
<td>4</td>
<td>431,669,664.00</td>
<td>712,800.00</td>
<td>15,774,750.00</td>
<td>15,061,950.00</td>
</tr>
<tr>
<td>5</td>
<td>562,968,832.00</td>
<td>307,800.00</td>
<td>15,309,000.00</td>
<td>15,001,200.00</td>
</tr>
<tr>
<td>6</td>
<td>733,256,064.00</td>
<td>97,200.00</td>
<td>15,365,430.00</td>
<td>15,268,230.00</td>
</tr>
<tr>
<td>7</td>
<td>890,057,472.00</td>
<td>6,226,952.00</td>
<td>21,209,522.00</td>
<td>14,982,570.00</td>
</tr>
<tr>
<td>8</td>
<td>992,141,440.00</td>
<td>20,188,338.00</td>
<td>35,000,000.00</td>
<td>14,811,660.00</td>
</tr>
<tr>
<td>9</td>
<td>993,871,360.00</td>
<td>11,265,264.00</td>
<td>26,169,264.00</td>
<td>14,904,000.00</td>
</tr>
<tr>
<td>10</td>
<td>1,046,078,080.00</td>
<td>1,312,200.00</td>
<td>16,443,000.00</td>
<td>15,130,800.00</td>
</tr>
</tbody>
</table>
```
MSEPC: Export Options

- *.xls
- *.xlsx
- *.pdf
- *.csv
- *.html
- *.mht
- *.rtf
- text file
- image file
Surface Operations

MSBASIS Procedure PSPSUFI.DAT

- Performs geometric operations on Gridded Surface Files

Suggested Display Options

Perspective view
Surface Operations
Surface Operations
Surface Operations
Surface Operations
Surface Operations
Surface Operations
Surface Operations
Surface Operations
Conclusion

MSEP is an excellent tool for analyzing a deposit’s value, determining mineable extents, and reporting that information effectively.
THANK YOU!