Fragmentation Assessment using 3D imaging

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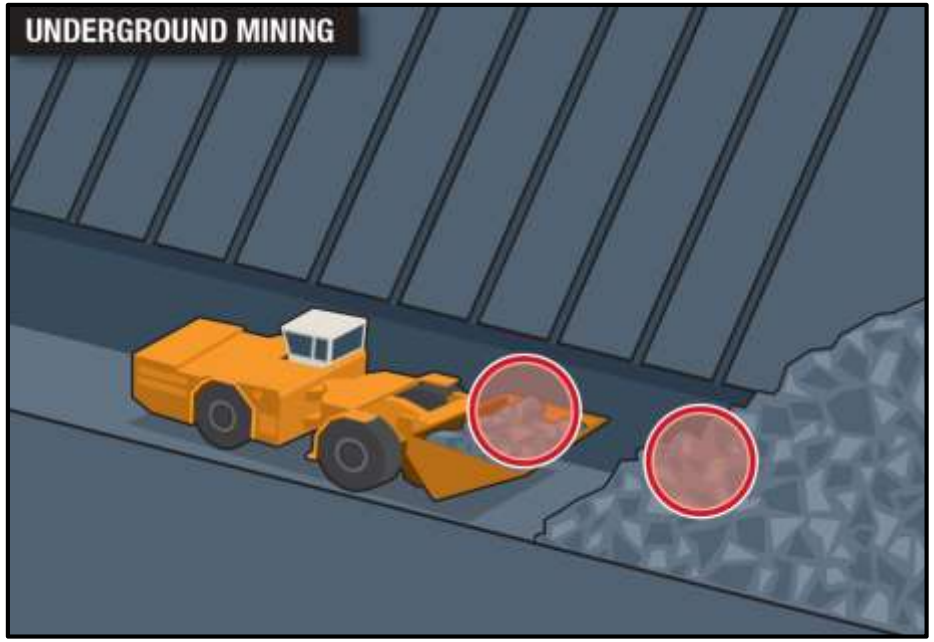
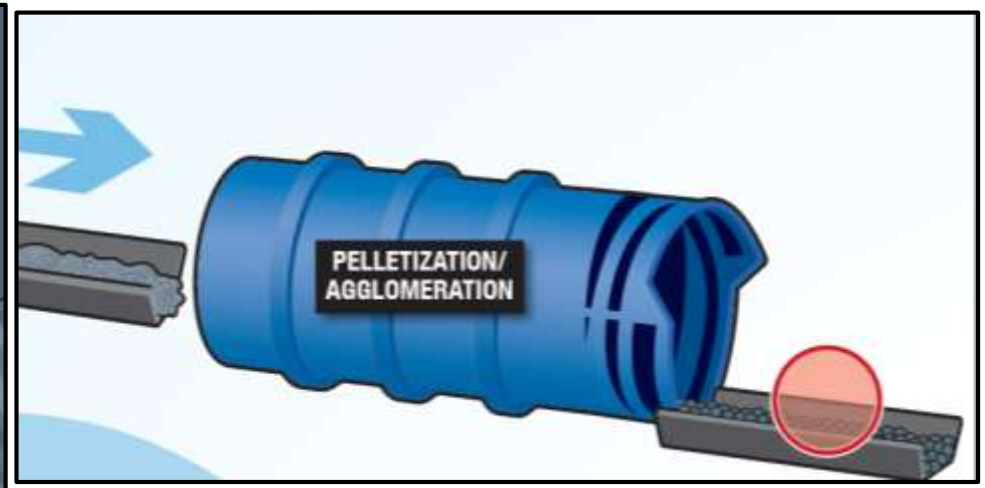
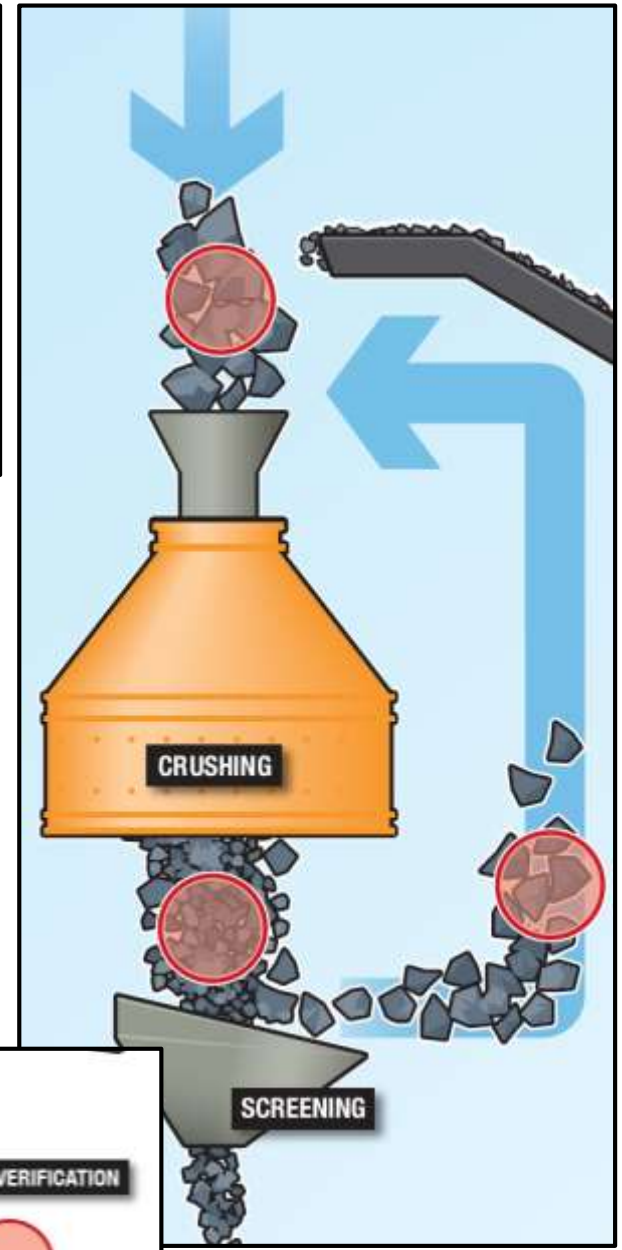
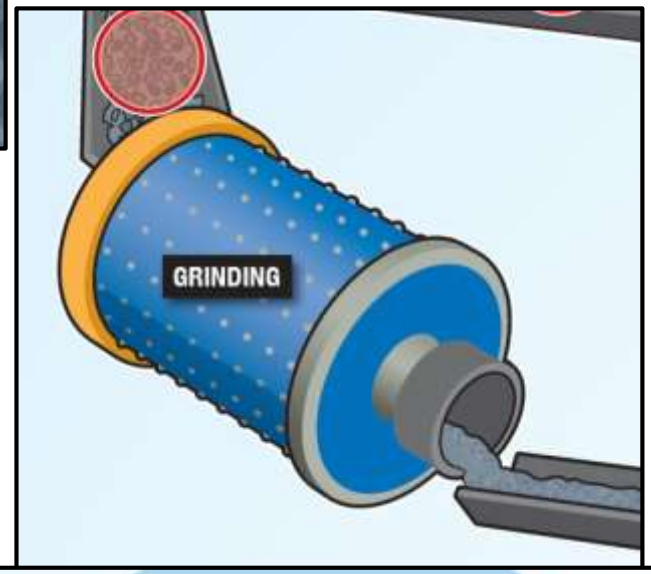
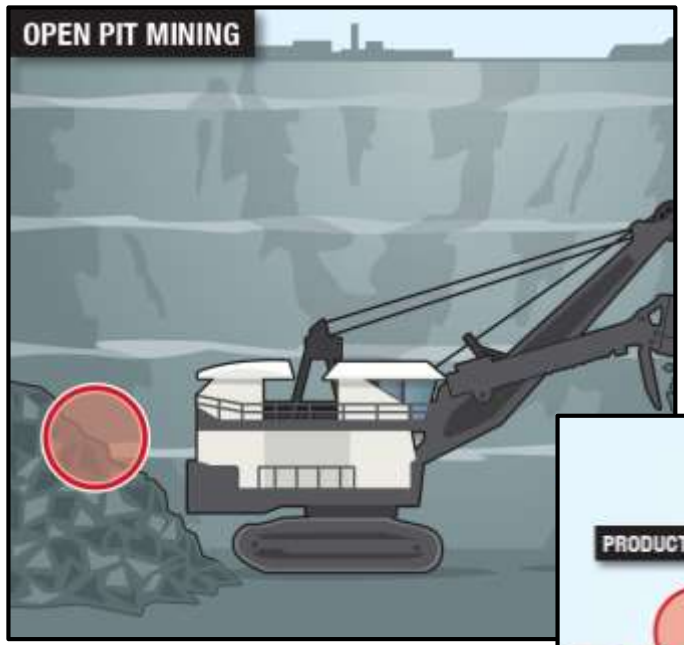
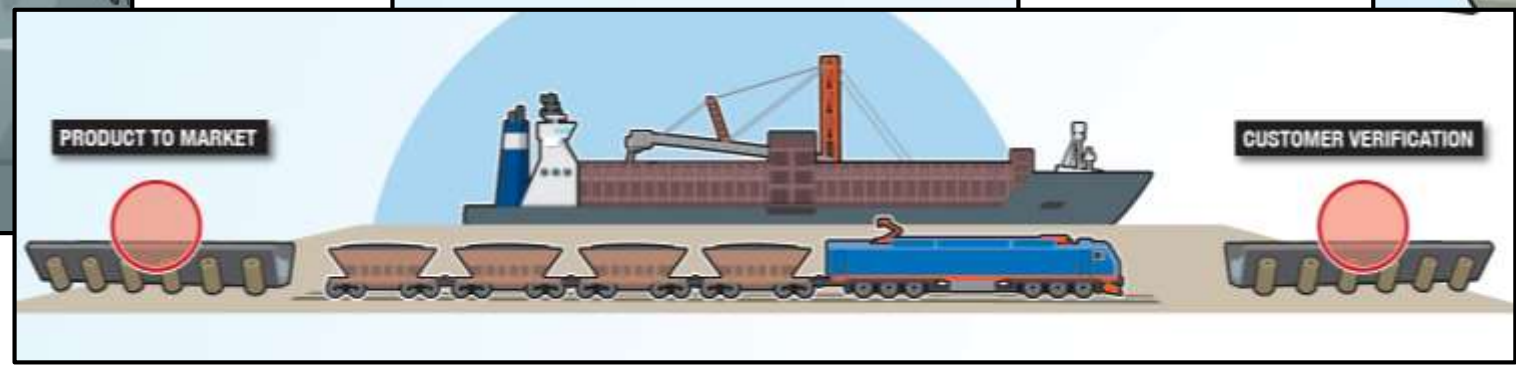

UNDERGROUND MINING

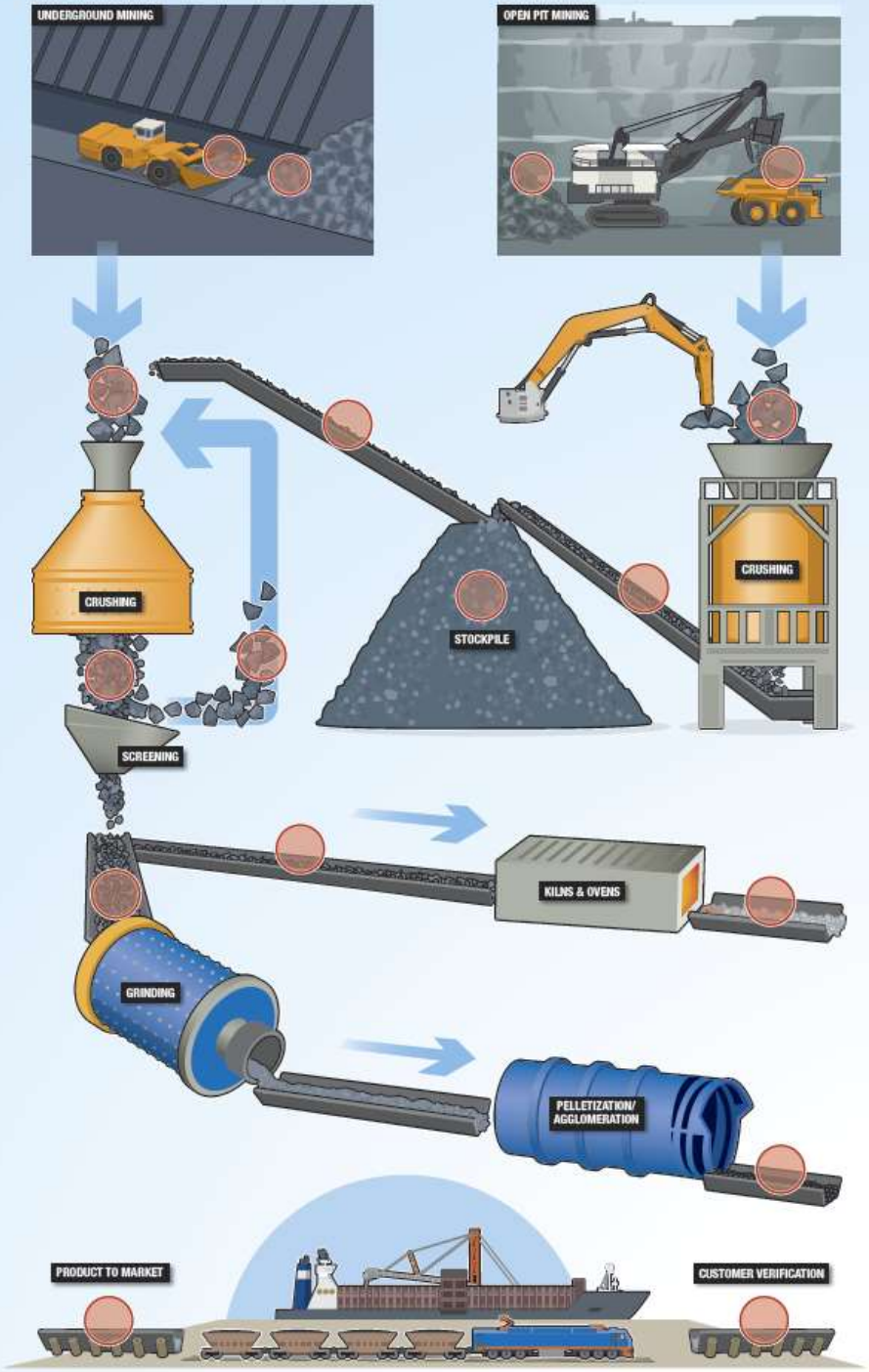

PELLETIZATION/
AGGLOMERATION


CRUSHING
SCREENING


GRINDING


OPEN PIT MINING


PRODUCT TO MARKET
CUSTOMER VERIFICATION



Vision for the Future

- Automated, online fragmentation measurement systems (no manual particle delineation required)
- Consistent, repeatable measurement
- Big data to make robust decisions (statistically significant)
- Feedback to blasting and caving
- Automatic control of mineral processes
- Integrated automated control strategies from mine to mill

Innovative Machine Vision

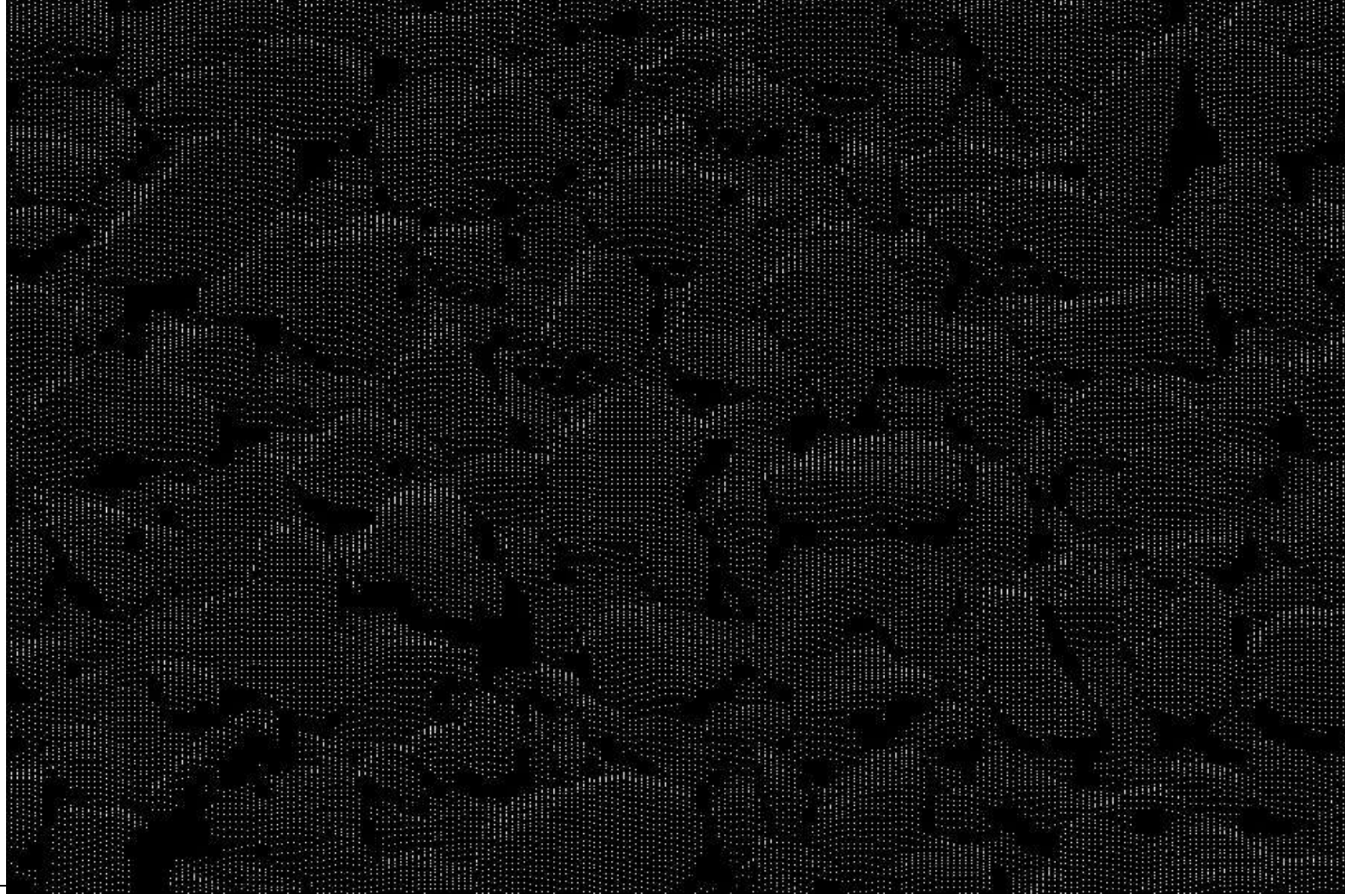
Fragmentation measurement products and services based on 3D imaging

1. On conveyor belt: commercial system available from Swedish firm MBV-Systems and distributed globally within mining by ABB. Innovative Machine Vision licences the fragmentation software library
2. For piles of blasted rock: Fragmentation assessment as a service based on 3D imaging from survey grade laser scanners
   - The mine survey team collects the 3D data based on an agreed methodology
   - IMV performs automated analysis of the data so that you get a consistent, repeatable analysis

3D Data

Conveyor belt

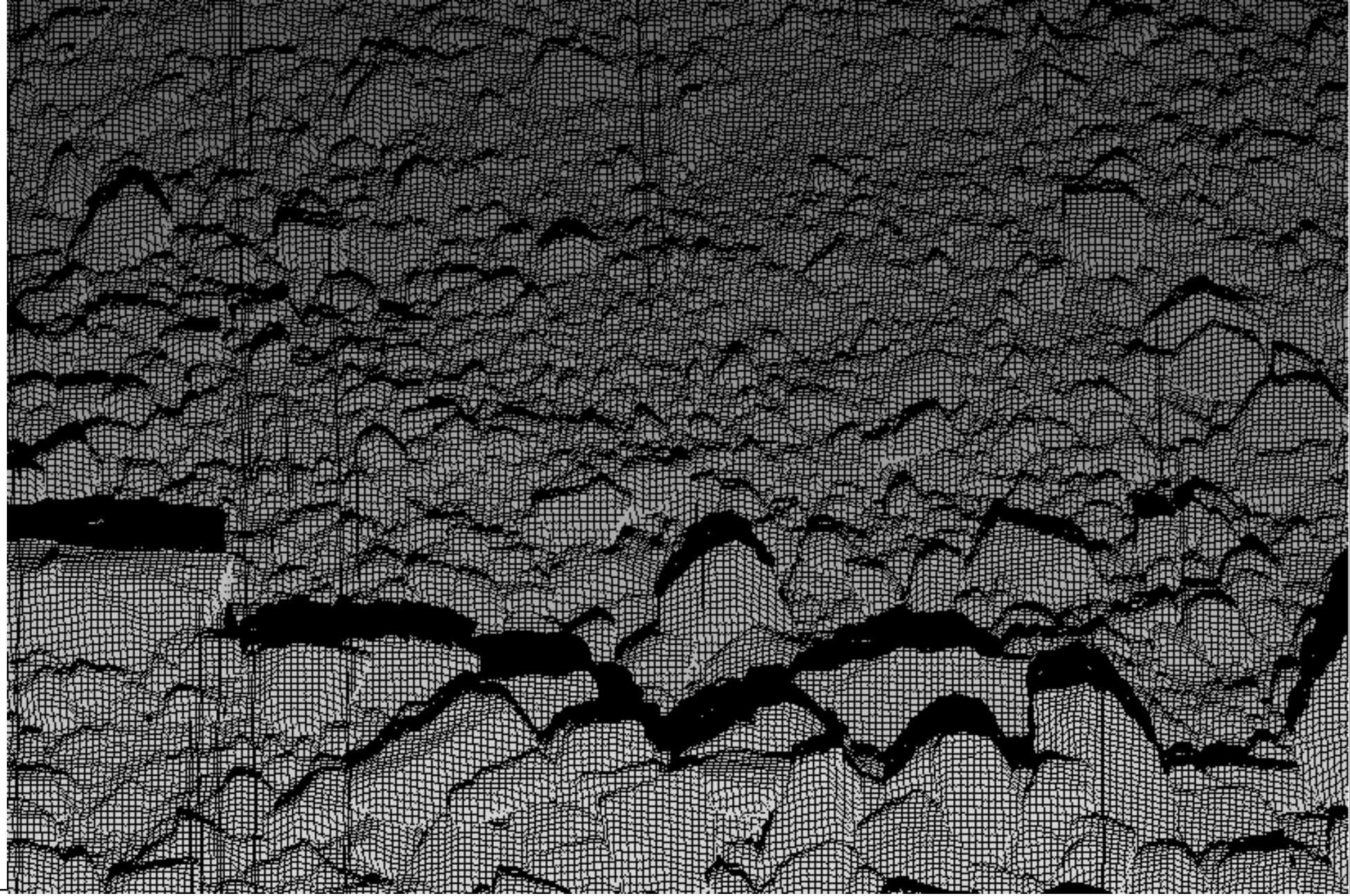
Laser triangulation



3D Data

Muckpile

Laser scanner



Advantages of good 3D data and smart algorithms

High resolution 3D imaging and IMV's advanced algorithms

- Overcomes limitations of 2D imaging
  - Good automatic particle delineation, avoids errors due to color variation in the rocks
  - Directly measure 3D dimension of the material therefore no scaling objects or perspecive distortion errors
- Detect overlapped particles preventing error from mis-sizing as smaller particles
- Detect areas-of-fines preventing error from mis-sizing as large boulders
- These two errors are opposing in their effect, which in combination can produce an unstable system. Mitigating these errors results in a stable and reliable measurement system.

Key Distinctions

- This is an image based system so the visible surface of the rock piles is measured
- Not the same as sieving or screening
- Does not require “calibration” to sieving (or ongoing-recalibration) because the measured results are a realistic representation of the visible rocks
- Automated analysis requires no manual delineation of particles
- Detects areas of visible fines in a realistic way
- Measurements provide a useful comparative measure of fragmentation

3 Examples

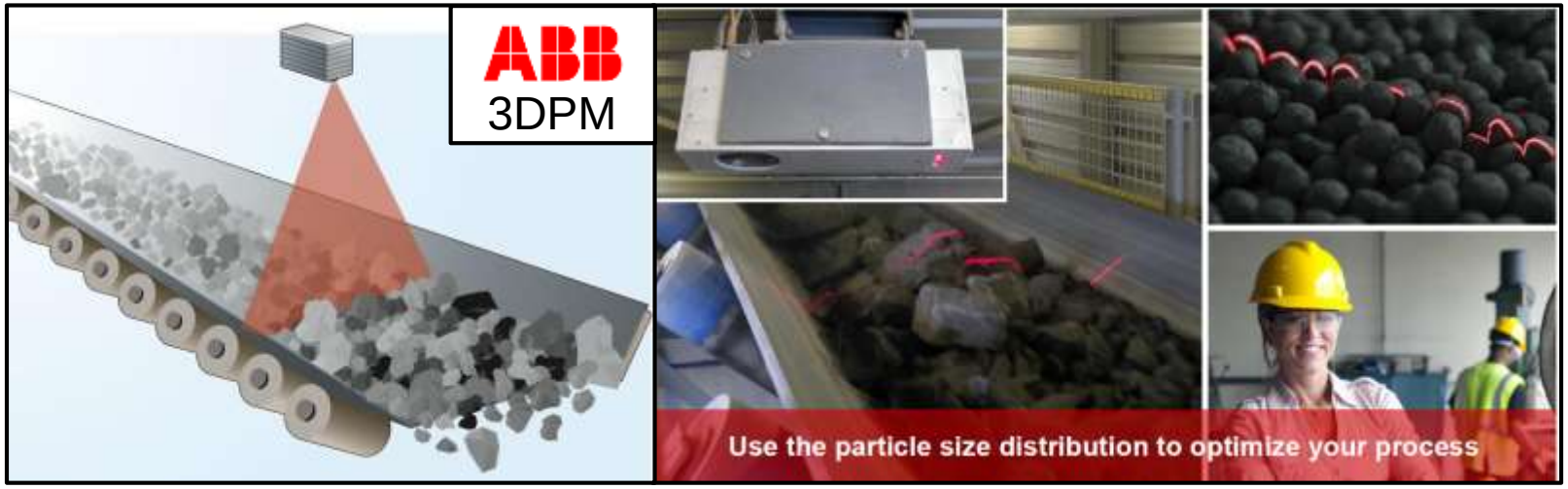
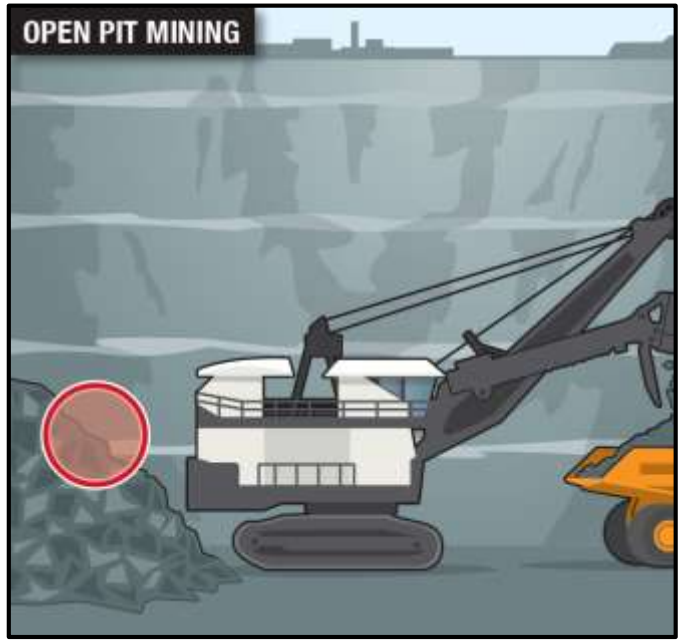
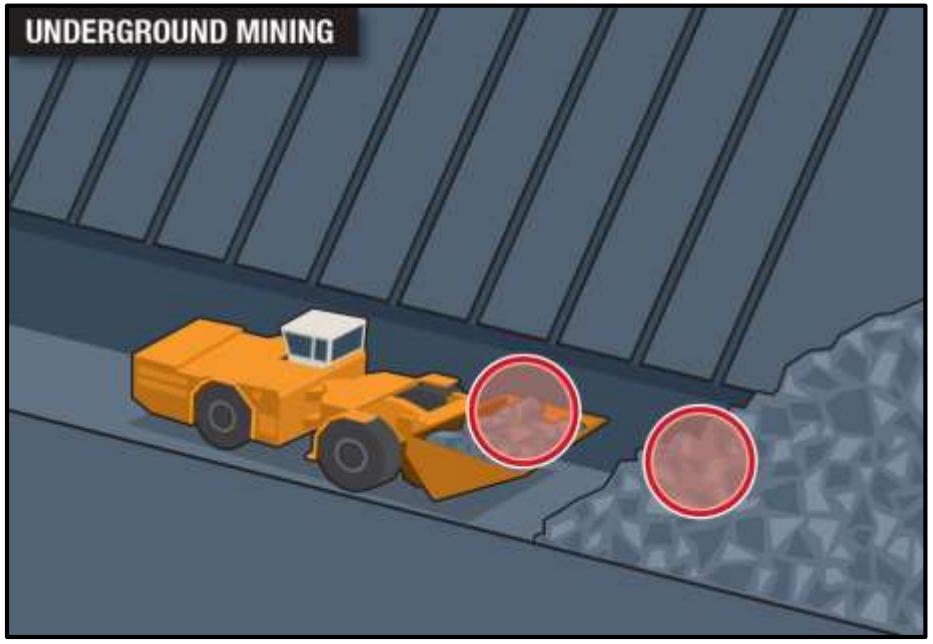


ABB
3DPM
Use the particle size distribution to optimize your process

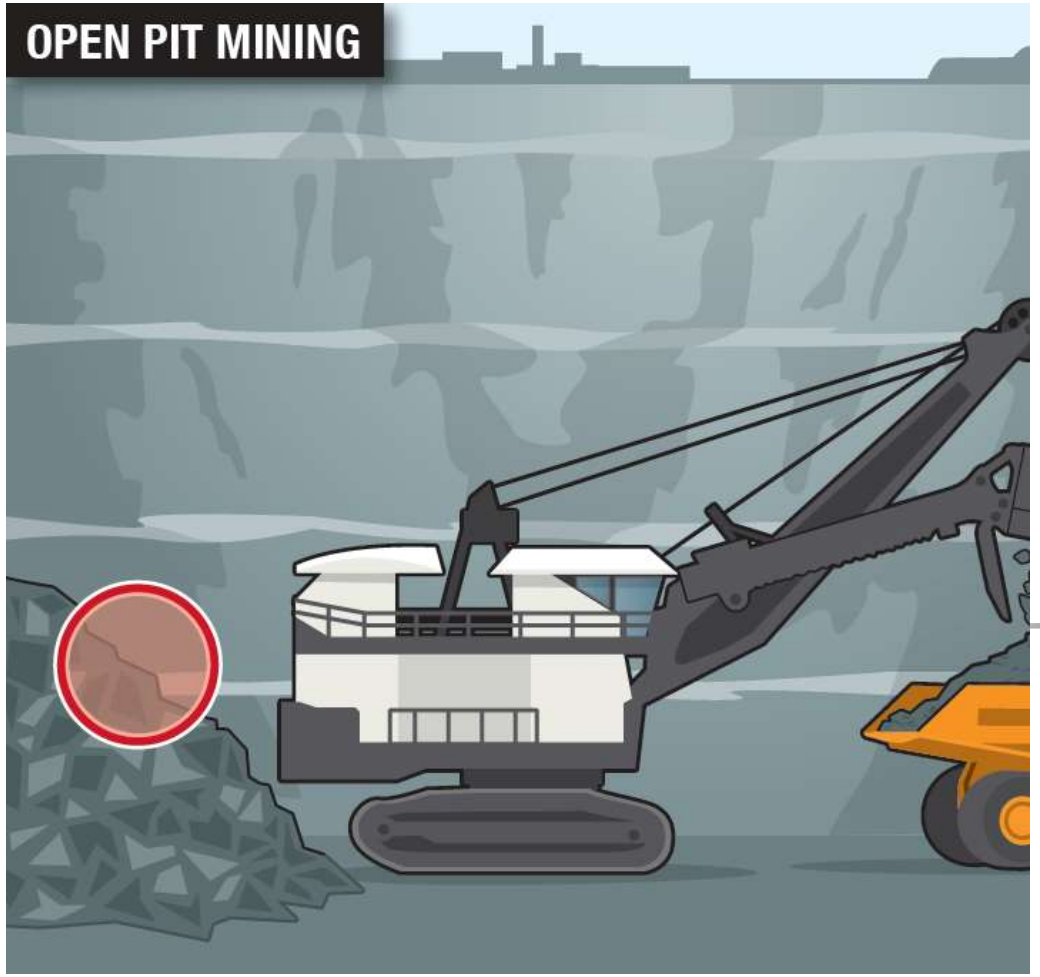

OPEN PIT MINING


UNDERGROUND MINING

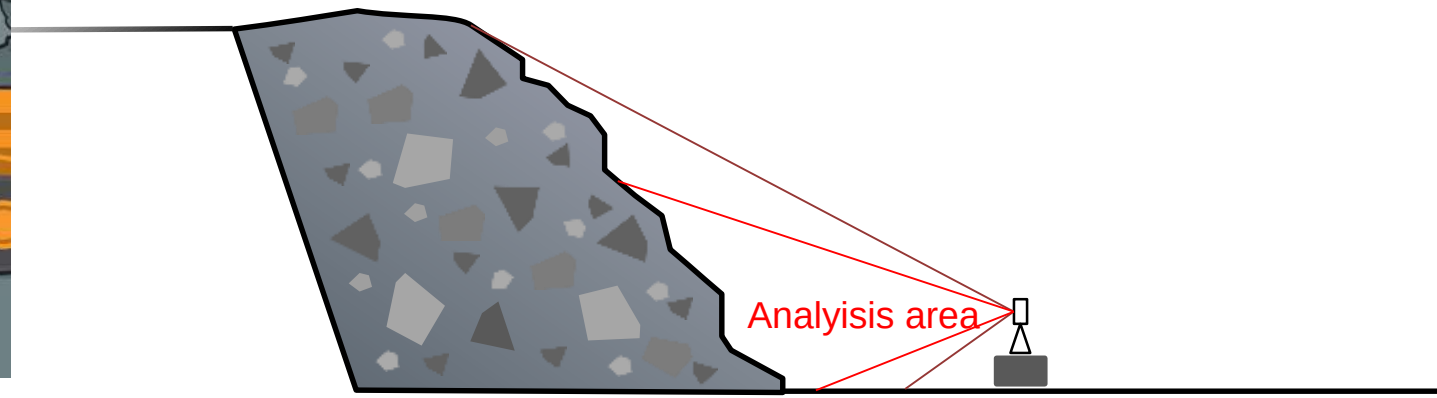
Open-Pit Muckpiles

Onederra, I, Thurley, M & Catalan, A 2015, 'Measuring blast fragmentation at Esperanza mine using high resolution 3D laser scanning' *Institute of Materials, Minerals and Mining. Transactions. Section A: Mining Technology*, vol 124, no. 1, pp. 34-46.

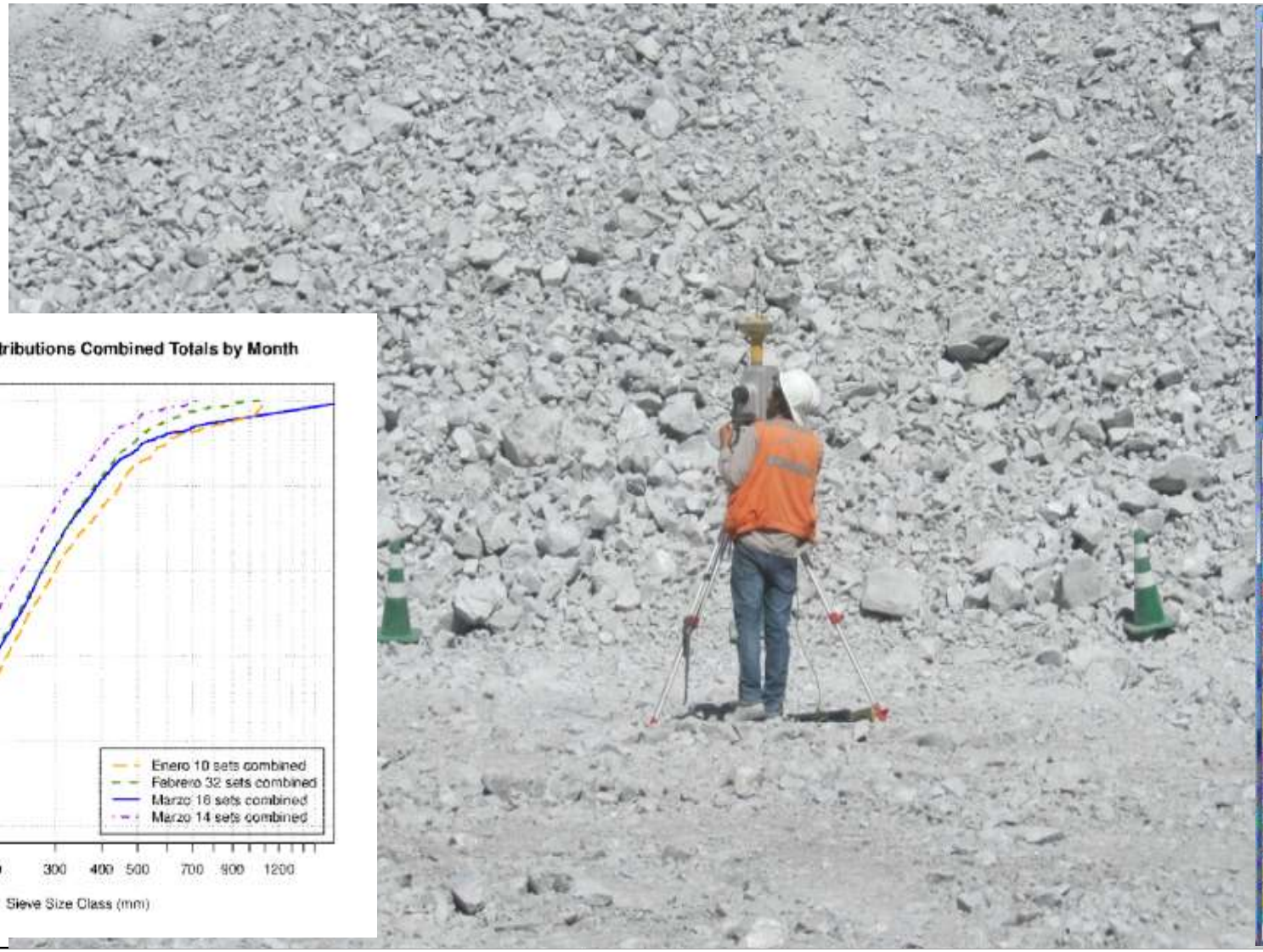
Open Pit Muckpile Measurement

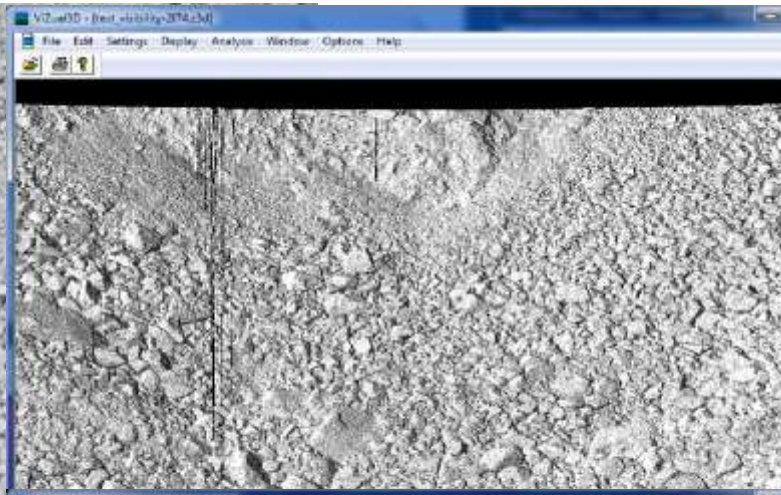


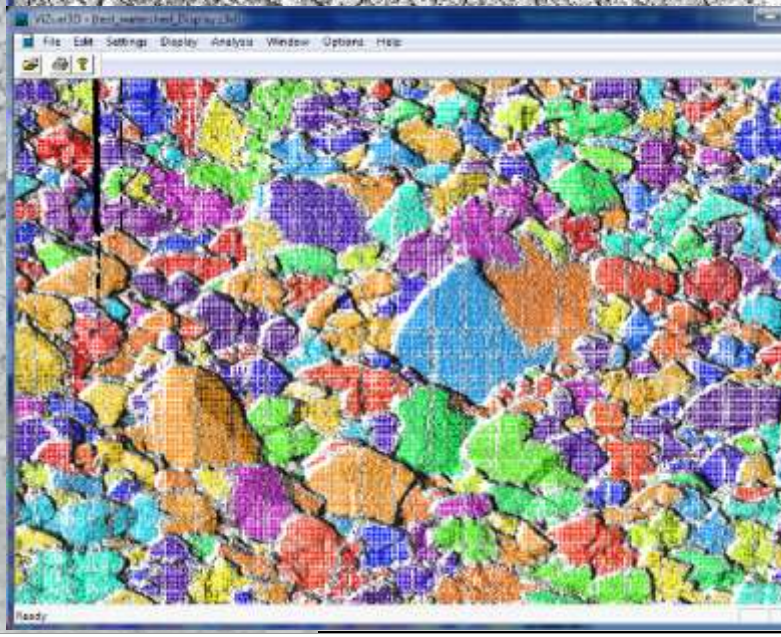
- Survey team collects data based on an agreed methodology
- Scans the muckpile periodically during excavation
- We perform automated fragmentation analysis



Fragmentation Assessment in a large Open Pit (Esperanza Mine - Chile)







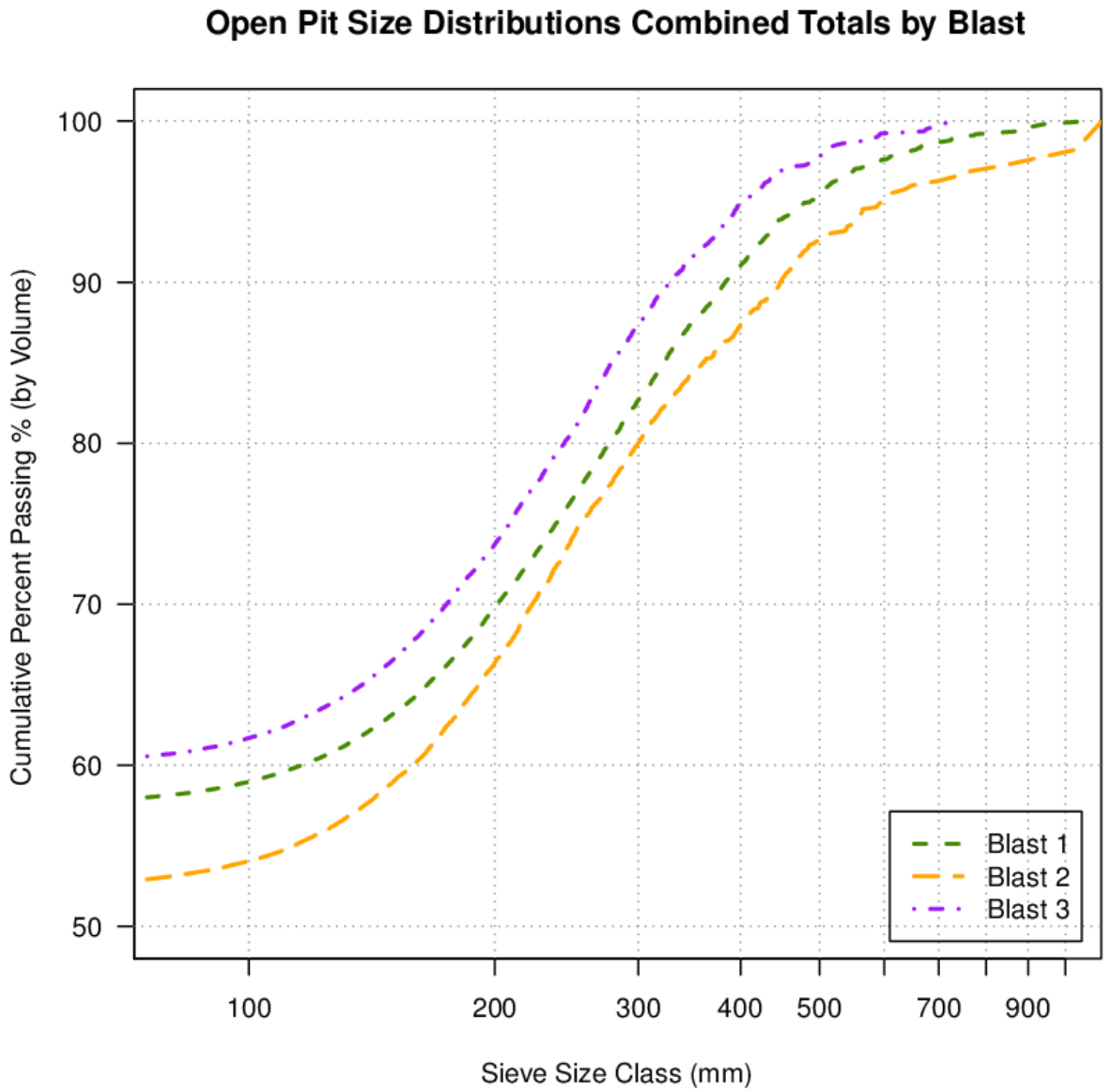
3 Blasts with 55 scans

Combined Sizing Results for

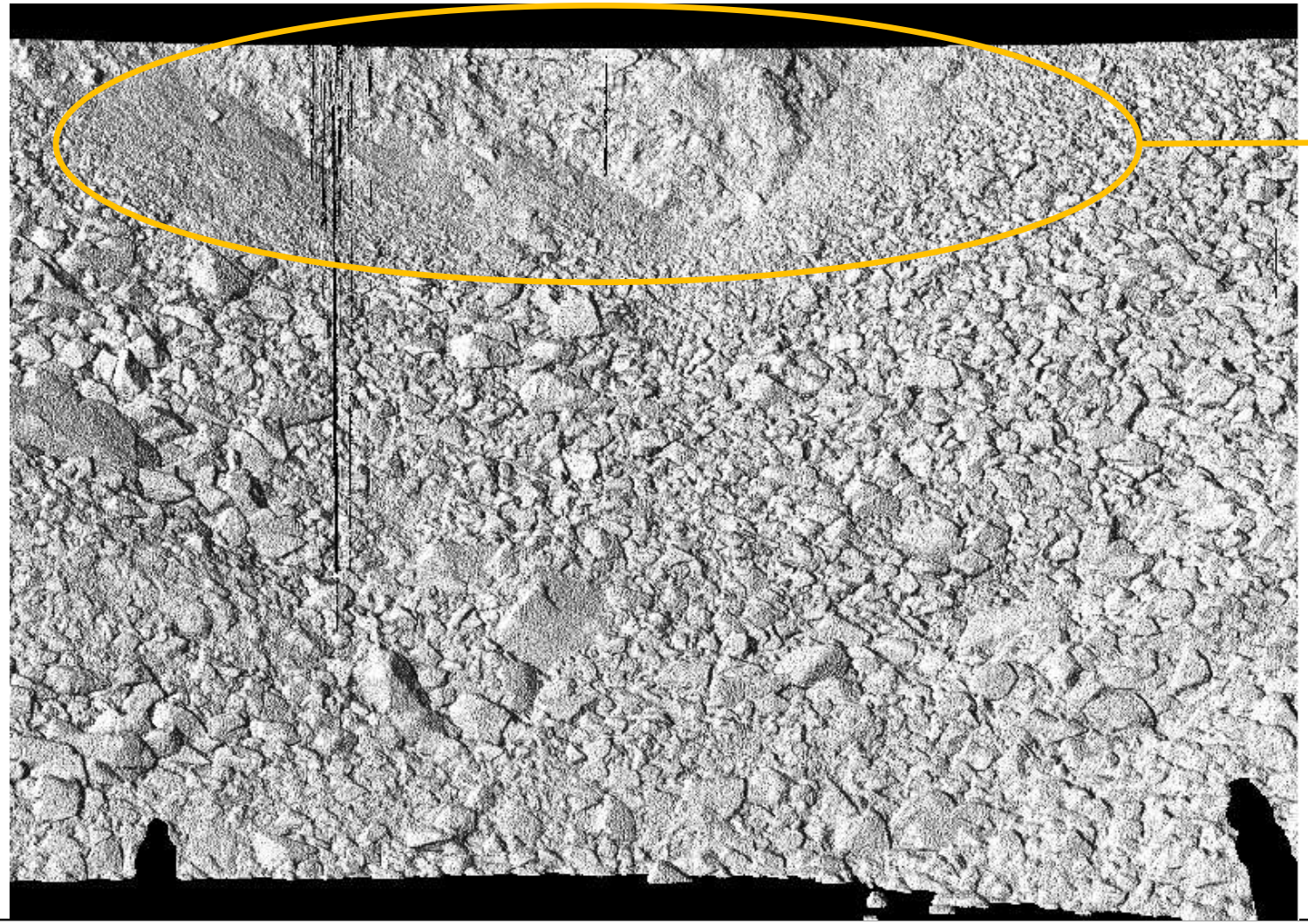
Blast 1
  10 scans

Blast 2
  30 scans

Blast 3
  15 scans

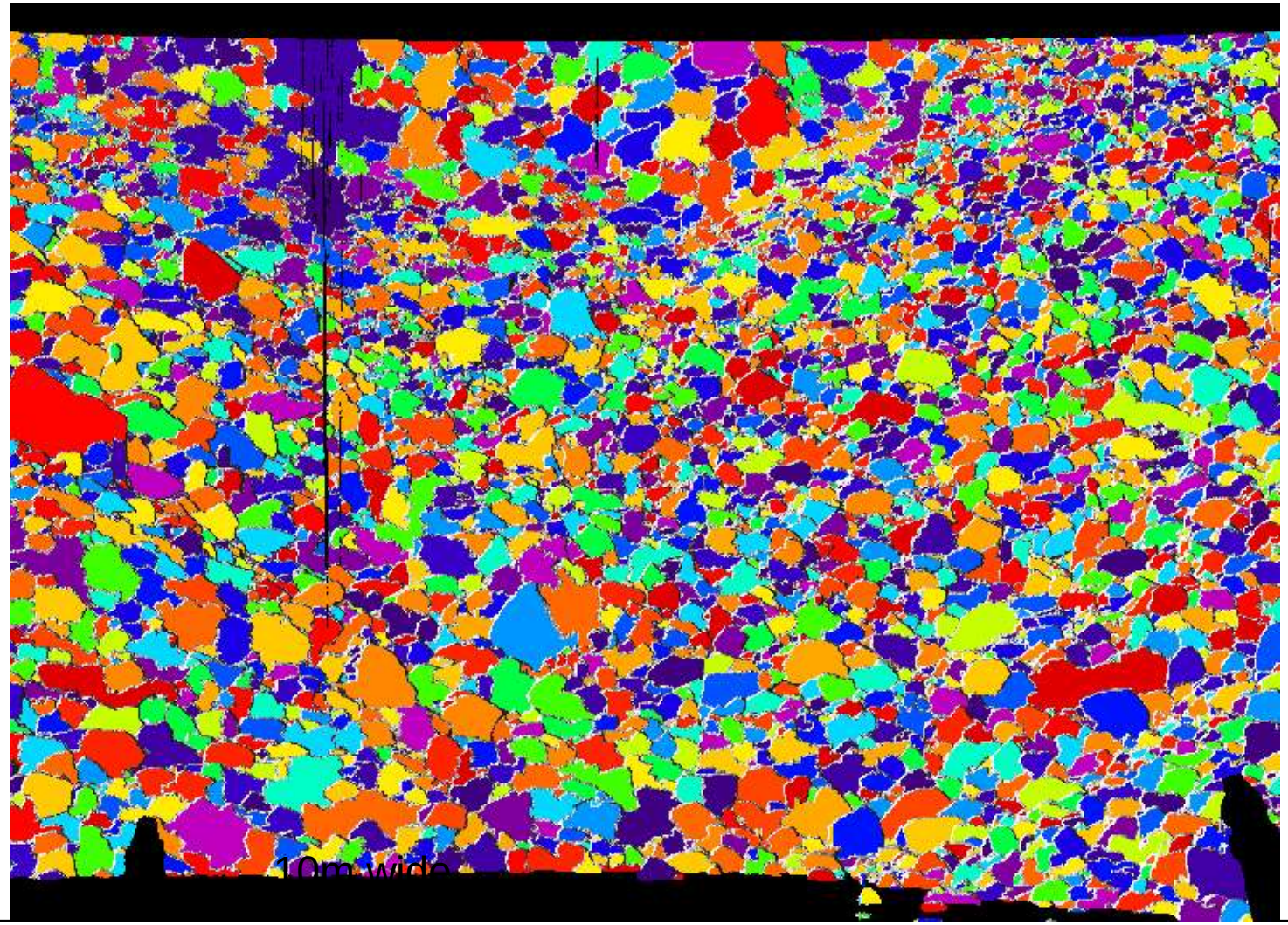


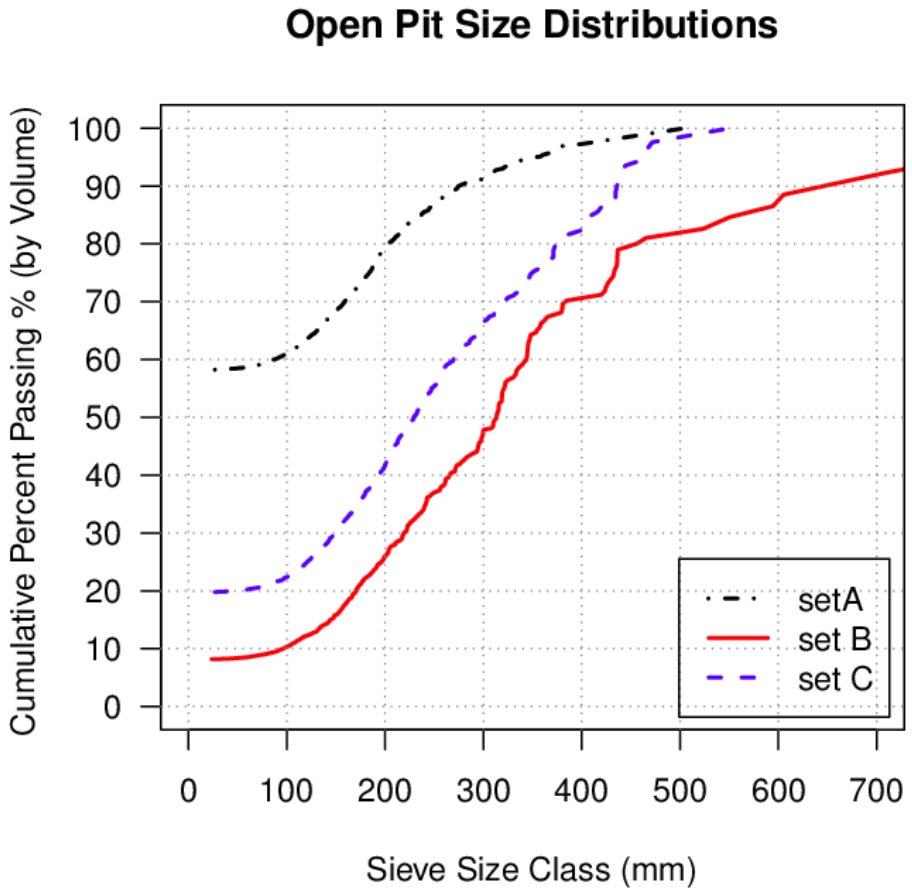
Open Pit Muckpile : 3D rock pile data



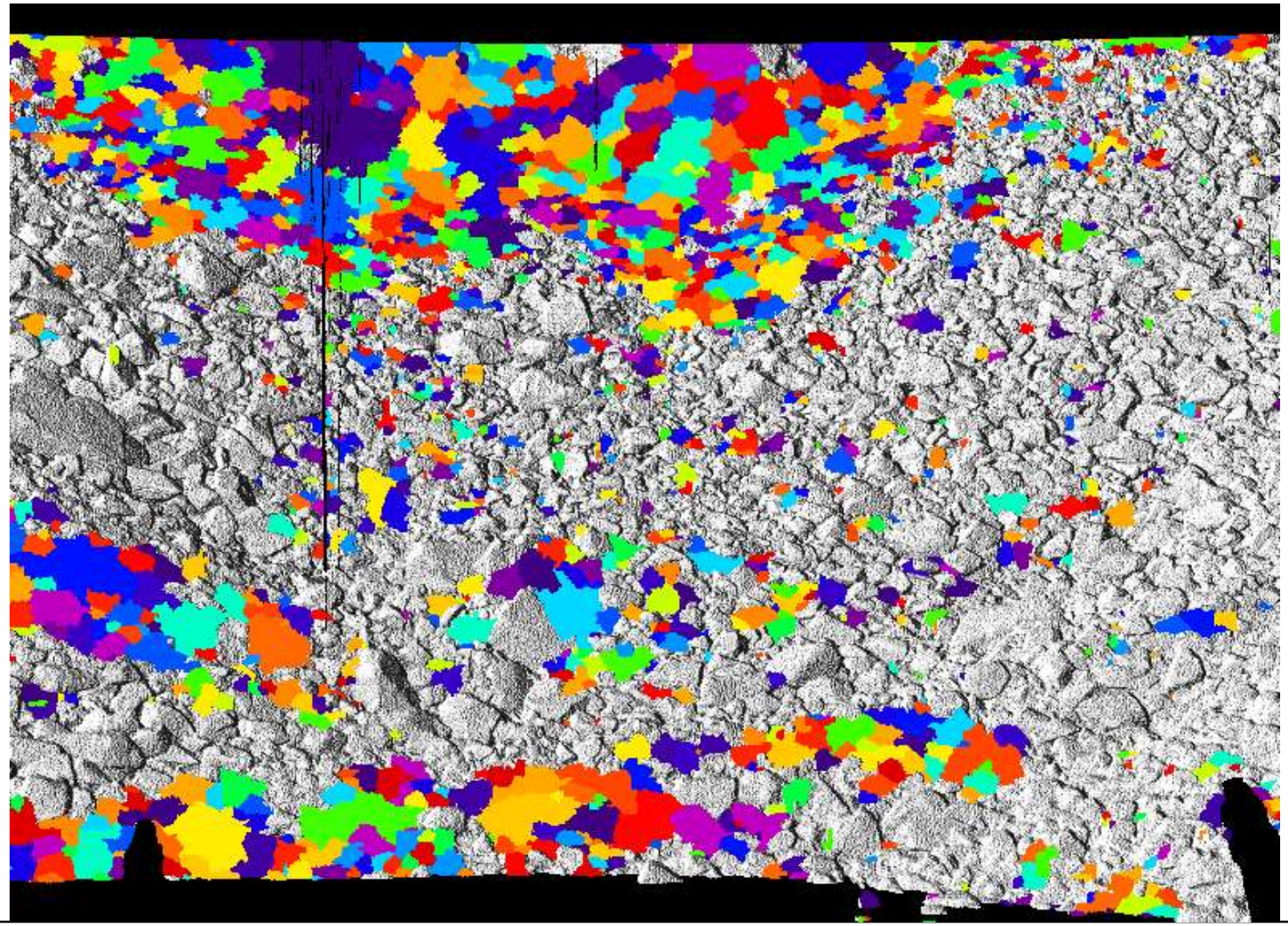
bench of compressed fines at the top

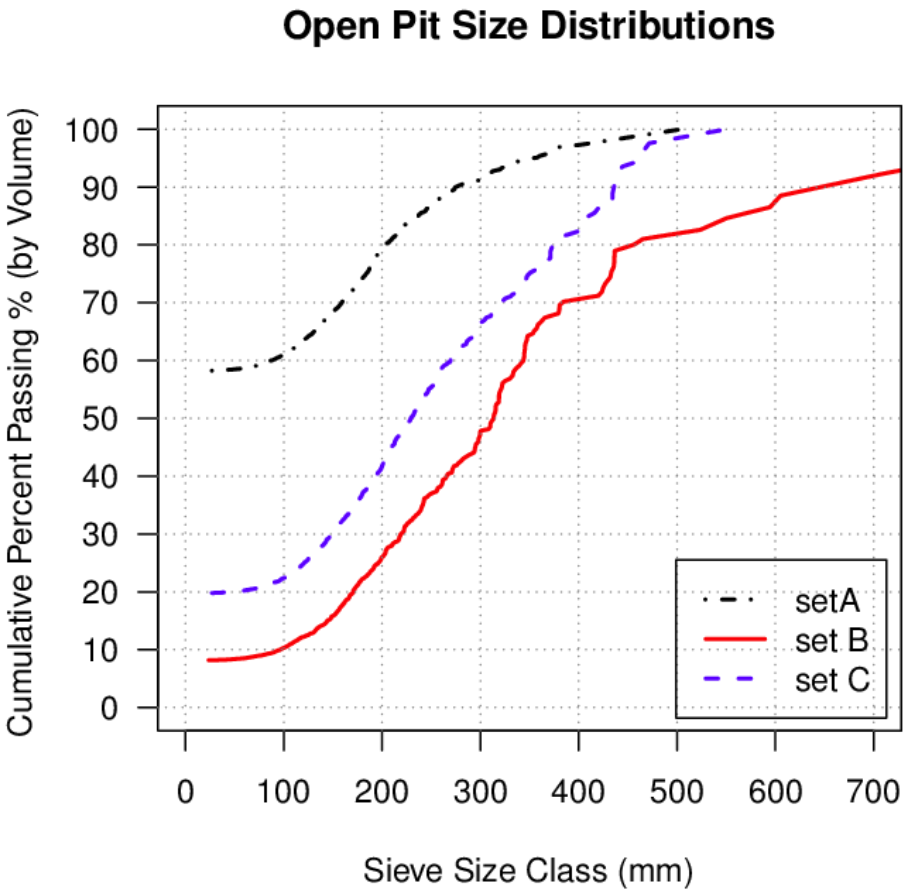
Complete Particle Delineation : Set A



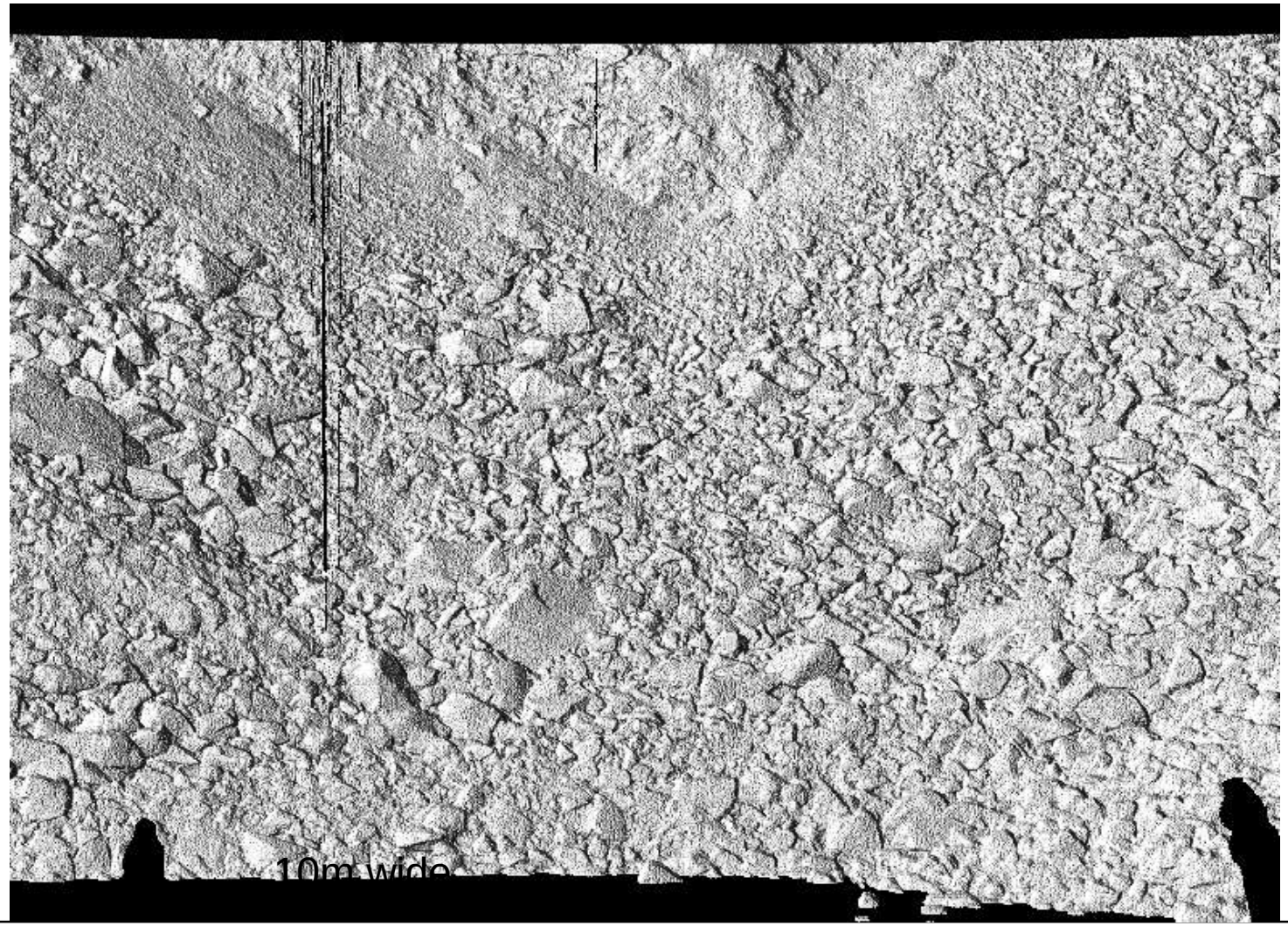


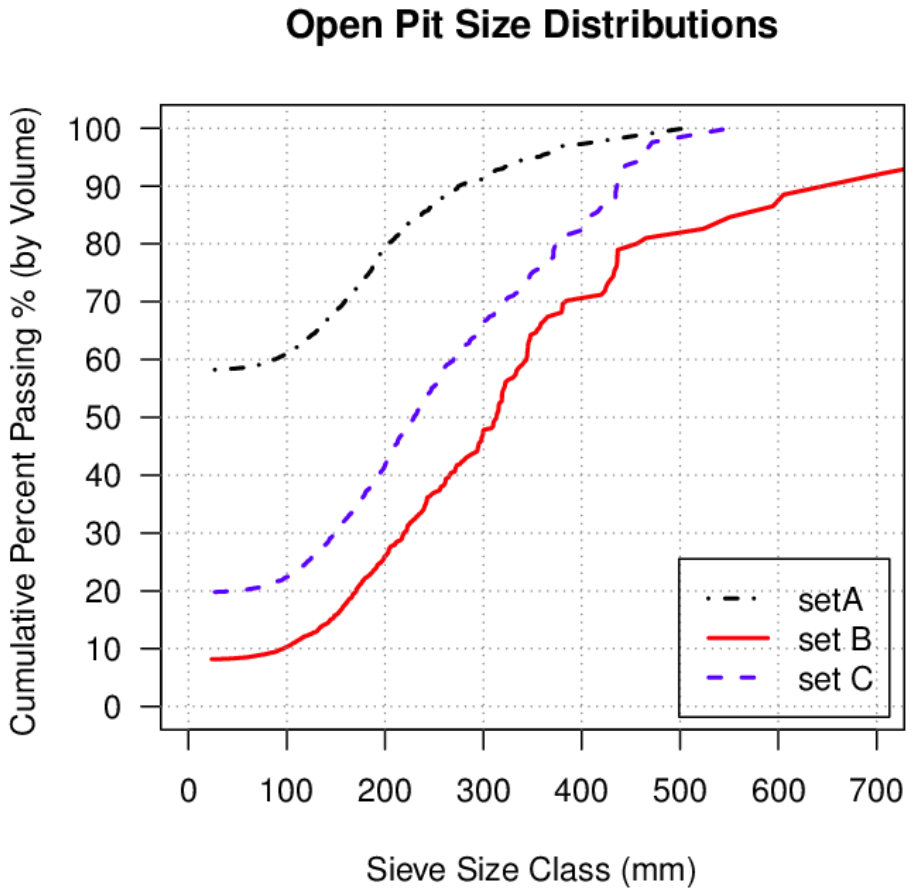
Automatic Fines Detction : Set A





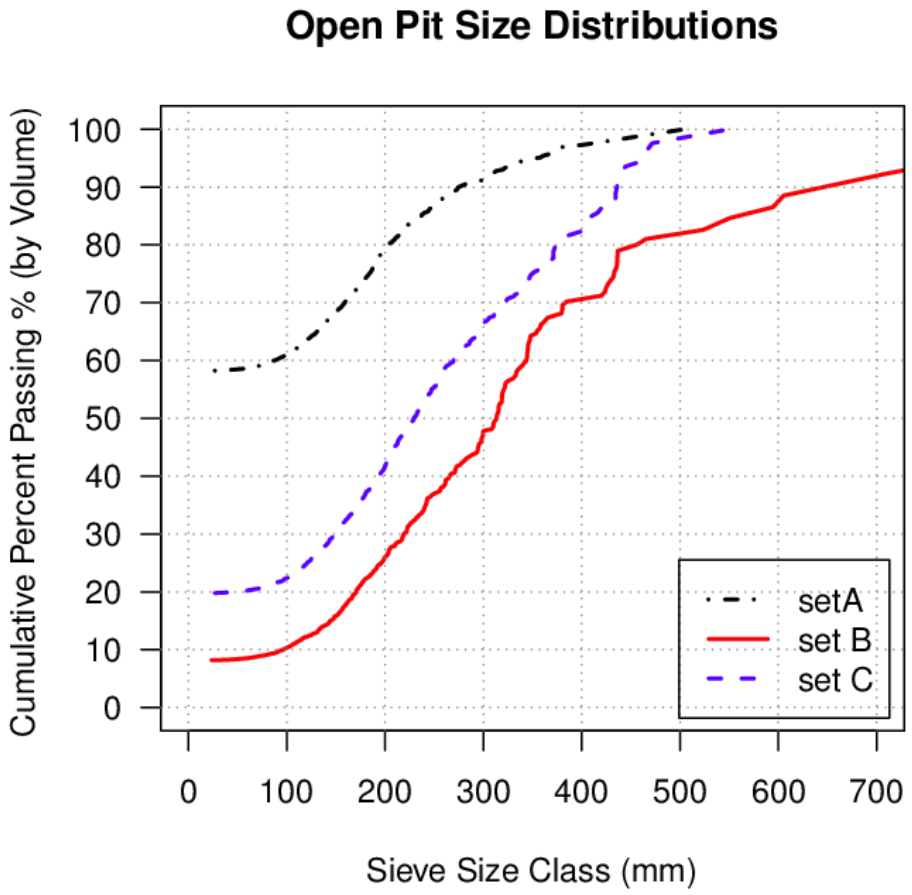
Set A


10m wide

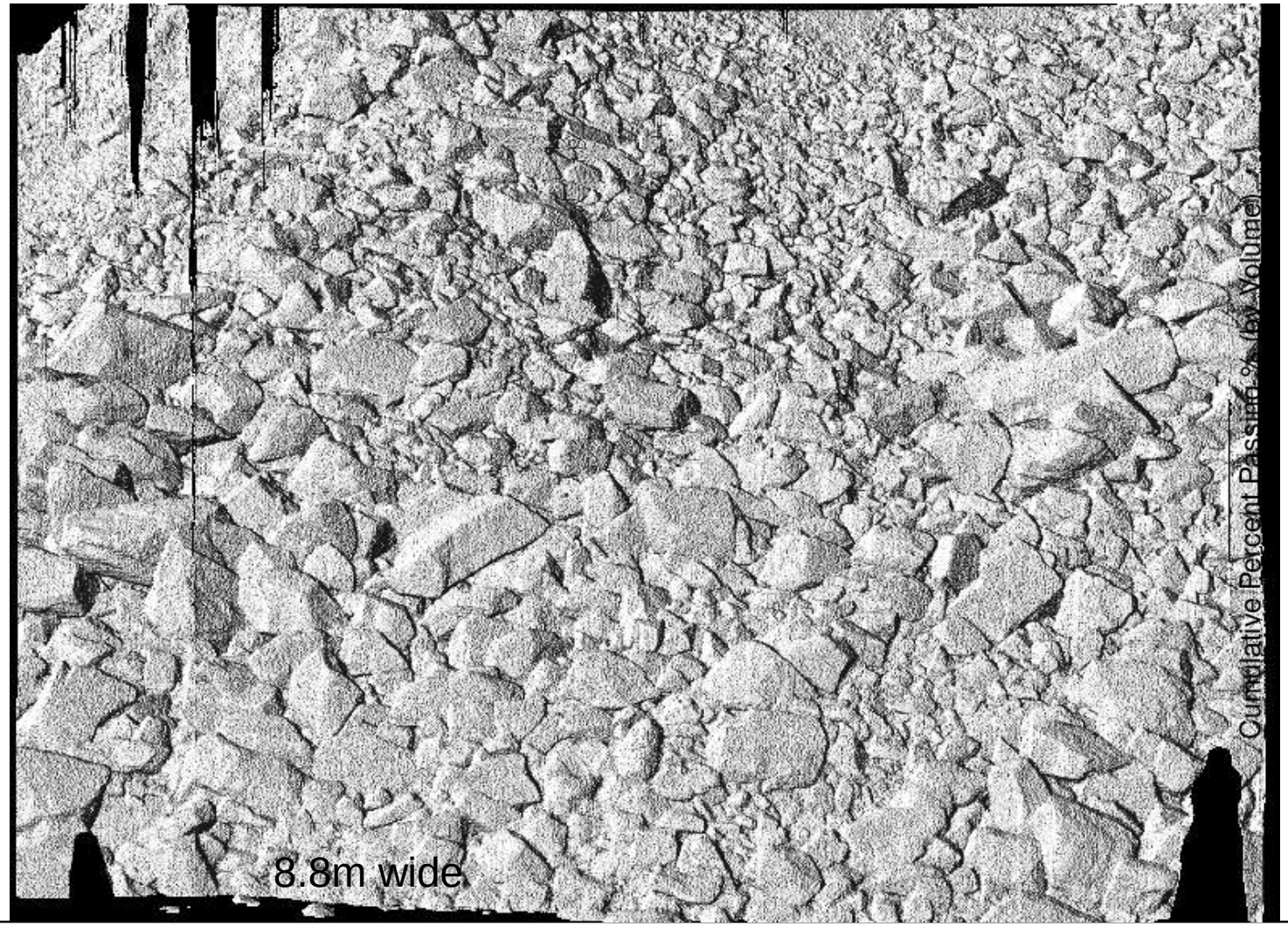

Open Pit Size Distributions
Cumulative Percent Passing % (by Volume)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
Sieve Size Class (mm)
setA
set B
set C

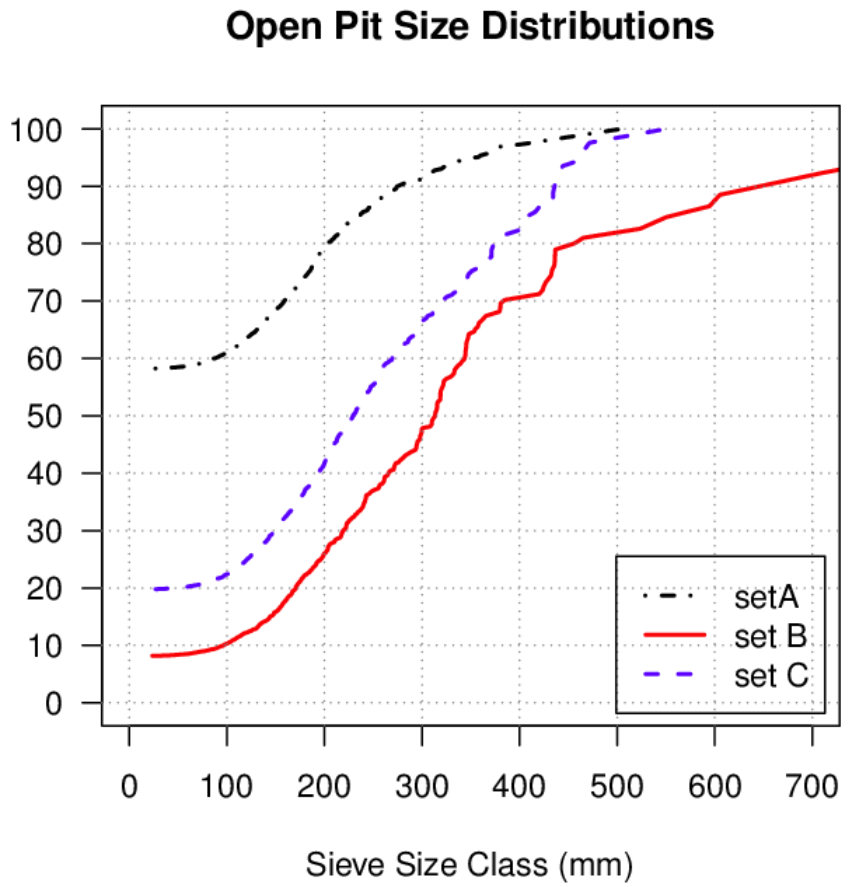
Set B


7.3m wide


Open Pit Size Distributions
Cumulative Percent Passing % (by Volume)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
Sieve Size Class (mm)
setA
set B
set C

Set C


8.8m wide


Open Pit Size Distributions
Cumulative Percent Passing % (by Volume)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
Sieve Size Class (mm)
setA
set B
set C

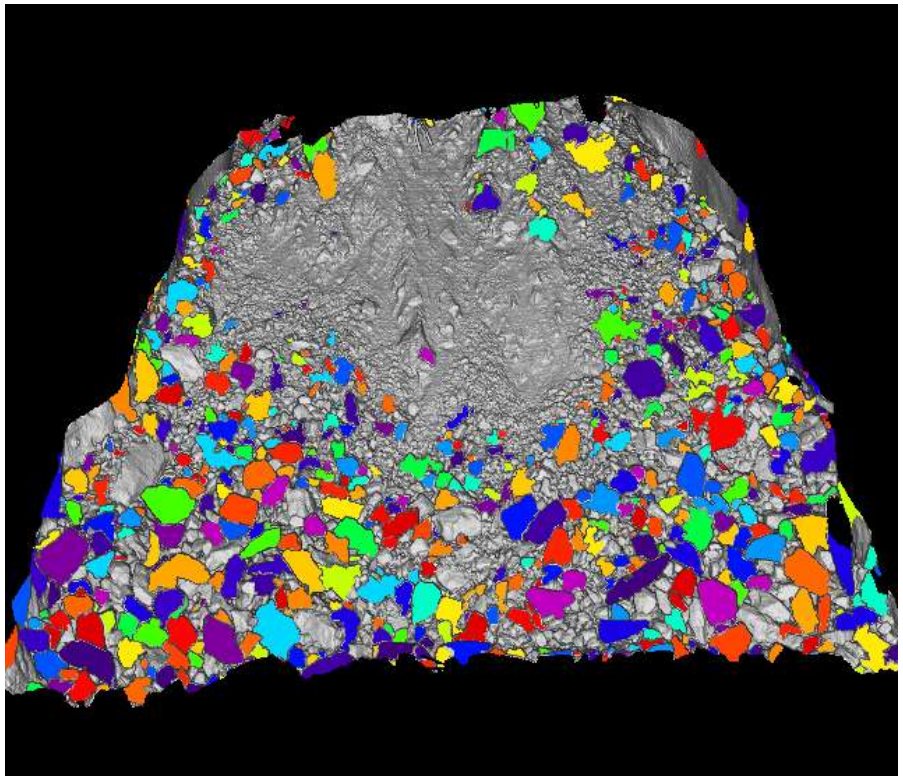
Underground Drawpoints

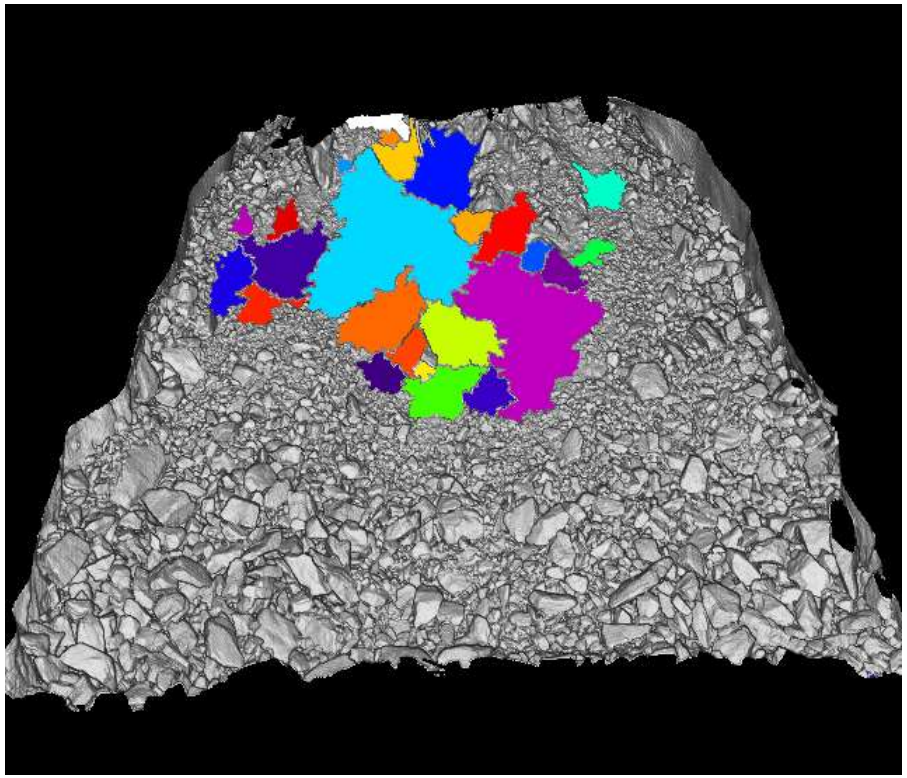
Drawpoints Example

- Project with Alex Campbell at Ernest Henry Mining
- Fragmentation study using a Riegl laser scanner mounted in the back of a ute
- 3D measurements performed approximately every 500 tonnes, taking several hundred measurements
- Following example shows the analysis images for 2 drawpoints and a size graph for the batch of 14 measurements

Drawpoint example 250t

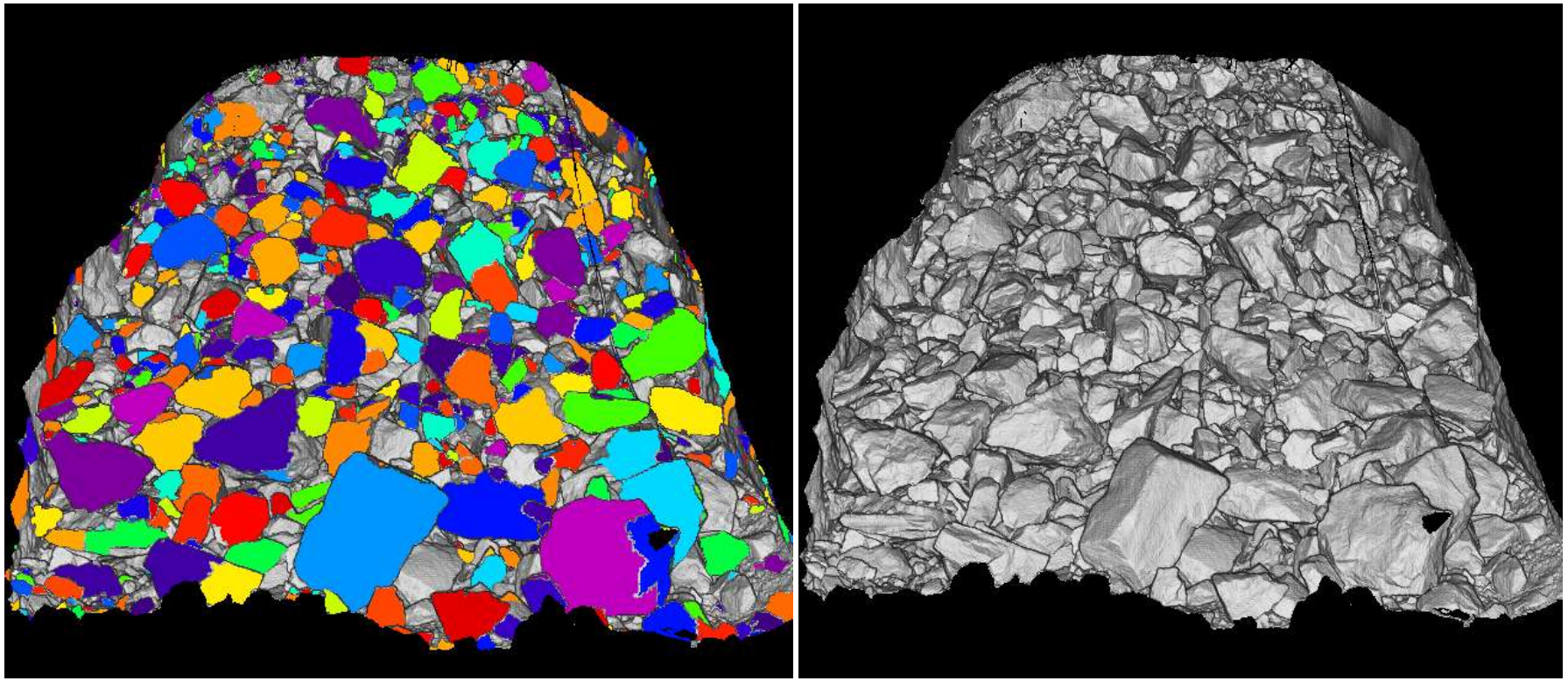
Automatically detected non-overlapped rocks (left image – shown in various colors) and areas-of-fines (right image – shown in various colors)
Many smaller rocks and large area-of-fines well detected





Drawpoint example 3500t

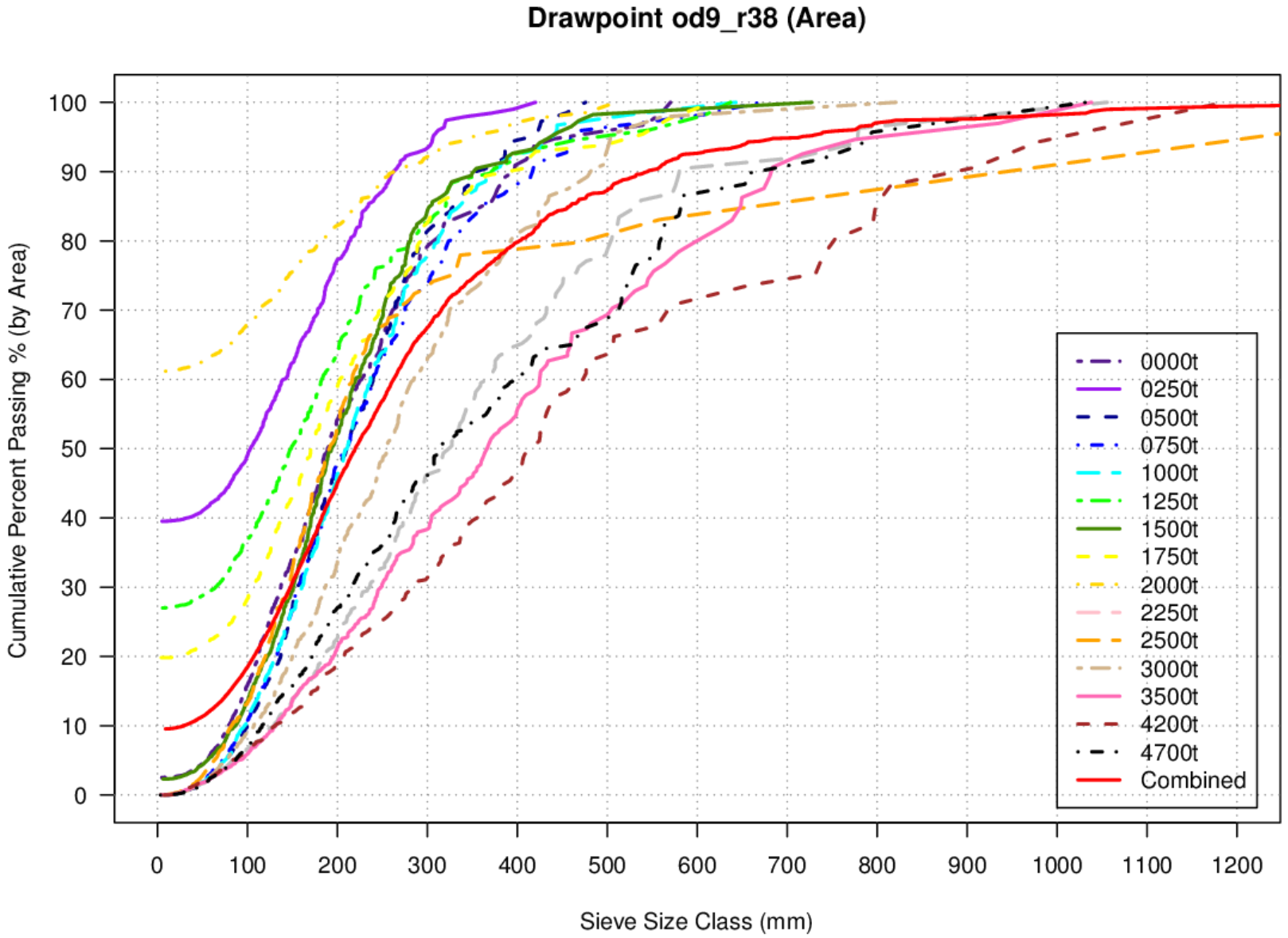
Automatically detected non-overlapped rocks (left image – shown in various colors) and areas-of-fines (right image)
Mostly larger rocks and no areas-of-fines present and non detected



Size results 1 ring of 14 drawpoints

250t shown in solid purple line

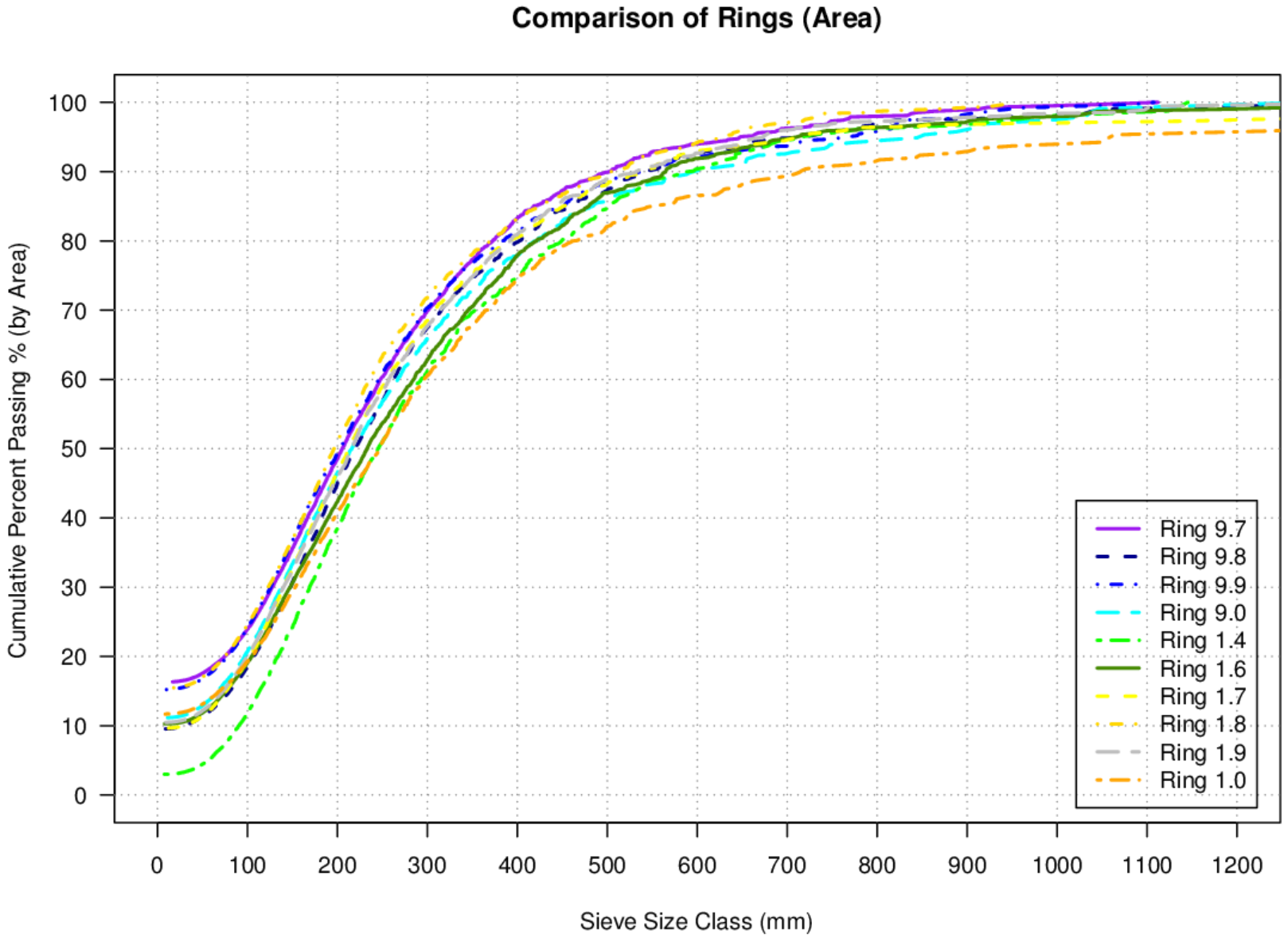
3500t shown in solid pink line



Size results 10 Rings

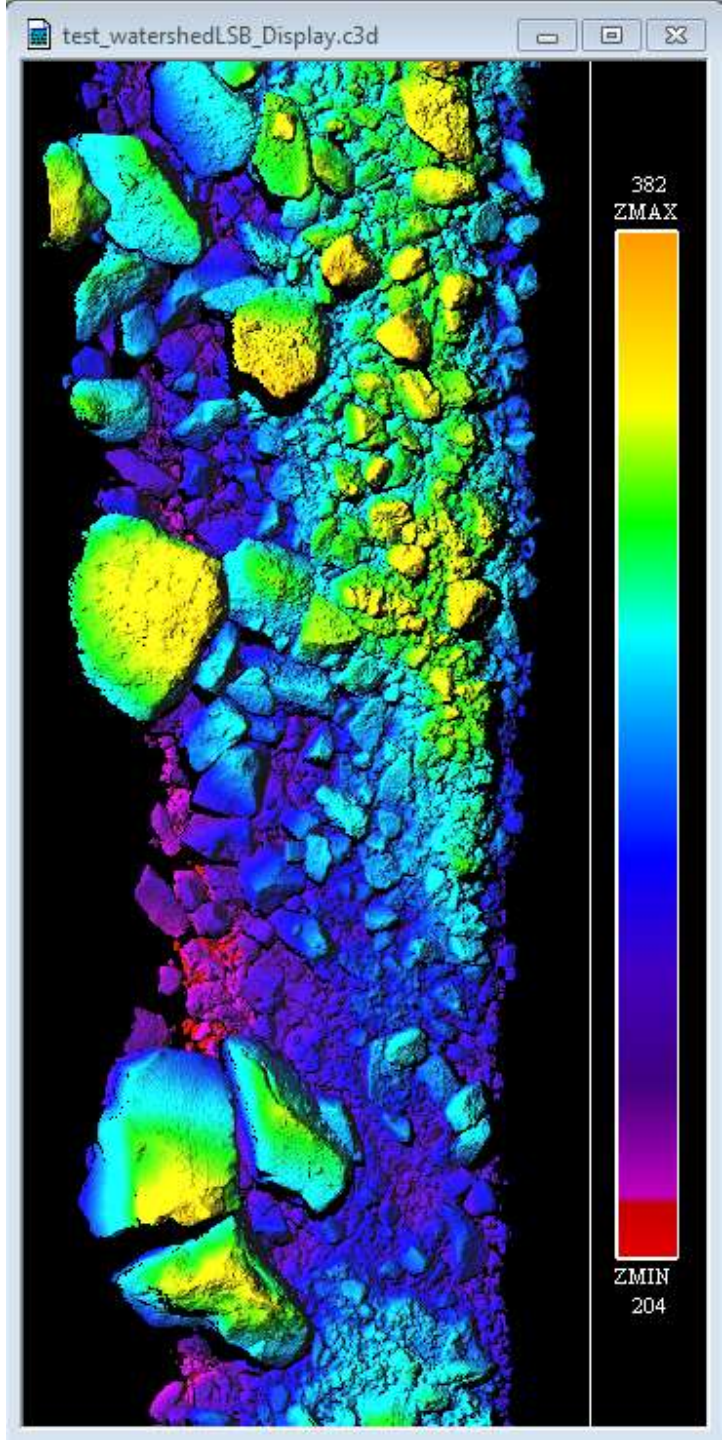
Ring 9.7 : 15 scans
Ring 9.8 : 15 scans
Ring 9.9 : 13 scans
Ring 9.0 : 10 scans
Ring 1.4 : 6 scans
Ring 1.6 : 13 scans
Ring 1.7 : 15 scans
Ring 1.8 : 16 scans
Ring 1.9 : 15 scans
Ring 1.0 : 9 scans

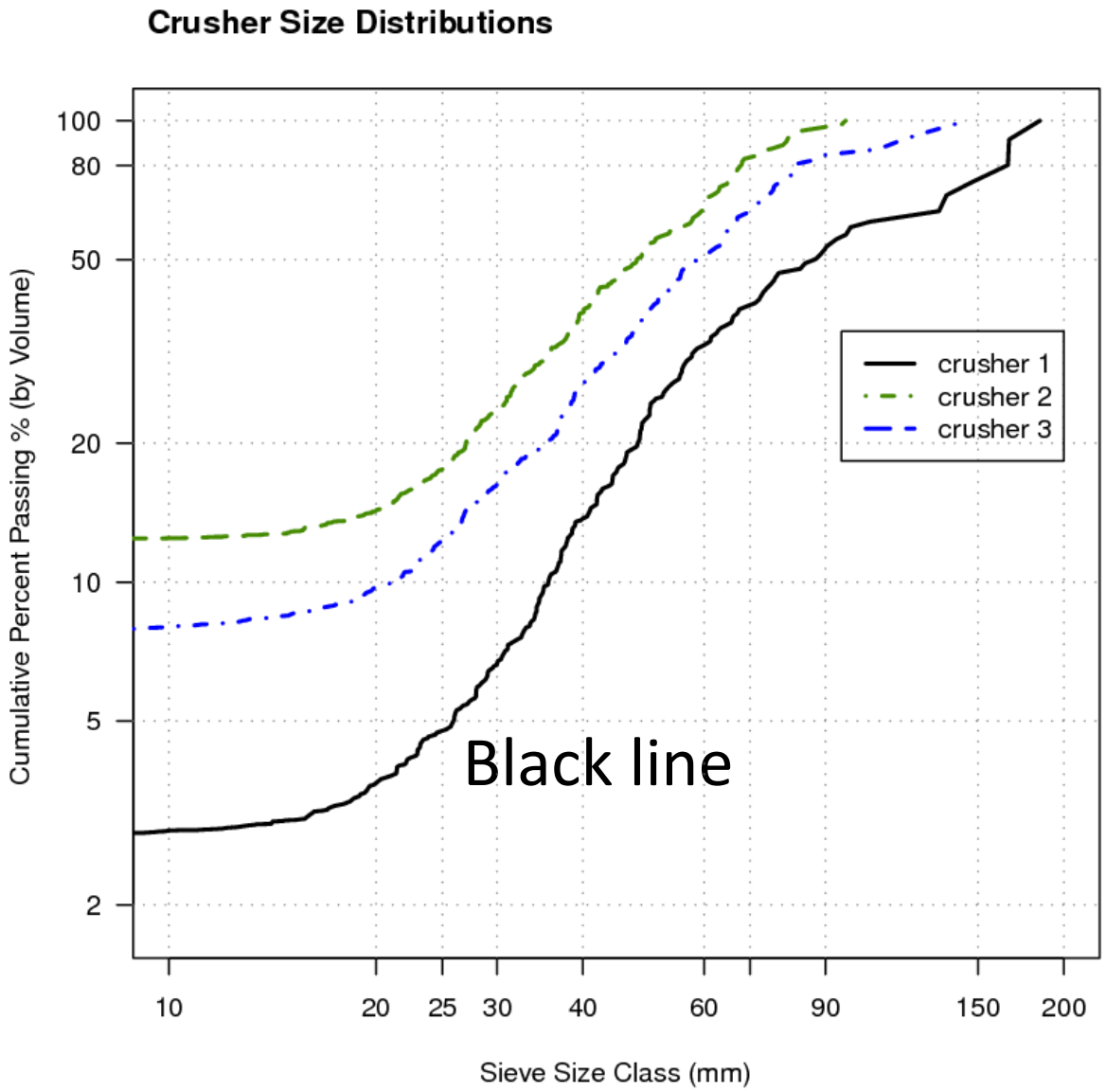
Total 127 scans

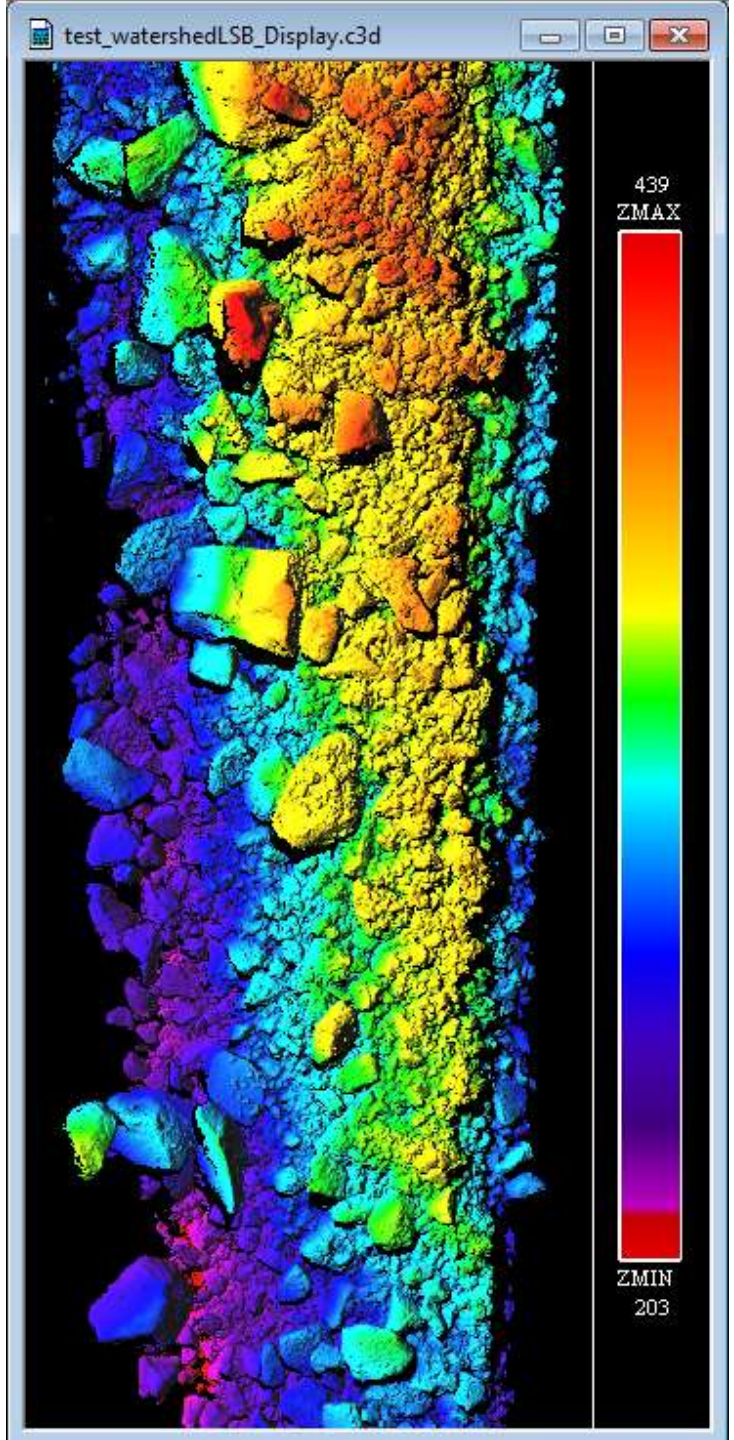


Conveyor Belt

Boliden Tara Mine: between primary crusher and grinding mill (2011 ongoing)


test_watershedLSB_Display.c3d
382
ZMAX
ZMIN
204


Crusher Size Distributions
Cumulative Percent Passing % (by Volume)
100
80
50
20
10
5
2
10
20
25
30
40
60
90
150
200
Sieve Size Class (mm)
crusher 1
crusher 2
crusher 3
Black line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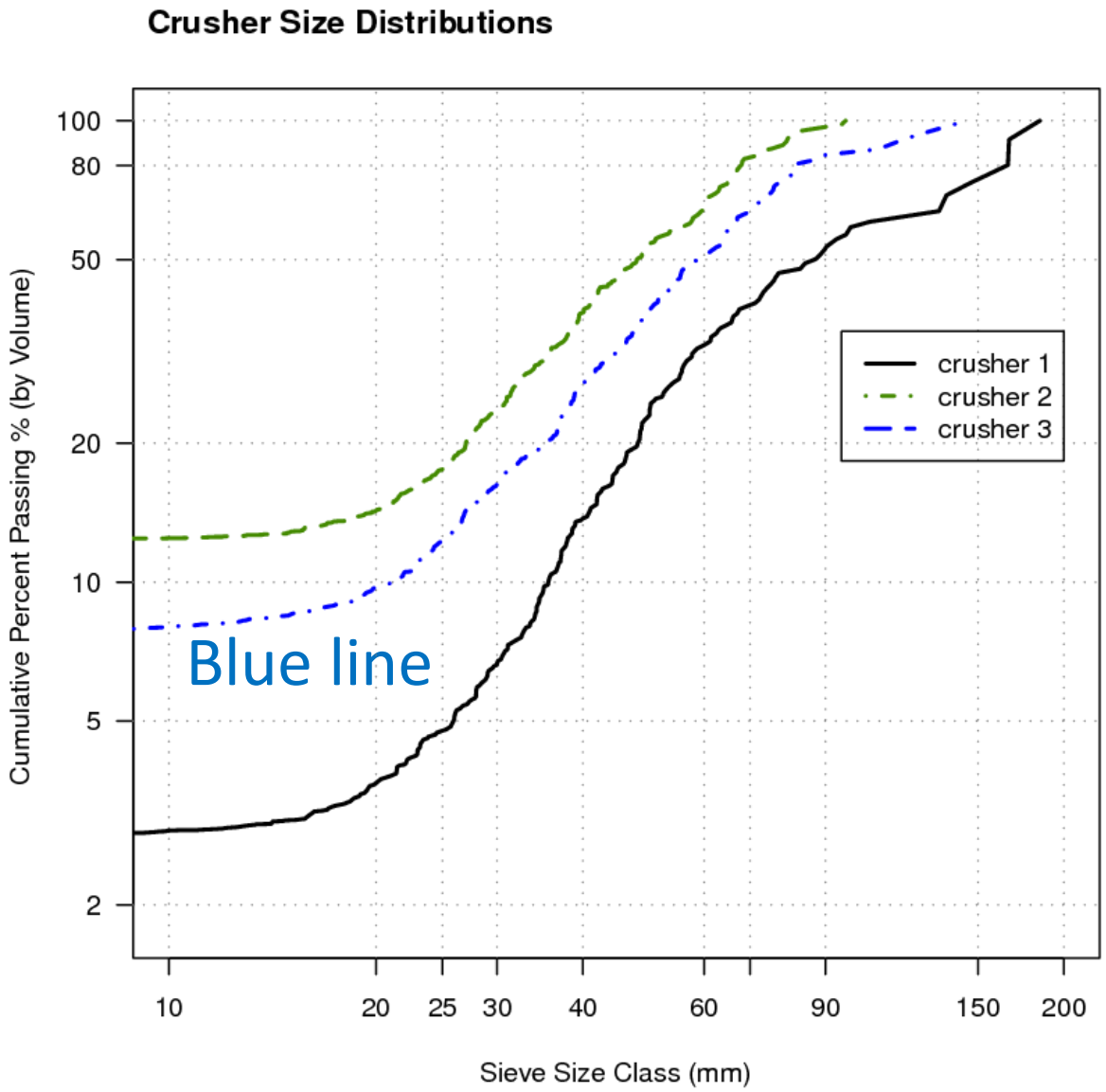
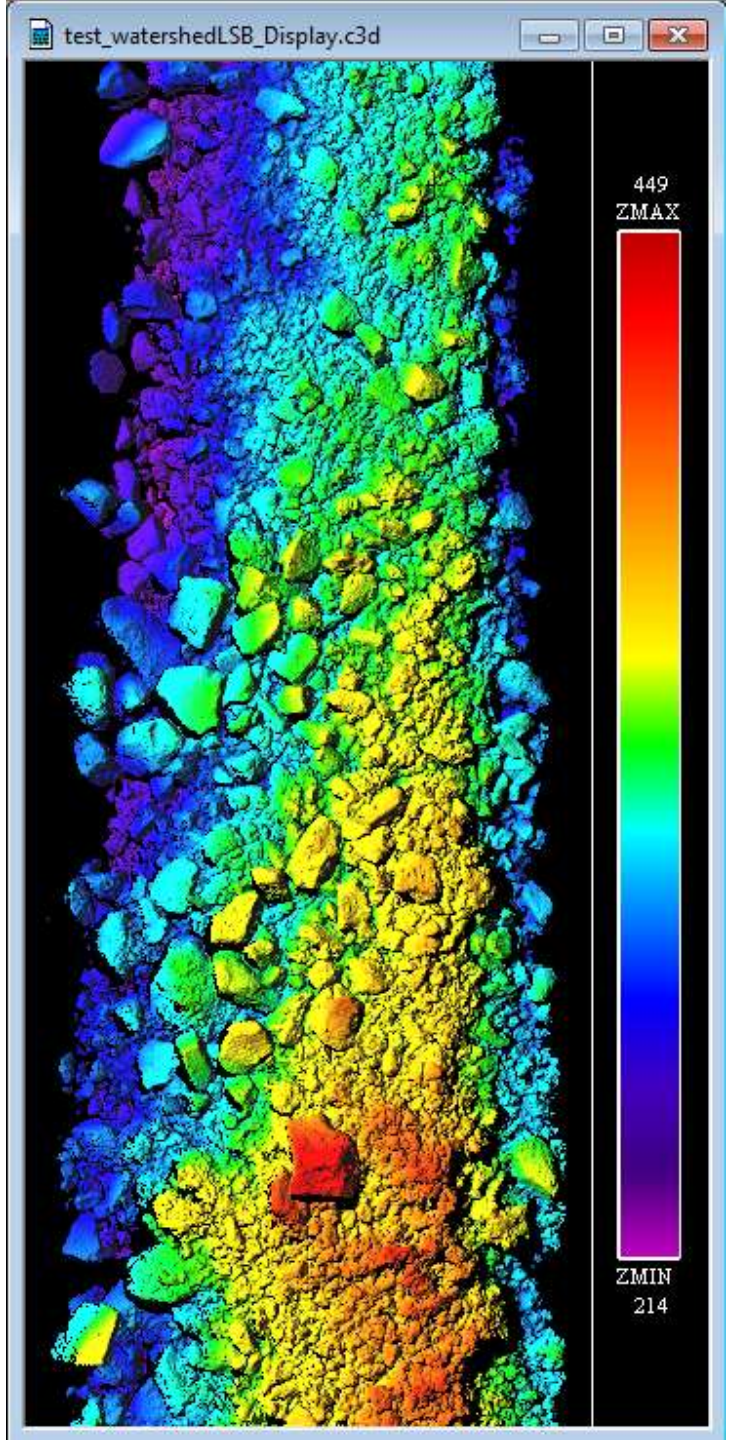
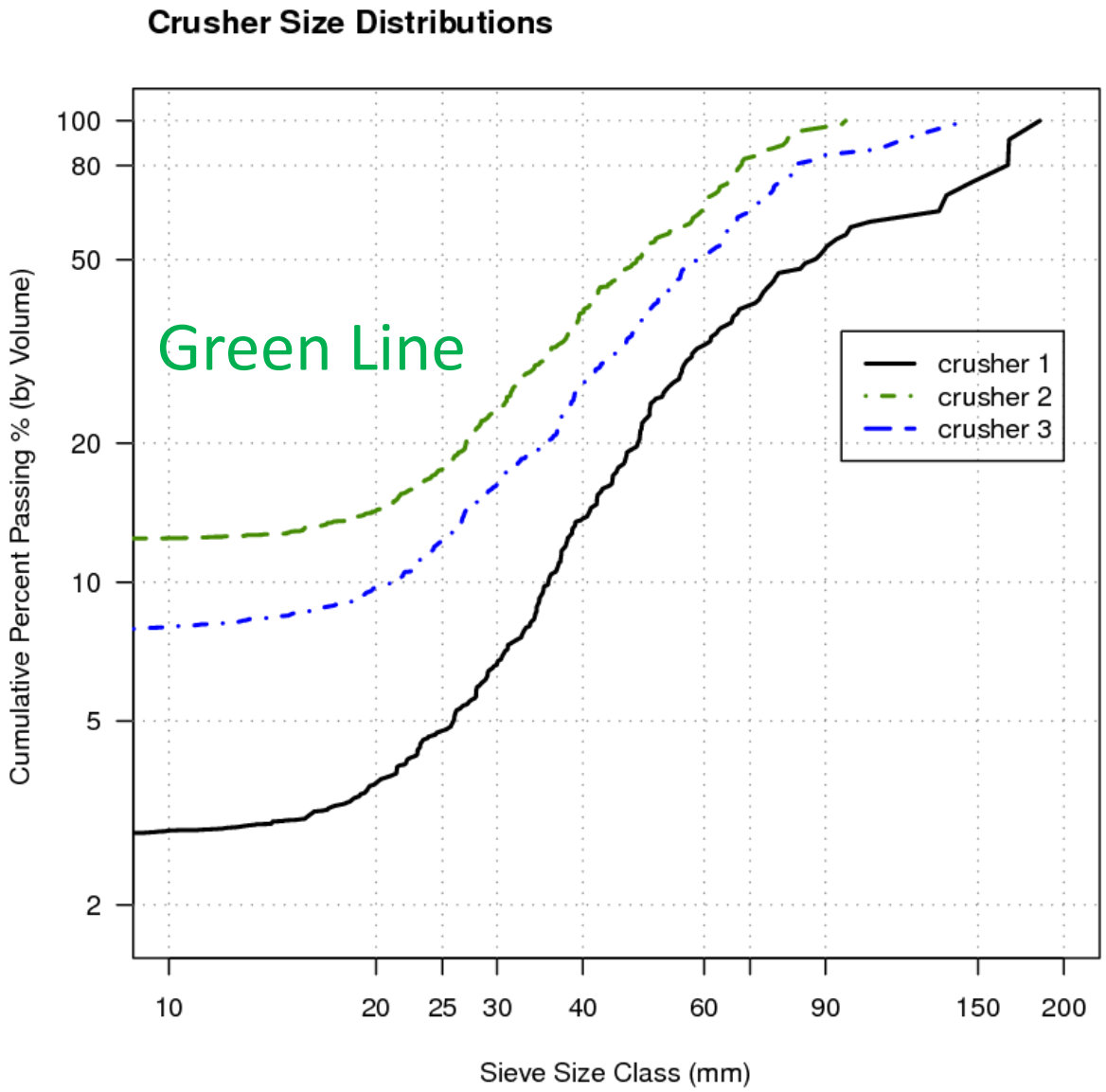
439
ZMAX
ZMIN
203


Crusher Size Distributions
Cumulative Percent Passing % (by Volume)
100
80
50
20
10
5
2
10
20
25
30
40
60
90
150
200
Sieve Size Class (mm)
crusher 1
crusher 2
crusher 3
Blue line

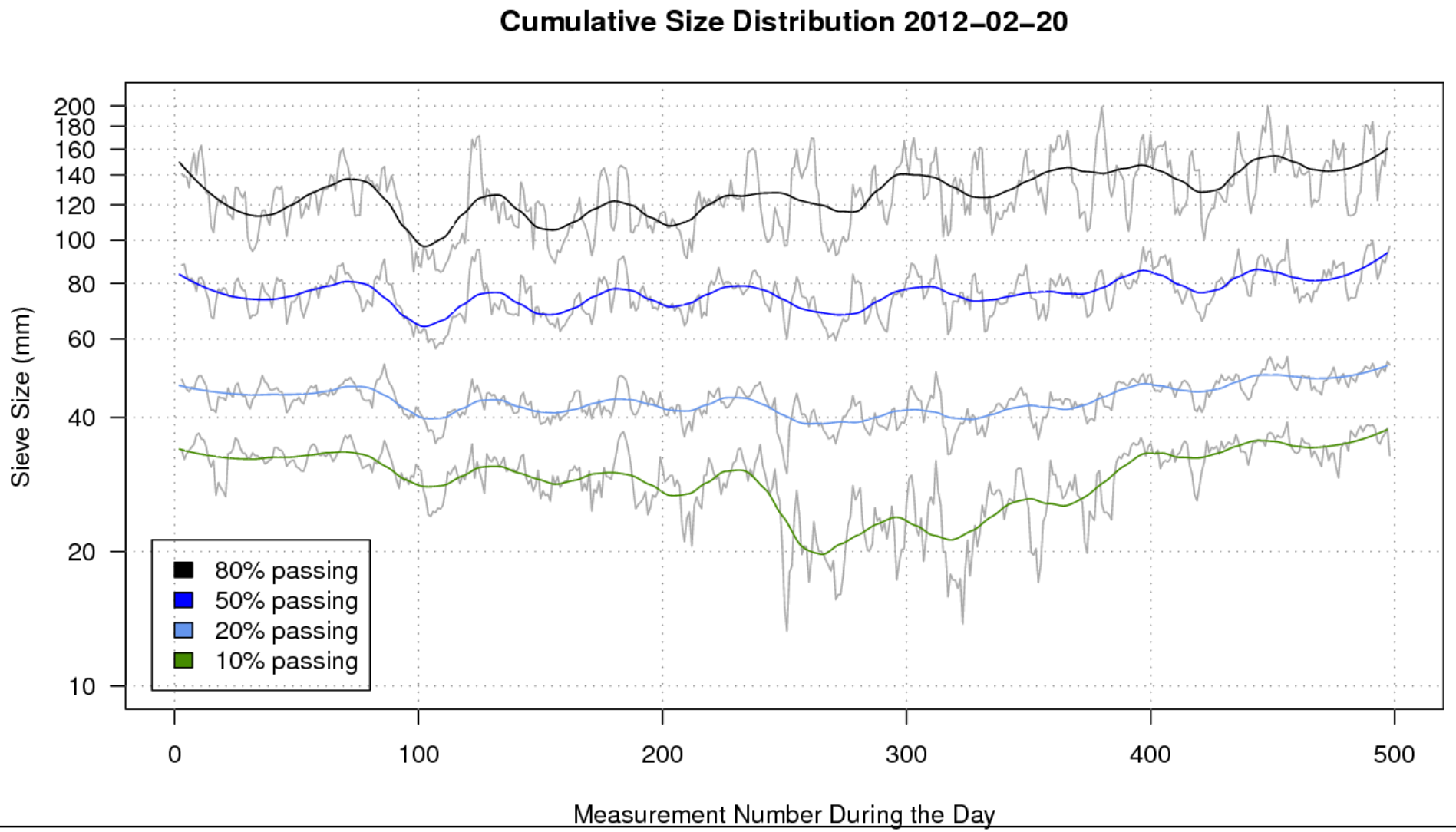

test_watershedLSB_Display.c3d
449
ZMAX
ZMIN
214


Crusher Size Distributions
Green Line
Cumulative Percent Passing % (by Volume)
100
80
50
20
10
5
2
10
20
25
30
40
60
90
150
200
Sieve Size Class (mm)
crusher 1
crusher 2
crusher 3

Compare with smart algorithms ON and OFF?

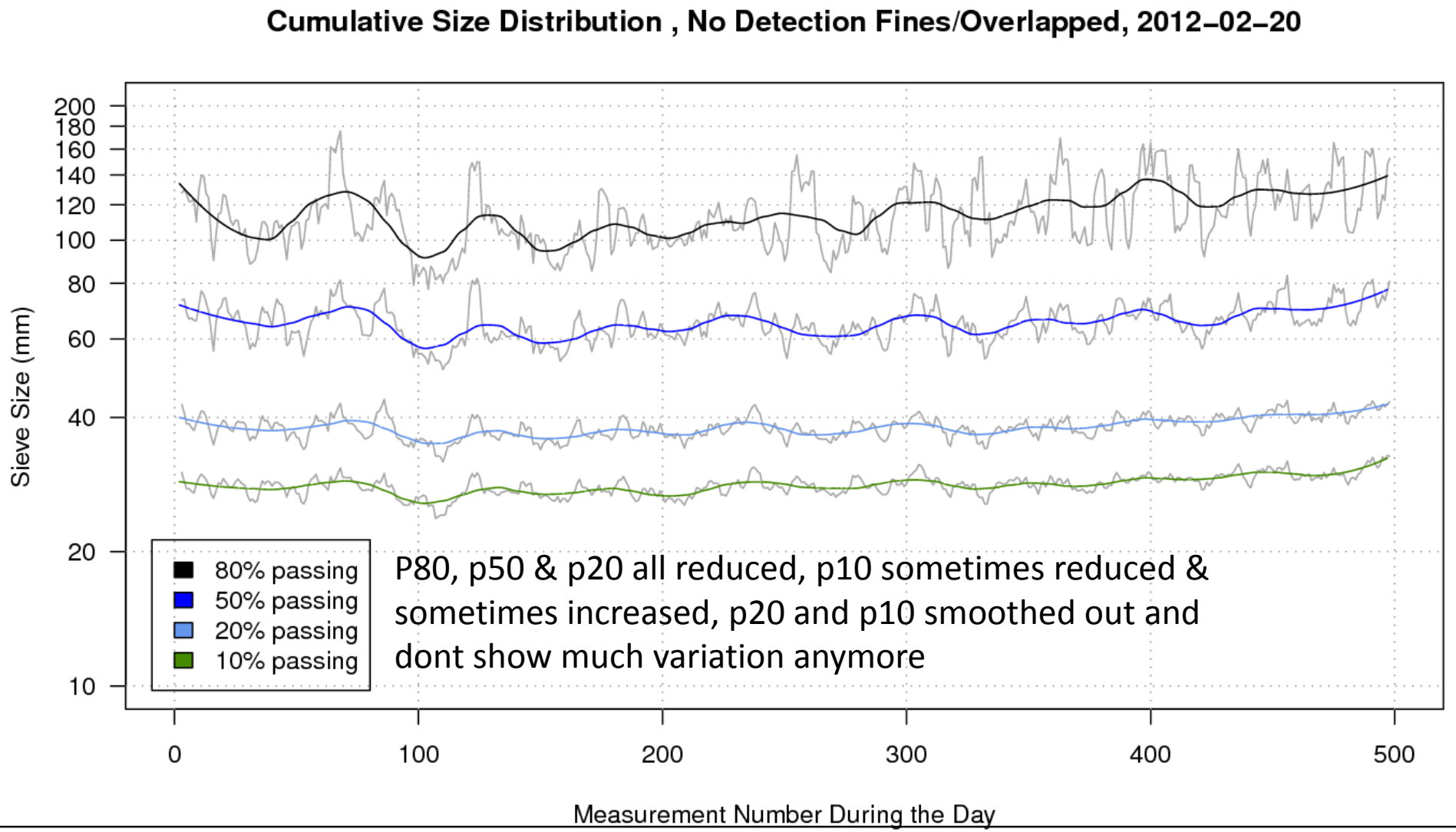
- What would the results be if we could not;
  - Detect areas-of-fines and
  - Detect and ignore overlapped particles
- But still had high quality 3D image data that overcomes limitations of 2D systems
  - Overcomes particle delineation errors from particle color variation and lighting variation
  - Directly measures material dimensions

Results for 500 measurements over 4+ hours 0-250mm



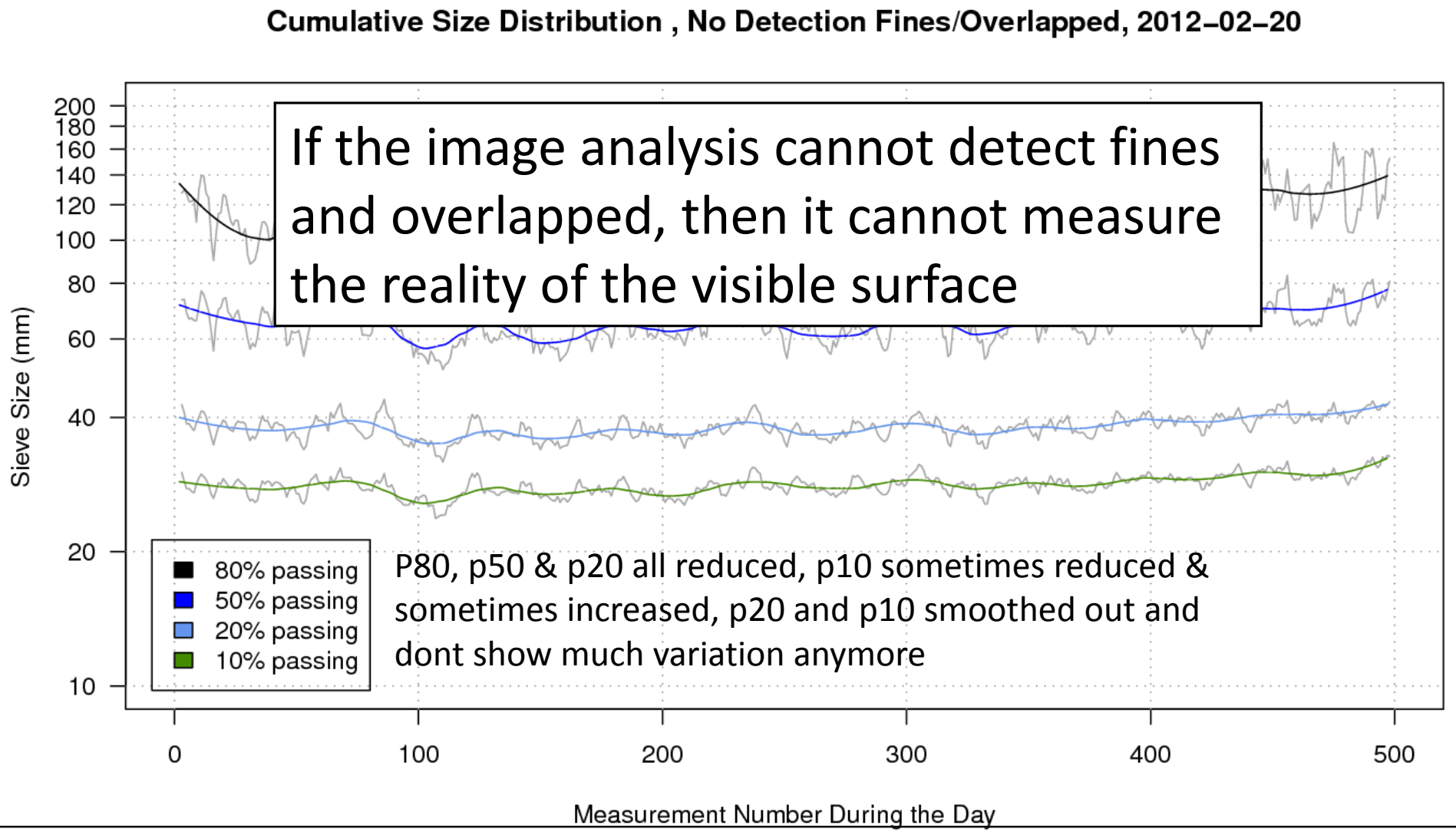
Results for 500 measurements over 4+ hours 0-250mm

BUT Detection of fines and overlapped is OFF



Results for 500 measurements over 4+ hours 0-250mm

BUT Detection of fines and overlapped is OFF



Summary

Particle Size Range

Application Example	Measured Size Range
Open-Pit	Fines < 80mm, Largest approx. 2000mm
Drawpoints	Fines < 25mm, Largest approx. 1500mm
Conveyor after primary crusher	Fines < 10mm, Largest approx. 500mm
Conveyor agglomeration circuit	Fines < 3mm, Largest approx. 50mm

Advantages of good 3D data and smart algorithms

High resolution 3D imaging and IMV's advanced algorithms

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  - Directly measure 3D dimension of the material therefore no scaling objects or perspecive distortion errors
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- These two errors are opposing in their effect, which in combination can produce an unstable system. Mitigating these errors results in a stable and reliable measurement system.

Thank You

Associate Professor Matthew Thurley
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Automated sizing in LHD buckets

- 3D data from cheap industrial 3D laser scanners
- Fully automated analysis
- Estimated the sieve size of the visible fragments