



Hanoi University of Mining and Geology

# **Overview on the development of rock fragmentation analysis based on 3D images**

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## The purpose of rock fragmentation analysis

- Larger fragments can hinder equipment loading and hauling, increase the frequency of sorting oversized boulders, need to secondary blasting, thereby increasing the mining costs.
- Excessive fines impact on explosive consumption.
- A consistent fragmentation distribution that minimizes both fines and oversized fragments is a desirable of most of the mines
- **Rock fragmentation is a measure of the fragment size distribution of the post-blast broken rock material. It is a function of blast design, rock strength, and natural discontinuities and can be considered a key parameter to measure the blast performance.**

## Fragmentation analysis techniques

### **Screening or Sieving**

Direct and precise approach, but time-consuming and costly

### **Oversize boulder count method**

Useful for small-scale blasts, but manual method.

### **Shovel Loading Rate Method**

Not effective for undersized fragmentation analysis.



## Fragmentation analysis techniques

### **Visual Analysis Method**

Not reliable

### **Photogrammetry Method**

Precise and reliable

### **Image Analysis Technique**

Enhanced Precision  
and cost - effective  
efficient method



# Traditional Rock Fragmentation Analysis Methods

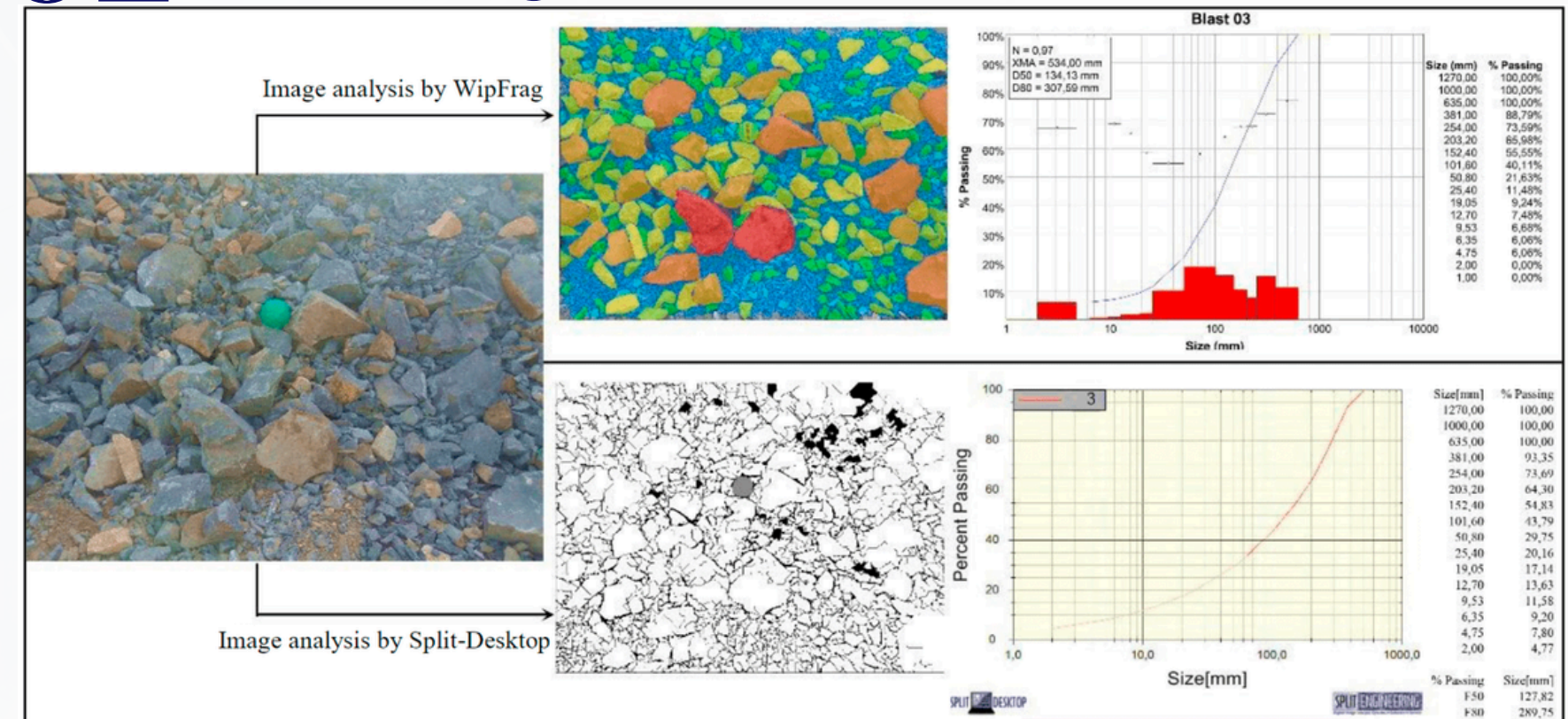
## 01 Screening or Sieving



Direct and precise approach, but time-consuming and costly

## 02 2D image analysis

A. Saadoun & nnk



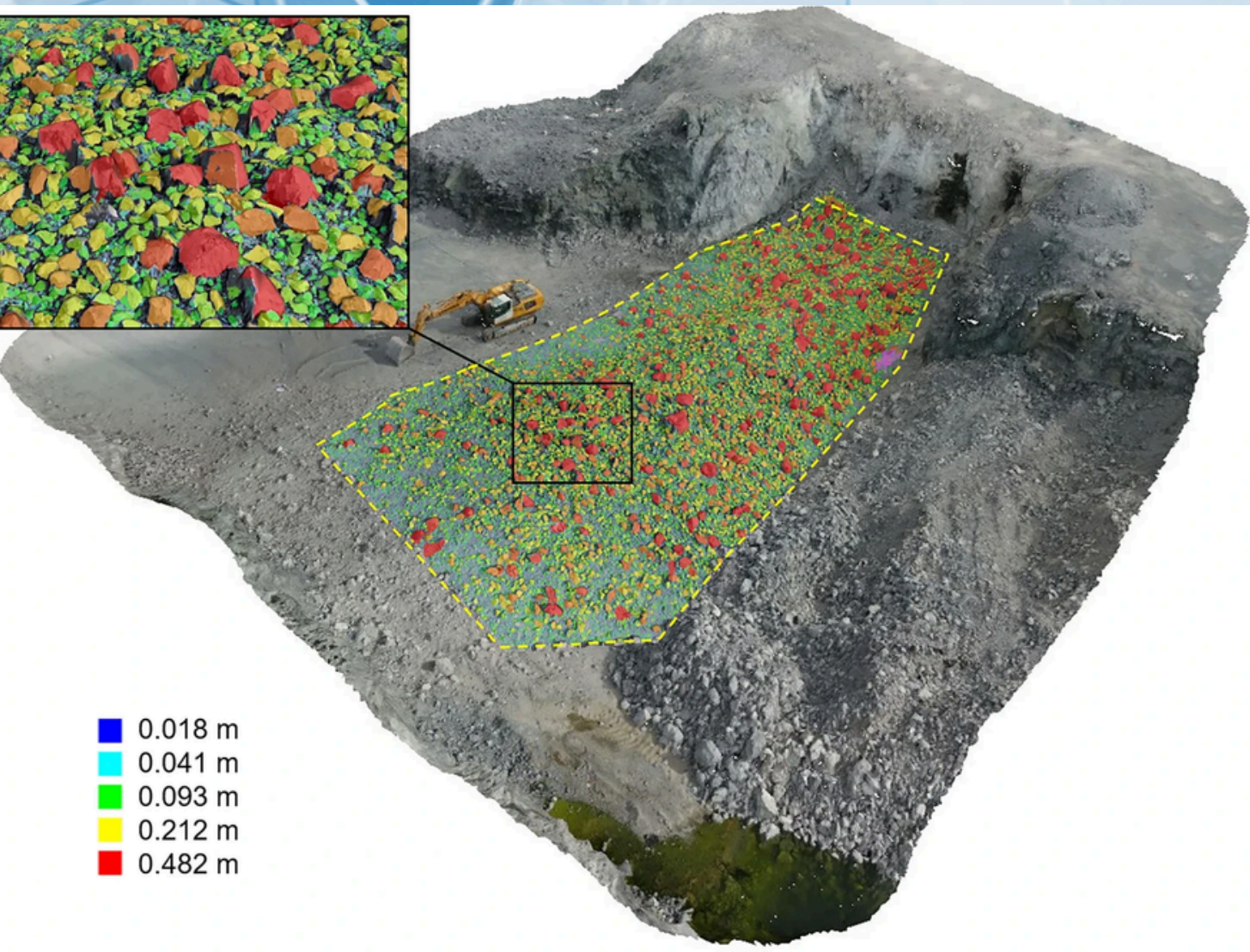
Enhanced Precision and cost - effective efficient method;

Disadvantages: lack of depth Information; Occlusion and Overlapping; Distortion and perspective Effects; Limited representation of complex Geometries; Sensitivity to Lighting and Image Quality; Difficulty in Analyzing Fine Particles



# 3D image-based rock fragmentation analysis

## 3D image advantages



■ 0.018 m  
■ 0.041 m  
■ 0.093 m  
■ 0.212 m  
■ 0.482 m

P. Segarra et. al. (2024)

Improved  
accuracy

better  
visualization

enhanced  
analysis  
capabilities



## 3D image capturing techniques

### **a. Laser Scanning**

Utilizing laser beams to create precise 3D representation of fragmented rocks

Laser scanners use to capture 3D surface topology of rock fragments. These include various configurations: terrestrial, airborne, or drone-mounted (depending on the scale and application)

### **b. X-Ray computed tomography**

X-ray CT scanning generates a series of 2D X-ray images that can be reconstructed into a 3D model of the rock sample, allowing for detailed analysis of the internal structure and external geometry of individual fragments.

### **c. Photogrammetry**

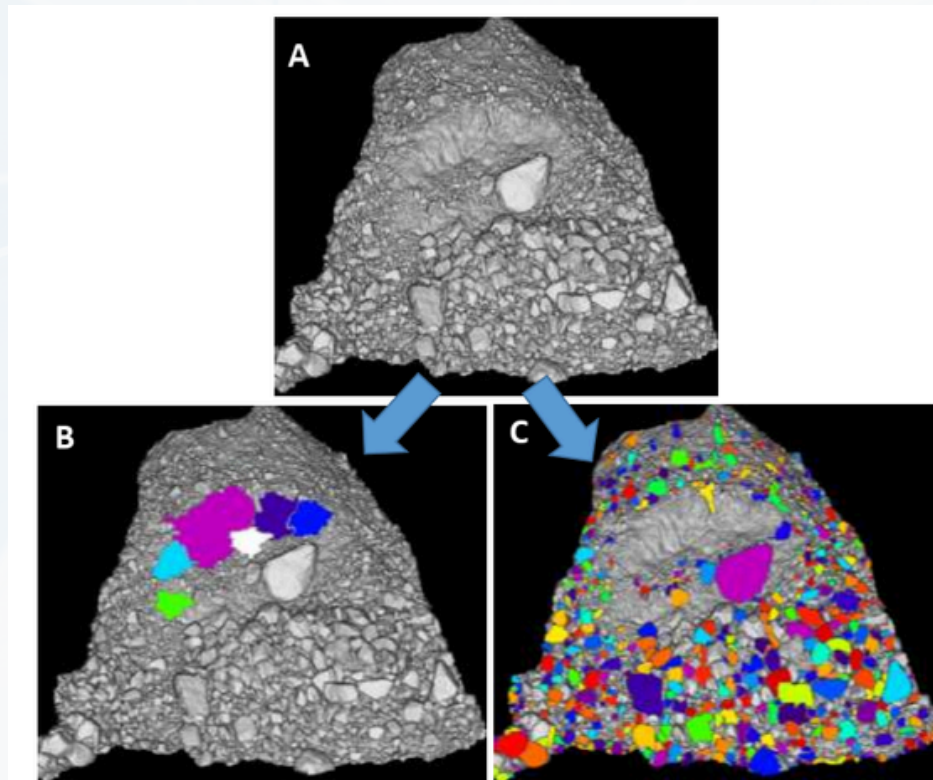
This technique uses a series of overlapping 2D images captured from different perspectives (angles) to reconstruct the 3D geometry of rock fragments through digital image processing and reconstruction algorithms.



# 3D image-based rock fragmentation analysis

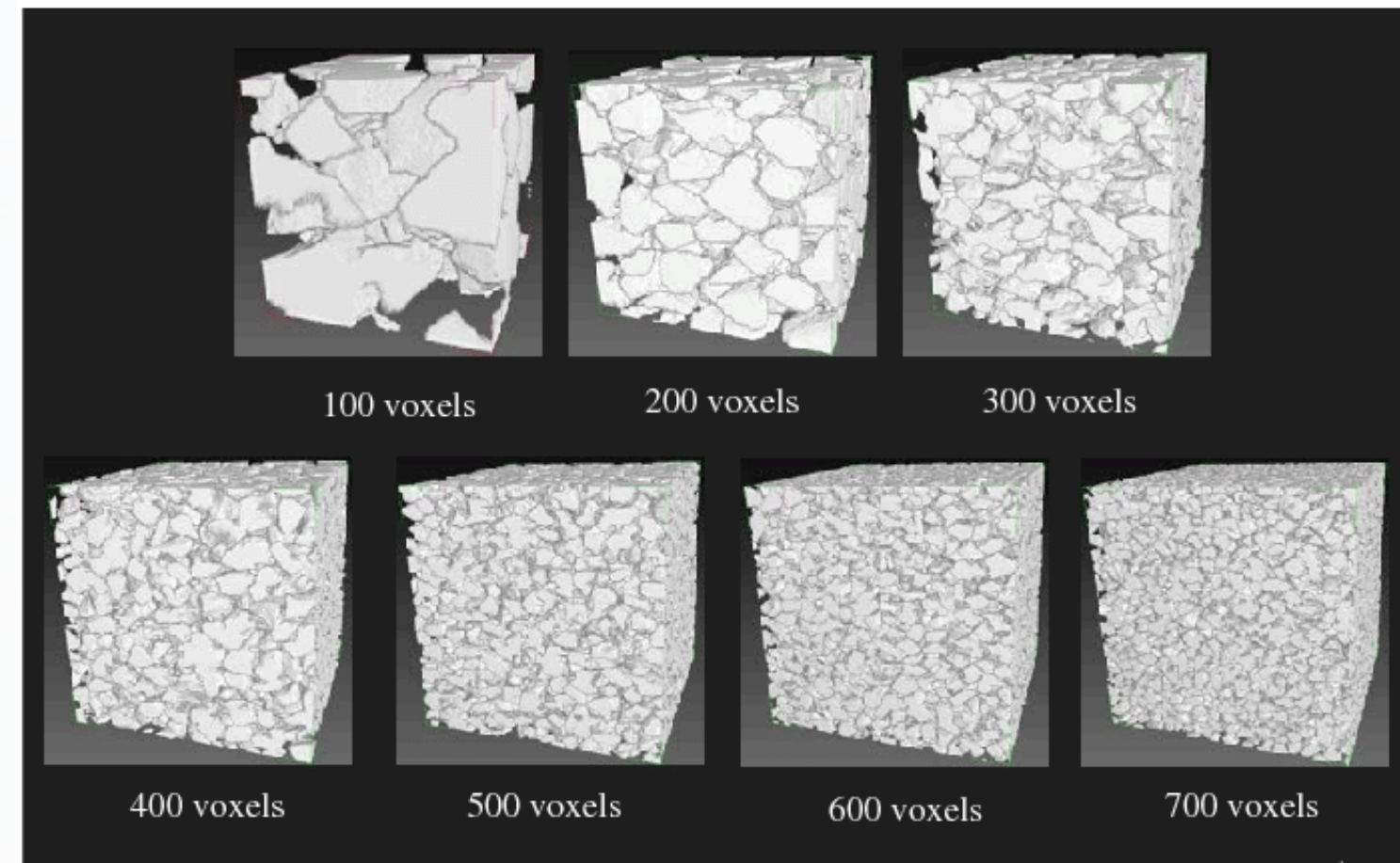
## 3D image capturing techniques

### a. Laser Scanning



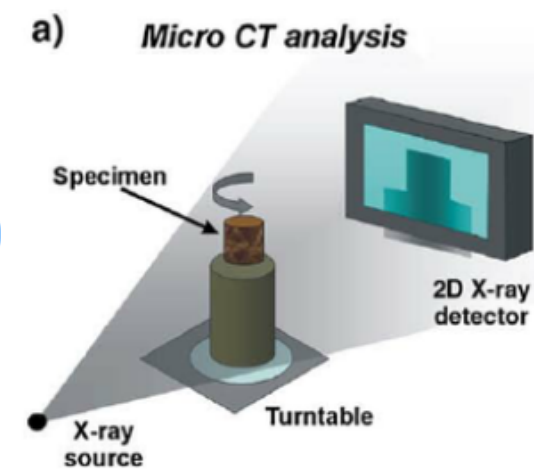
A.D. Campbell (2017)

### b. X-Ray computed tomography



Yoshihisa Miyata,

This non-destructive technique reveals the internal structure of objects.



Matthew Field

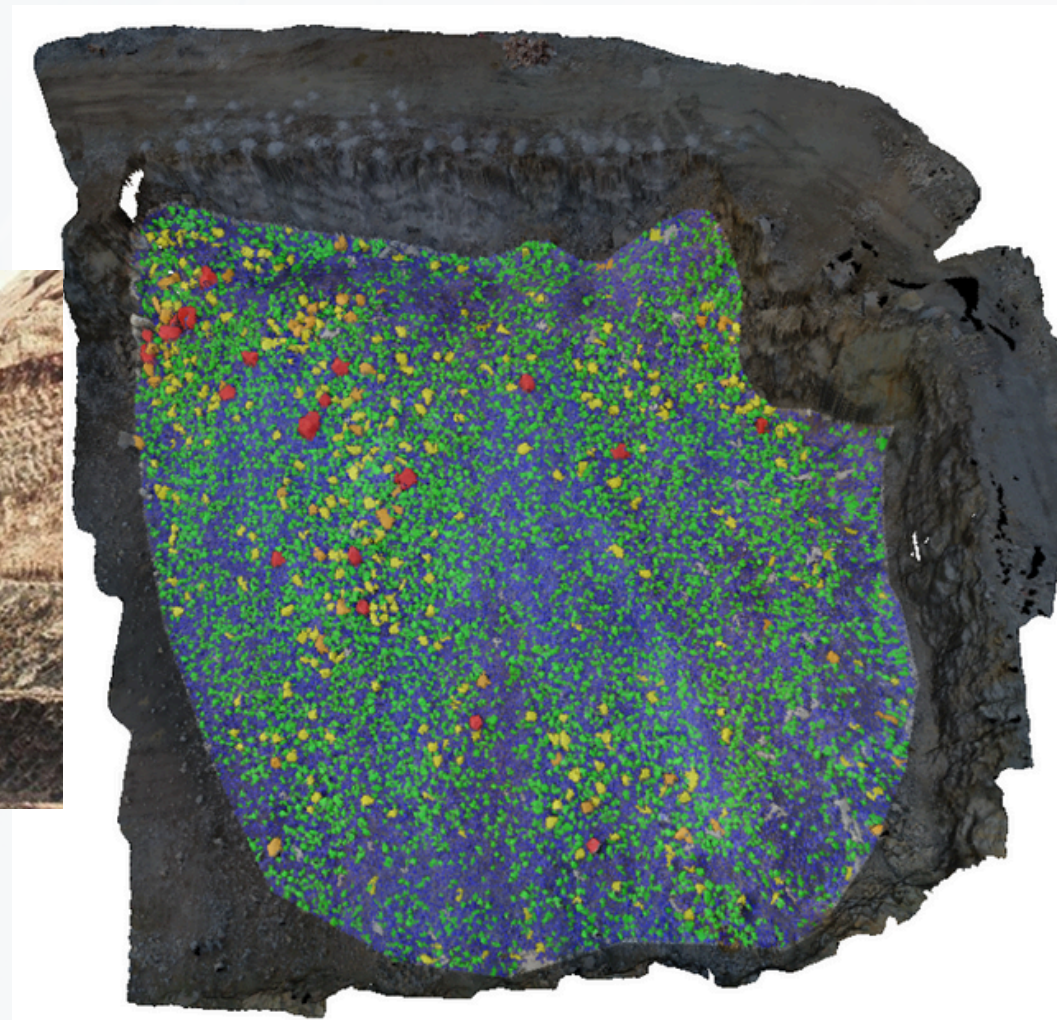
### c. Photogrammetry



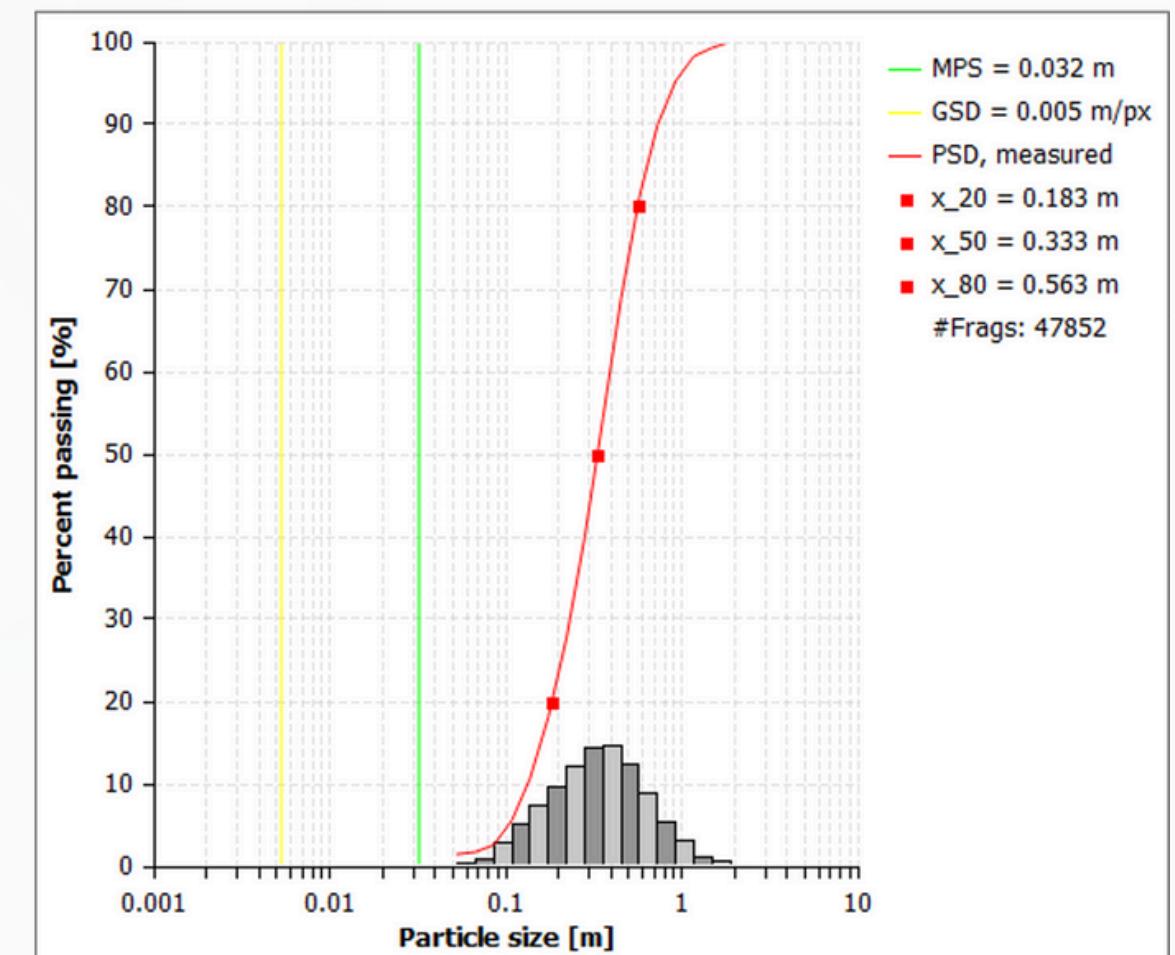
# 3D image-based rock fragmentation analysis

## 3D image capturing techniques

### c. Photogrammetry



[3gsm.at/blast-analysis](http://3gsm.at/blast-analysis)



From the images of muck pile, the software features the delineation of single particles on a 3D model by a combination of 3D surface analysis and 2D image analysis. For best Fragmentation Analysis: conduct multiple drone flights during loading.



# 3D image-based rock fragmentation analysis



Example: Drone for Fragmentation analysis (by Strayos)



# Benefits of 3D image-based Rock Fragmentation analysis

## **Improved Accuracy:**

Accurate measurement and characterization of rock fragments in 3D space

## **Enhanced Visualization:**

Clear visualization of rock size, shape, and distribution for detailed analysis.

## **Comprehensive Analysis:**

Quantification of fragmentation parameters such as size distribution, volume, and surface area.

## **Optimization Potential:**

Data-driven decision-making for blast design, explosives selection, and process efficiency improvements



# Challenges and Furture Directions

Challenges accosiated with implementing 3D image-based rock fragmentation analysis

- data processing
- equipment costs

Ongoing developments in the field

- automated analysis algorithms
- real time monitoring systems

- Improved Spatial Resolution and Scanning Speed
- Intergration with In-situ Experiments
- Multi-scal and Multi-modal Imaging
- Artificial Intelligence and Machine Learning
- Real-time Process Monitoring and Control:
- Multiphysics Modeling and Simulation
- Environmental and Sustainability Considerations



# Conclusion

- 01** 3D image-based rock fragmentation analysis offers improved accuracy and visualization.
- 02** Various techniques like photogrammetry, laser scanning, and CT are used for 3D imaging
- 03** Benefits include enhanced analysis capabilities and optimization potential
- 04** Real-life case studies demonstrate the effectiveness of 3D image-based analysis
- 05** adopting 3D image-based rock fragmentation analysis for better blasting outcomes and operational efficiency



# Question and Answer...



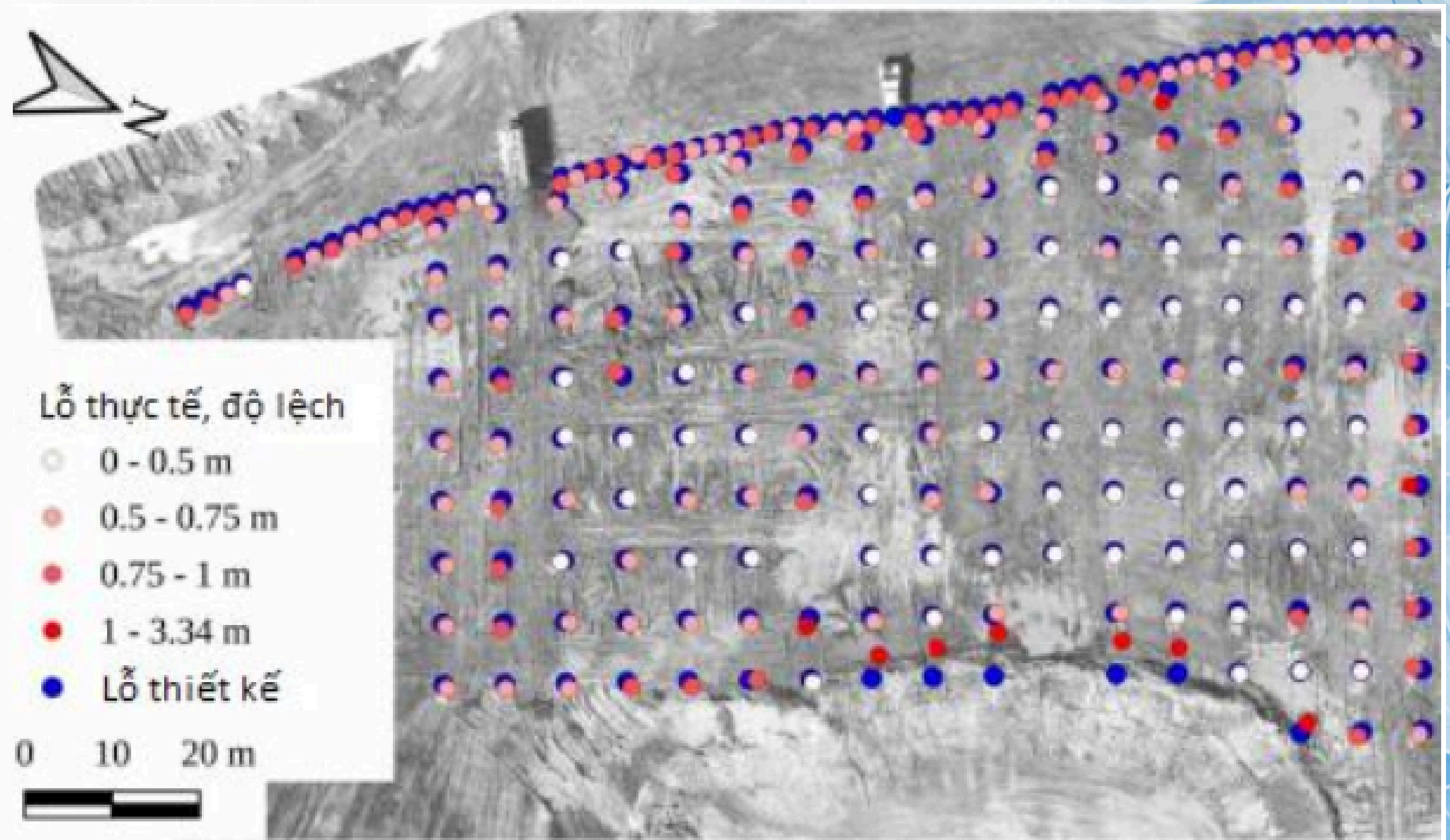




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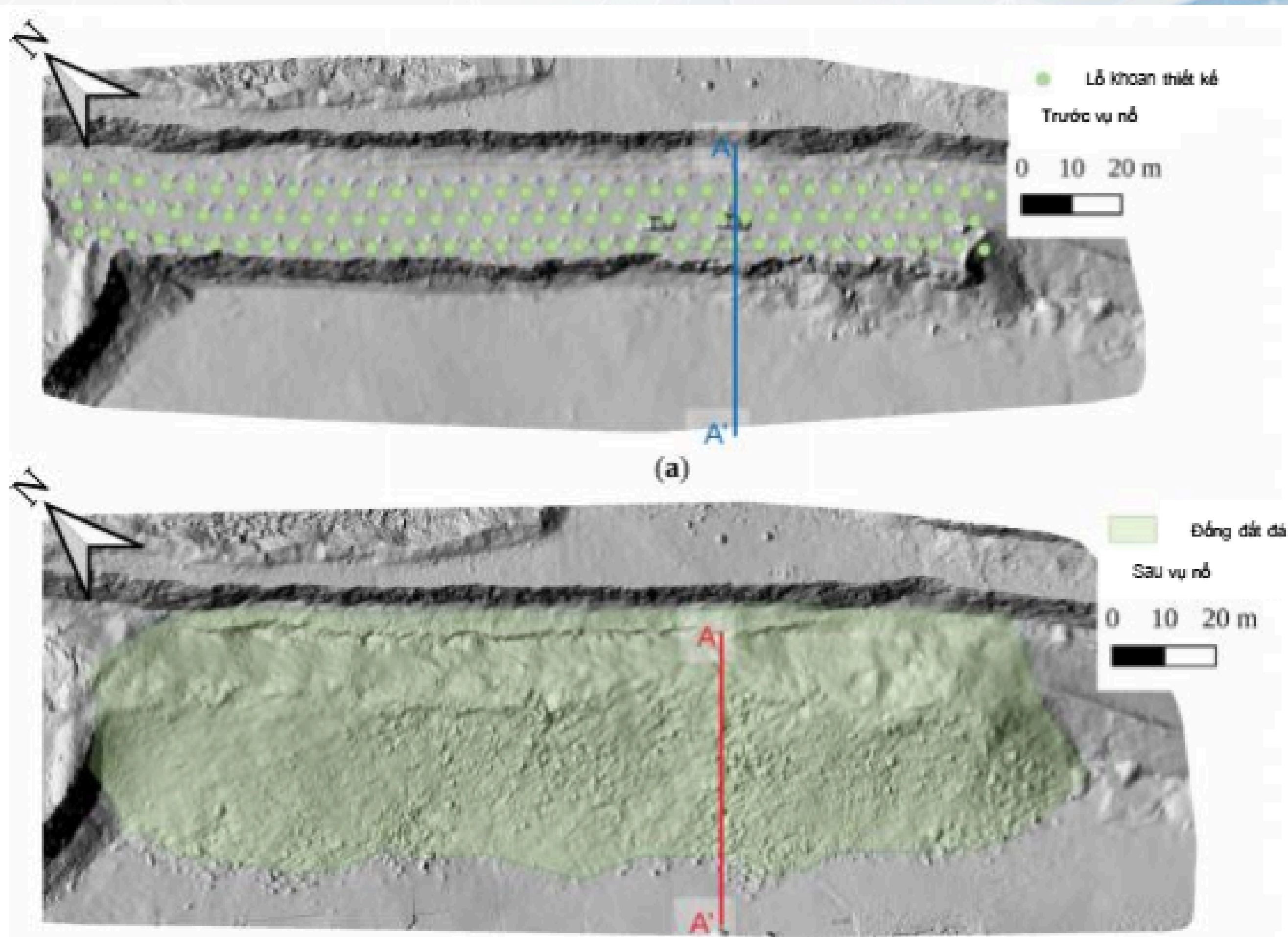
# Thank You !





Source: Airobotics





Source: Airobotics