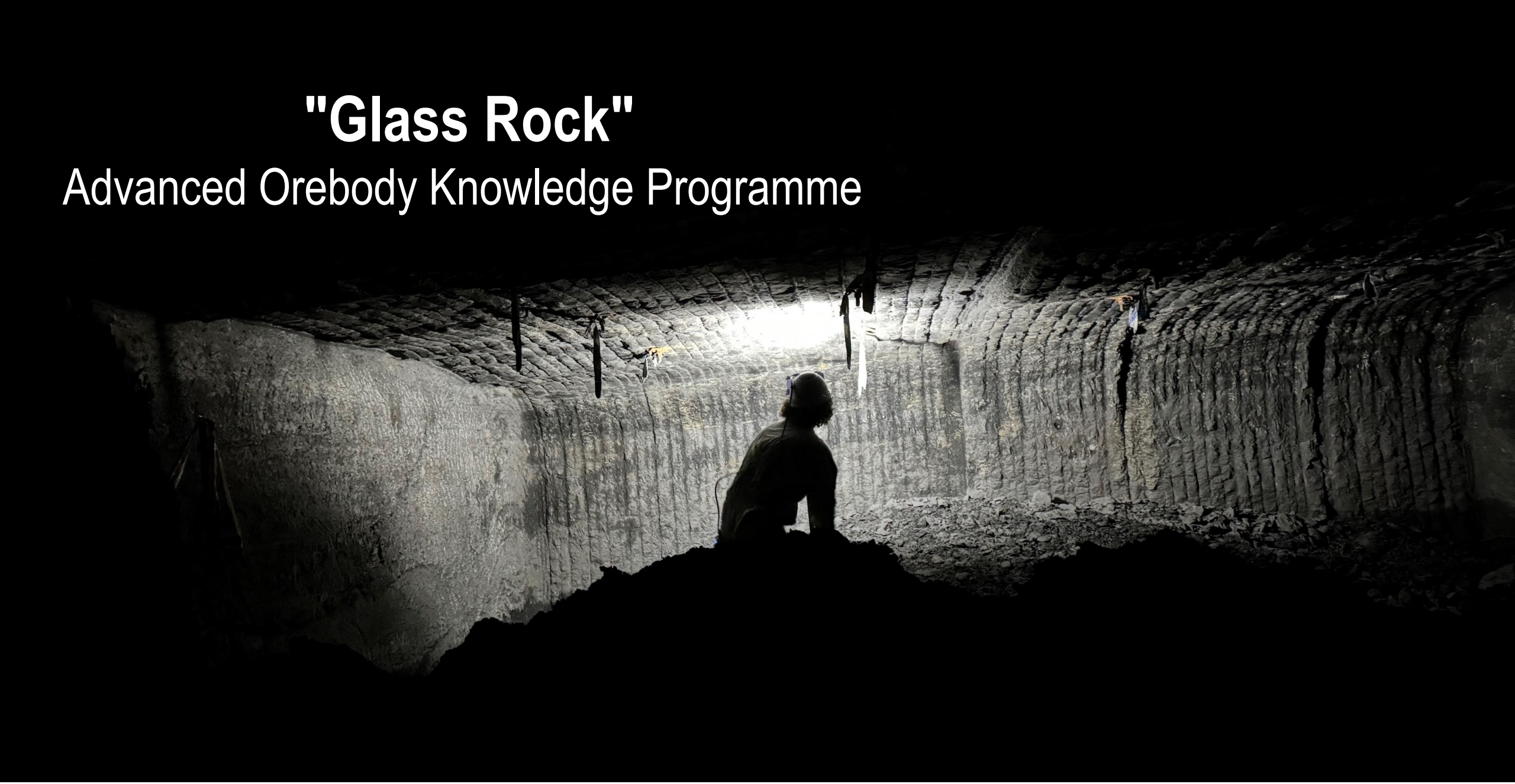
"Glass Rock"

Advanced Orebody Knowledge Programme



MINERALS COUNCIL SOUTH AFRICA

science, technology & innovation
Department: Science, Technology and Innovation
REPUBLIC OF SOUTH AFRICA

CSIR
Touching lives through innovation

MANDELA MINING PRECINCT
MINDS FOR MINES

Accelerating Mining RDI

Integrating Research Excellence with Mining Innovation

MANDELA MINING PRECINCT

MANDELA MINING PRECINCT
MINDS FOR MINES

The Mandela Mining Precinct facilitates and coordinates the implementation of the SAMERDI strategy and associated strategic initiatives in the minerals sector

SAMERDI MISSION

"To maximise the sustainable returns of South Africa's mineral wealth through collaborative research, development, innovation & implementation of mining technologies in a socially, environmentally and financially sustainable manner that is rooted in the local community and national economy."

- **Successful Application of Technologies Centred Around People** (SATCAP) - The aim of the SATCAP Programme is to understand the challenges, effects and impacts of mining modernisation on people in the minerals sector. **Dr Sherin Ramparsad**
- **Longevity of Current Mines** (LoCM) – Designed to increase the efficiency of ore reserve extraction, improvement in Occupational Health and Safety and the reduction in costs of current conventional mining operations. **Martin Pretorius**
- **Mechanised Mining Systems** (MMS) – providing sustainable mechanised drill, blast and mechanical rock breaking solutions in advancement to facilitate achieving zero harm, whilst maintaining and defending desired production rates at minimised costs, within the Au, and PGM mining industries. **Martin Pretorius**
- **Real Time Information Management Systems** (RTIMS) - Aims to develop and implement smart connected systems for mining from sensor to dashboard. **Marius Auret**

GLASS ROCK: REEF & HAZARD MAPPING AHEAD OF THE FACE

- **Advanced Orebody Knowledge** (AOK) – Aims to create the ultimate ''Glass Rock'' environment which includes improving geological confidence ahead of the face, reduction or identification of risks associated with geology & ultimately to have timeous information.

Smart Drill	*Further development of the ''Smart Drill'' which will include machine learning and optimisation of diamond drilling practices.*
Technologies ahead of the face	*A tool which can be used for mine design and planning. Further investigation and Development of plug-and-play software for geological data and analysis.*
Technologies on the face	*Technologies on the face which will include a sensor mounted console prototype development that can identify risk associated with Falls of ground.*
Research Dissemination	*Research dissemination which includes participating/presenting at the most applicable technical conferences which will include having work done peer reviewed and published.*

FALL OF GROUND ACCIDENTS

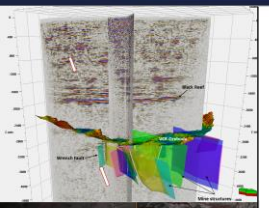
Fall of ground (FoG) accidents are one of the most dangerous hazards in mining, often resulting in injuries, fatalities, and financial losses. These incidents occur when rock or material detaches from the roof, sidewalls, or face of an excavation.

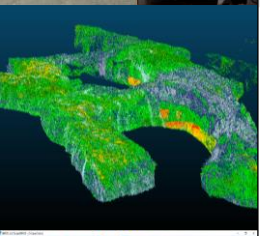
Causes:

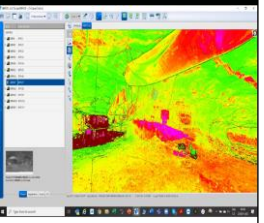
- **Geological Weaknesses** - faults, joints, dykes, bedding planes
- **High-Stress Conditions** - rock bursts due to mining-induced stress
- **Blasting-Induced Destabilisation**
- **Poor Ground Support** - insufficient bolting, netting, or backfilling
- **Water Ingress & Weak Rock Masses**

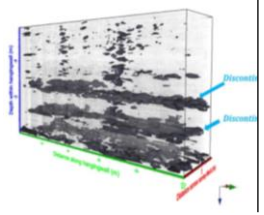
- The Advanced Orebody Knowledge Programme (AOKP) enhances subsurface visibility to mitigate these risks.
- This programme integrates geophysical, geological, and technological solutions for predictive safety measures.
- Improve underground rock mass visibility through data-driven approaches.

AOK TECHNOLOGIES









Geophysical and Remote Sensing

- **Tunnel Seismic Profiling (TSP) -** A geophysical method used in mining to detect geological structures ahead of the tunnel face, improving safety and mine planning
- **Ground Penetrating Radar (GPR) -** A geophysical technique used in mining to detect geological discontinuities, fractures, and lithological variations within the hanging wall and footwall.
- **Electric resistance tomography (ERT)**– Locates conductive weak zones and discontinuities
- **LIDAR** – Tracks subsidence and surface deformations.
- **EPEGS -** RTLS enhancing underground tracking with UWB technology, improving deployment, scalability, monitoring, and safety in mining.

Diamond Drilling and Sampling

- **The Smart Drill -** Improves underground drilling efficiency by enhancing accuracy and providing real-time geological data.
- **Laser-Induced Breakdown Spectroscopy (LIBS) is -** rapid chemical analysis technology used in mining to assess platinum and gold grades, helping improve ore characterization and resource evaluation.
- **X-ray Diffraction (XRD) and X-ray Fluorescence (XRF) -** analytical techniques used in mining to determine mineral composition and elemental content, aiding in ore characterization, grade control, and processing efficiency.

Data/AI/ML

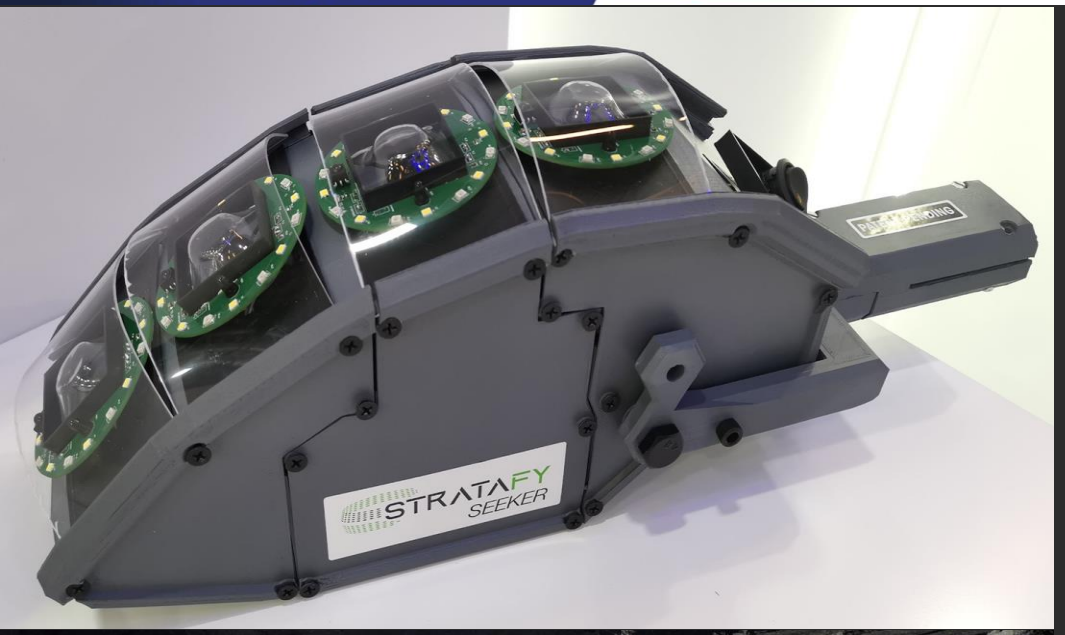
- **Statistical analysis and machine learning -** were used to predict potholes, ore grades, and geological structures ahead of the mining face.
- **AI in Smart Drilling -** Development of an intelligent diamond drill rig with AI-driven real-time data processing.
- **AI -** Rock Hazard Identification (ITAD & Stratafy Seeker)
- **AI in Geophysical Data Integration**: - AI-assisted data fusion integrates multiple technologies like GPR, LiDAR, Seismic Profiling, and ERT to build high-resolution 3D model.

STRATAFY SEEKER

For *Assisted RISK IDENTIFICATION*

BY: ***STRATAFY SOLUTIONS***

STRATAFY SEEKER



AIM

- A system that allows real-time monitoring
- Pro-active warning of unsafe environments and possible hazards at the face
- Integrated scanning hardware and software for reef identification
- Support quantification
- Identify geological structures on the face
- Optimise lighting and camera layout
- Need to be user friendly
- Need to be able to scan the side-wall and hanging-wall
- Scanning difficult areas
- Easily adoptable by any individual

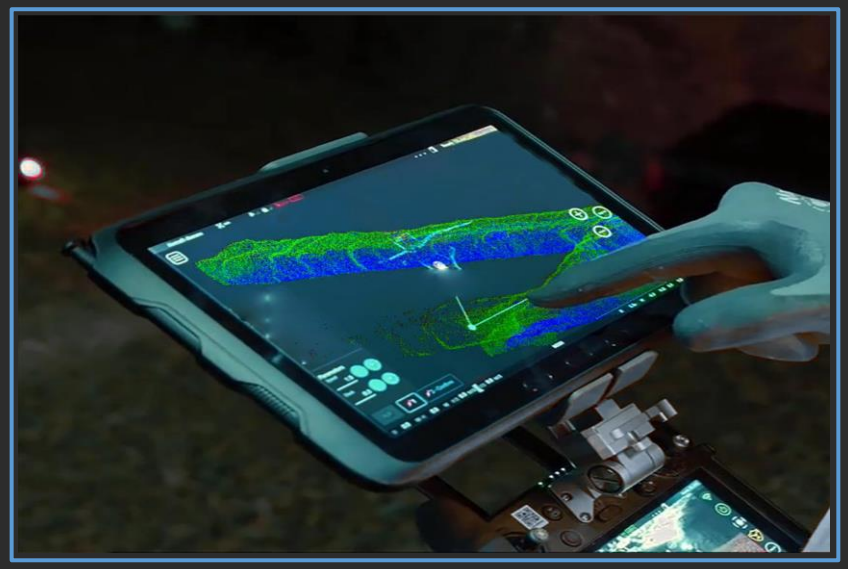
STRATAFY

STRATAFY SEEKER

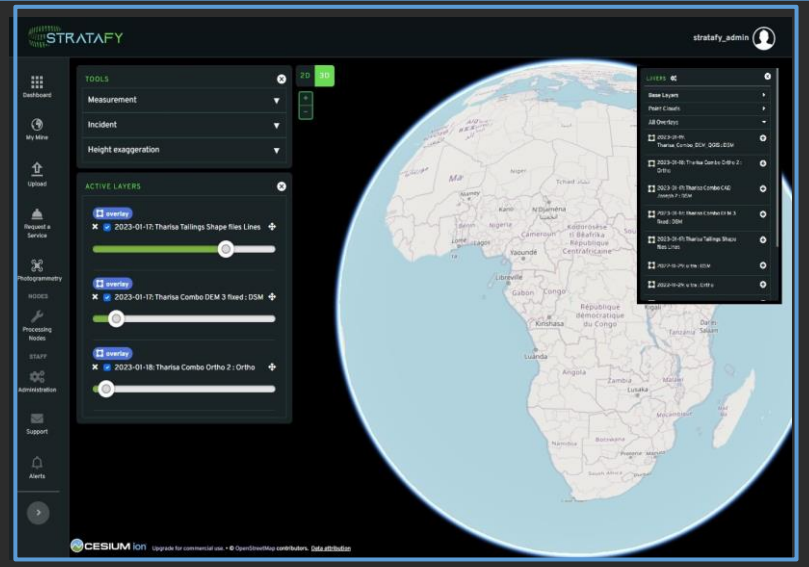
Completed (With Continuous Development)

Part 1:
The SEEKER Scanning Head

Initiated on both Part 1 & Part 2



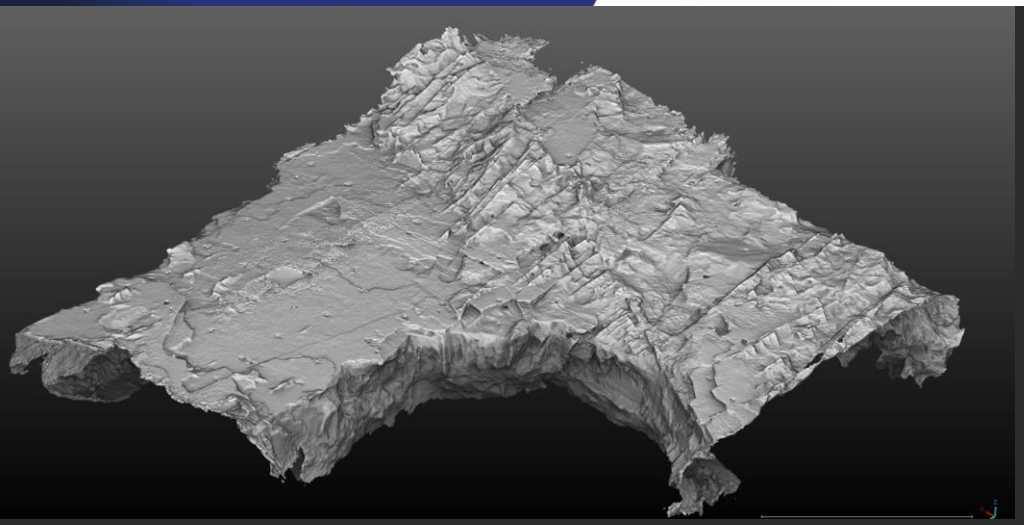
Part 2:
Processing Pod with Display Screen (Handheld Device)

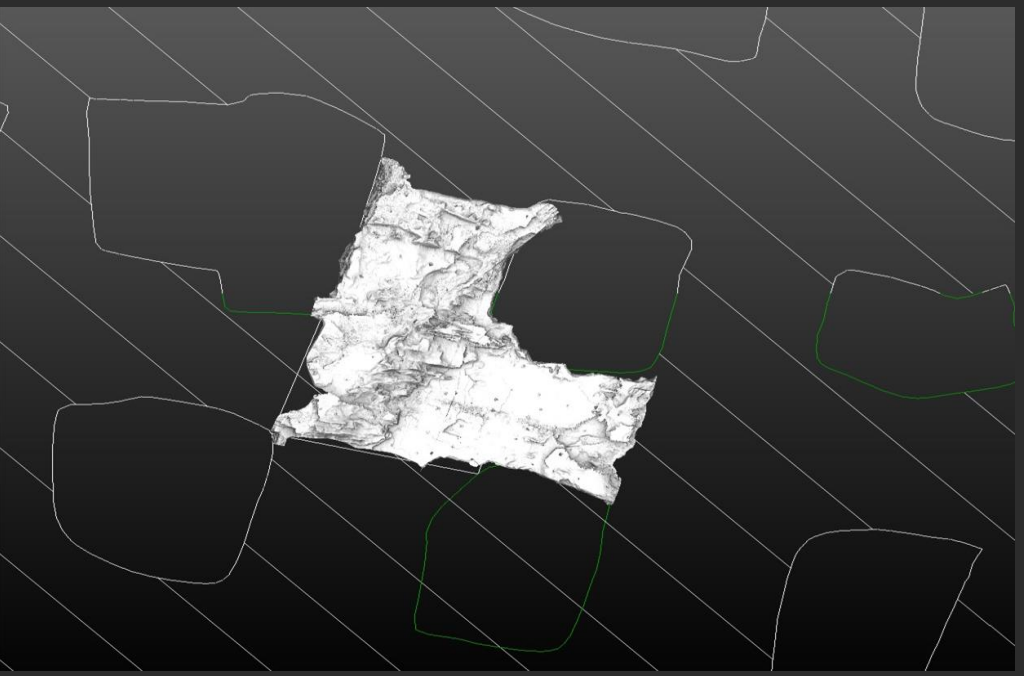


Part 3:
Cloud Computing Platform (Stratafy)

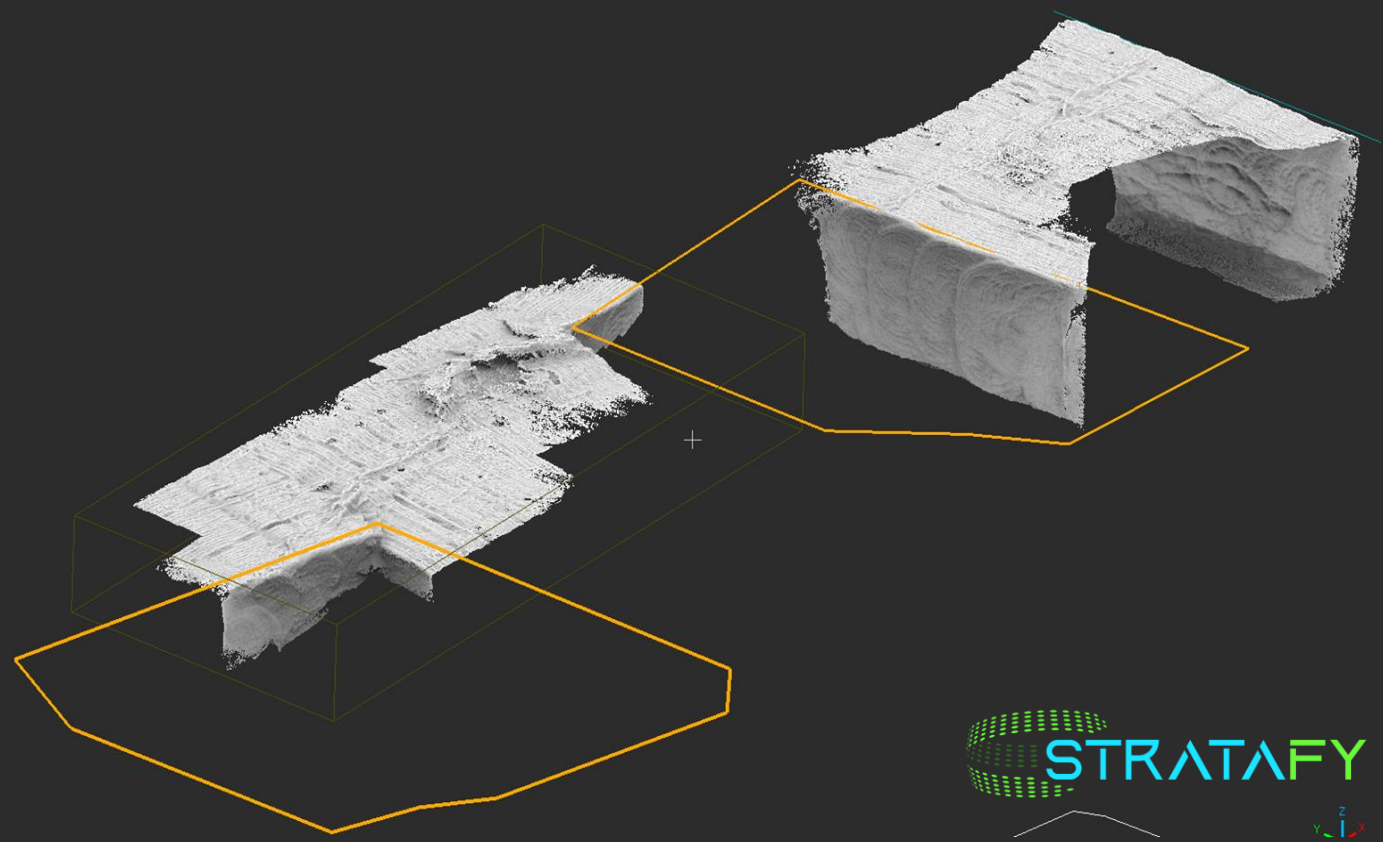
STRATAFY

STRATAFY SEEKER - GEOREFERENCING



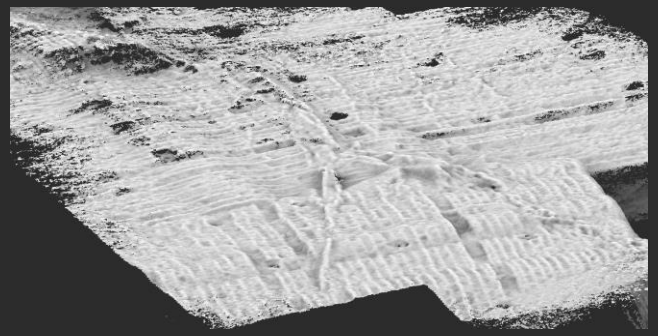


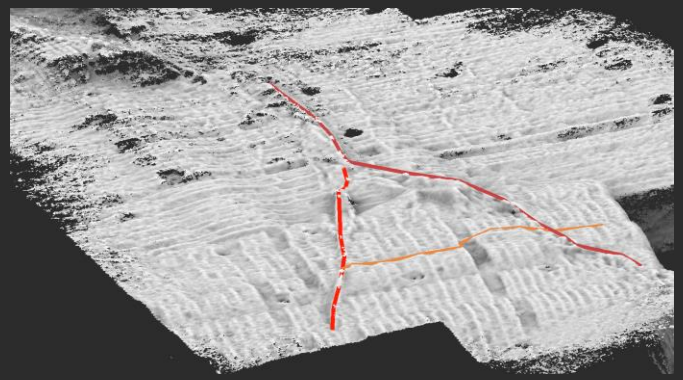
- Point cloud is georeferenced and scaled into CAD
- High resolution and small details can be identified

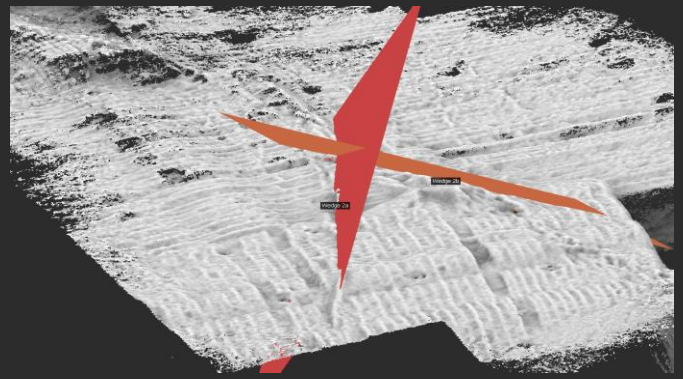


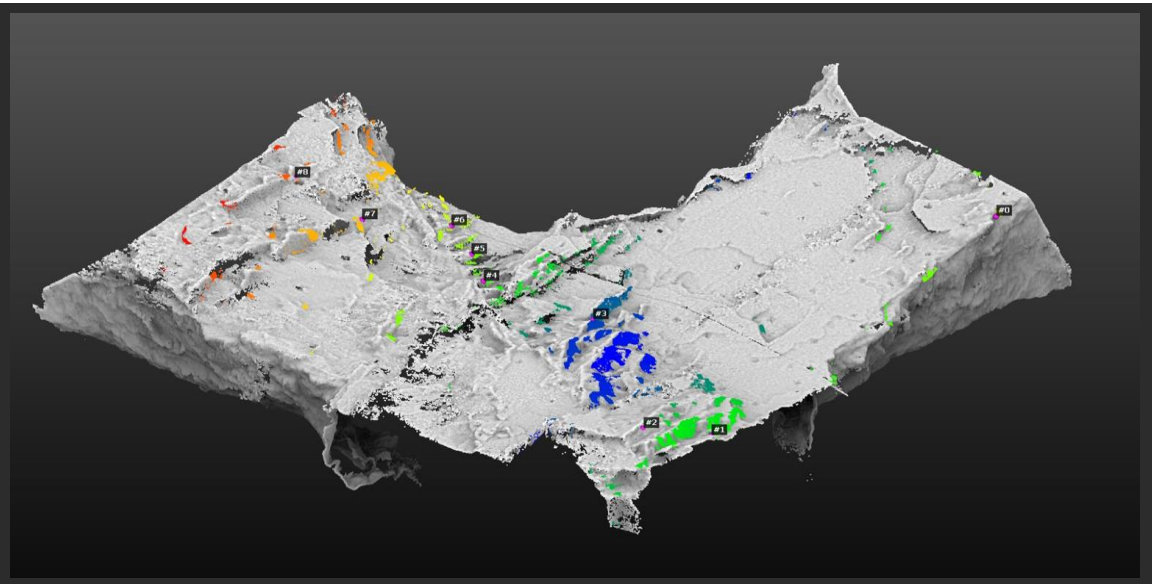
STRATAFY

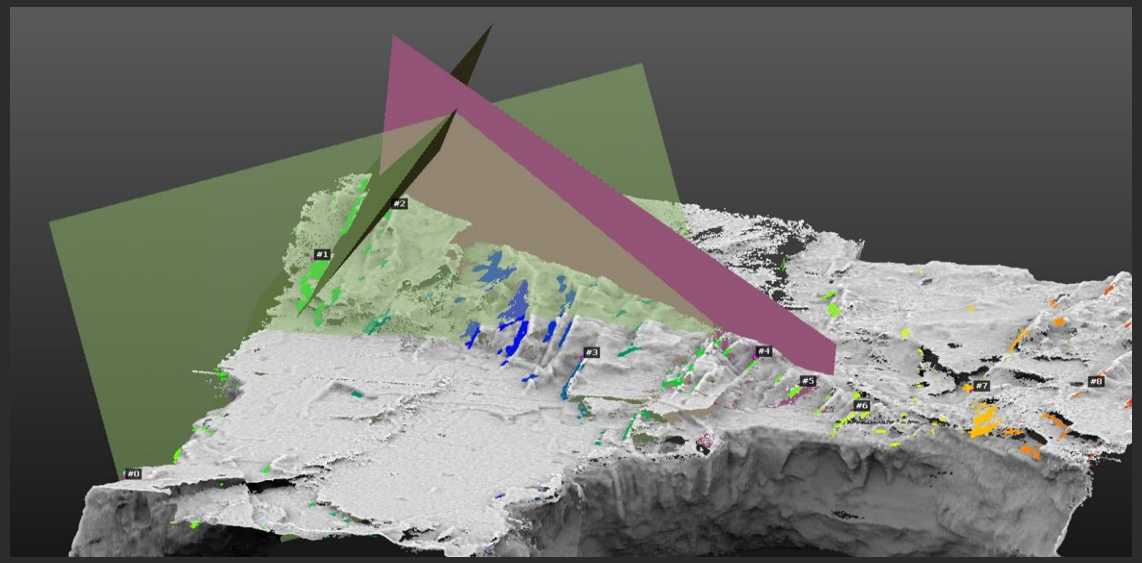
STRATAFY SEEKER – DISCONTINUITIES











STRATAFY

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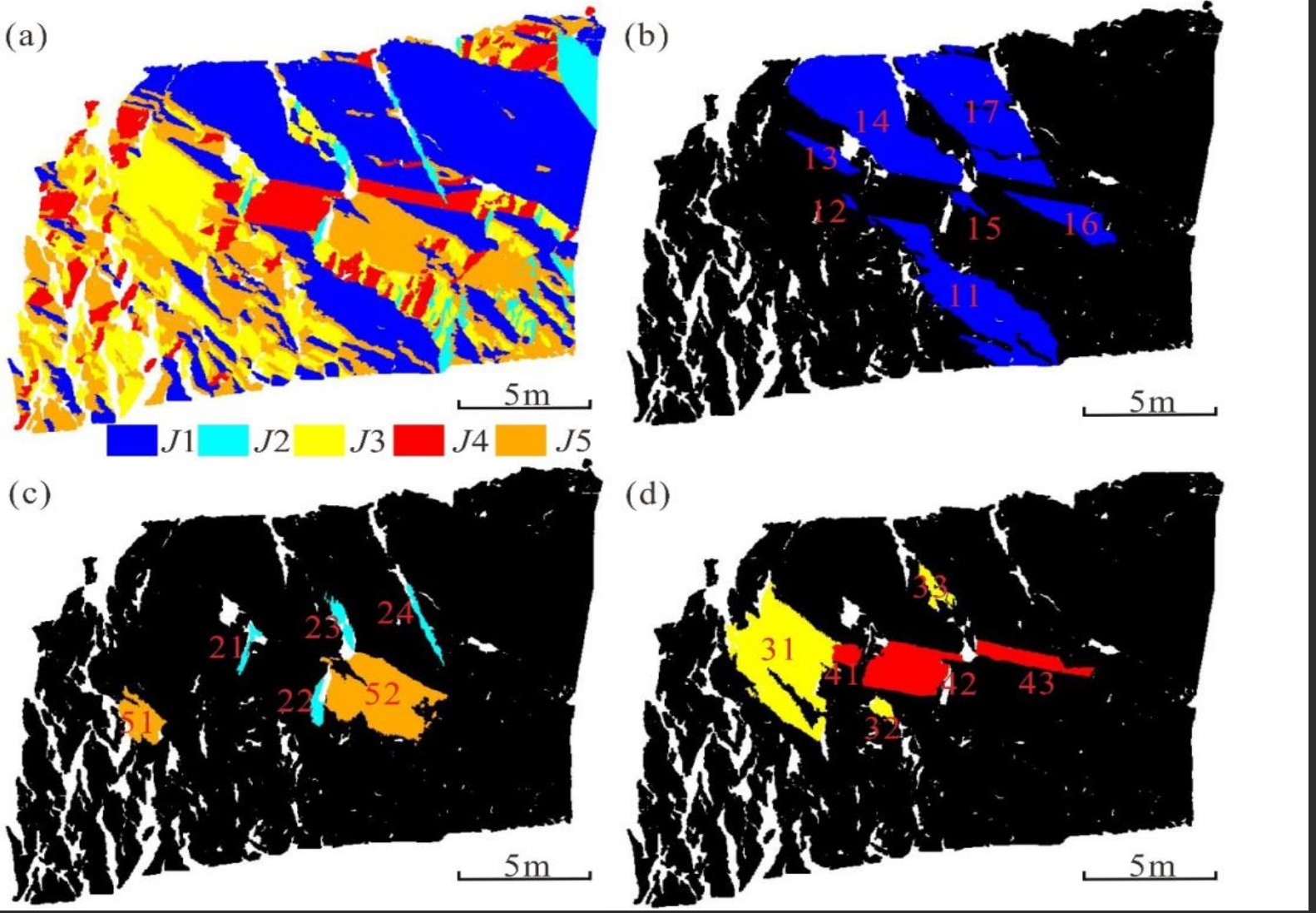
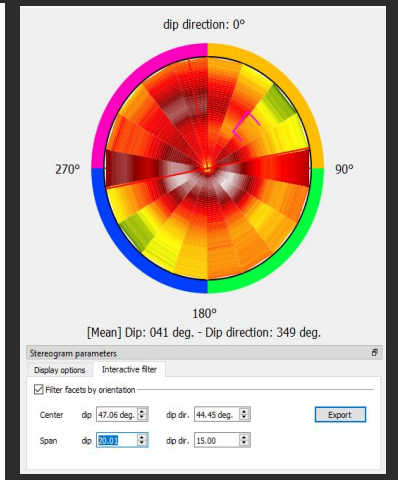
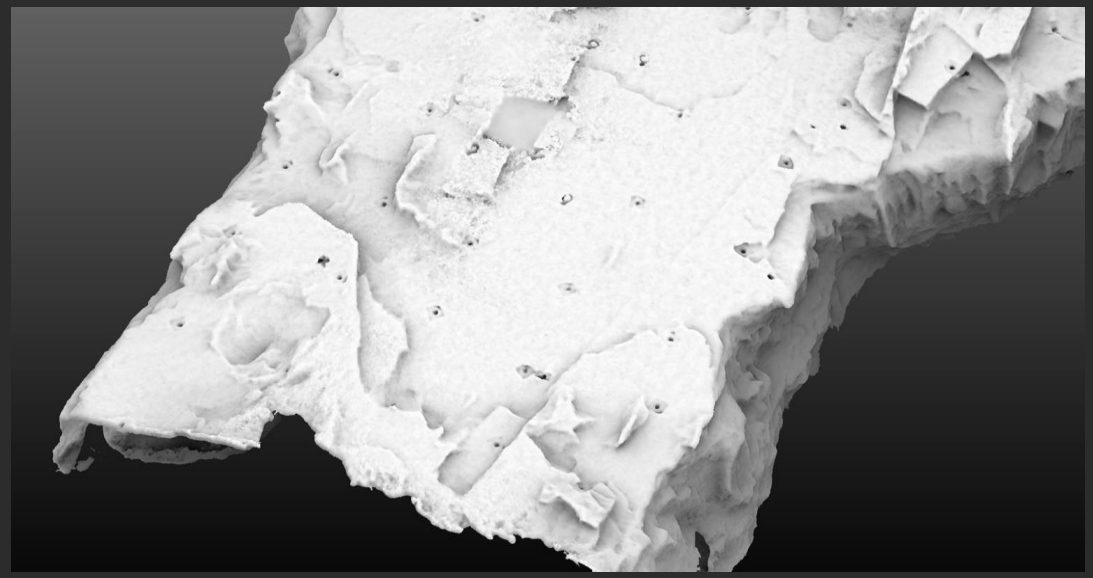
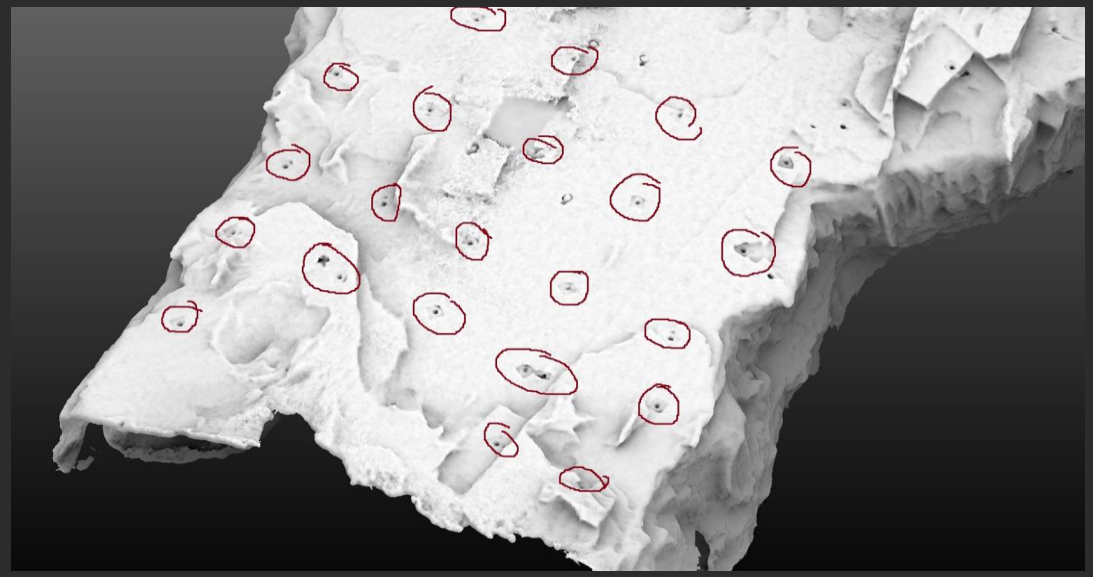




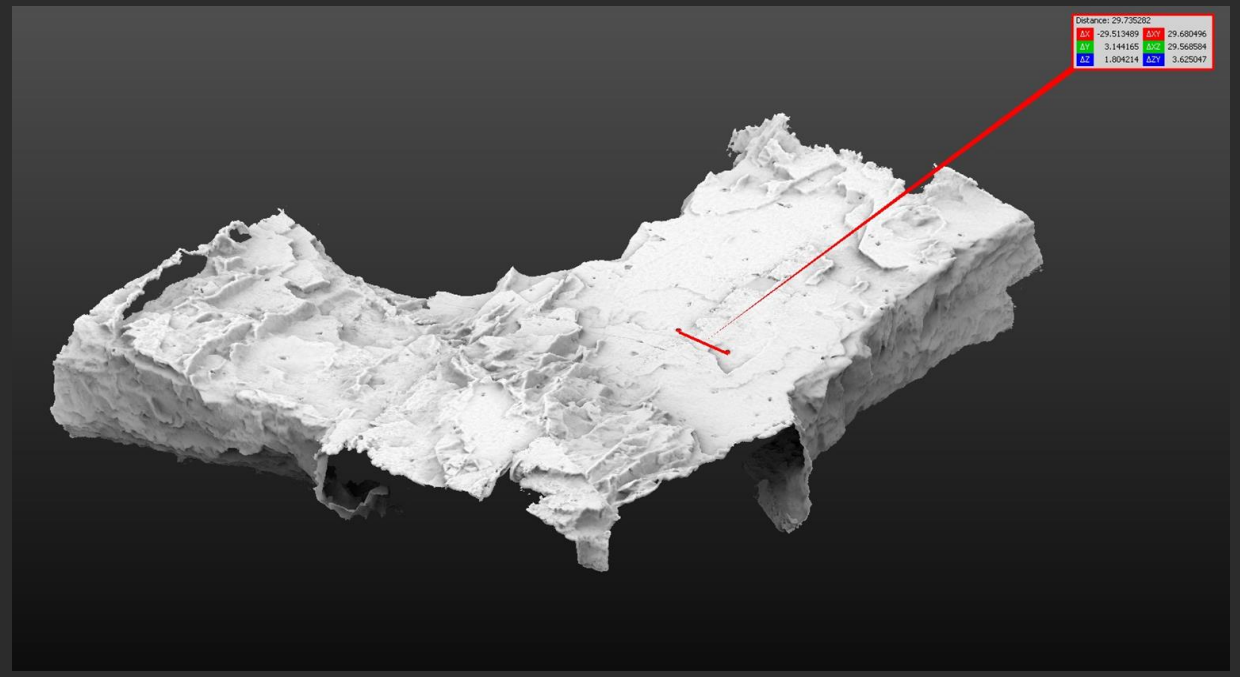
STRATAFY

STRATAFY SEEKER – SUPPORT MEASUREMENTS



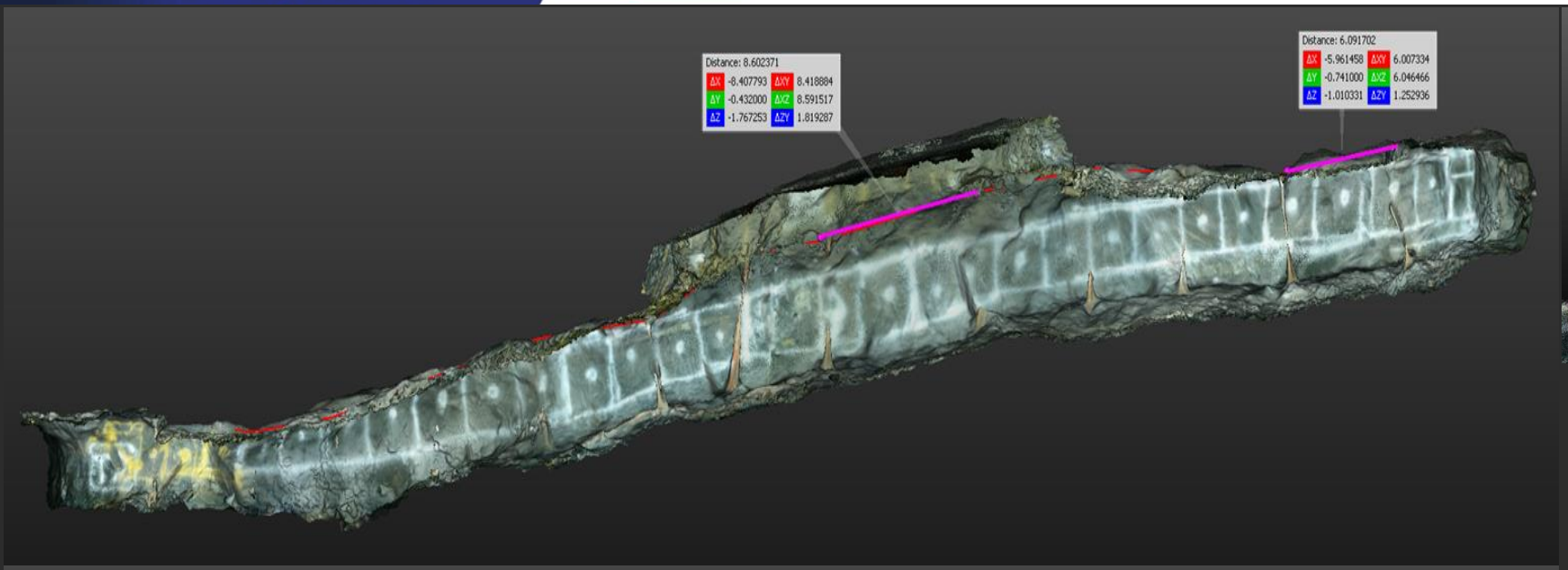


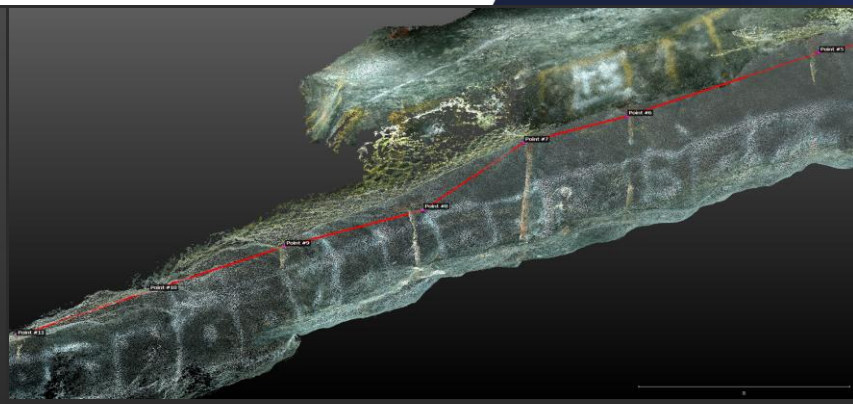
- Able to digitally identify roofbolts based on the 3D model
- Can measure support spacing and placement

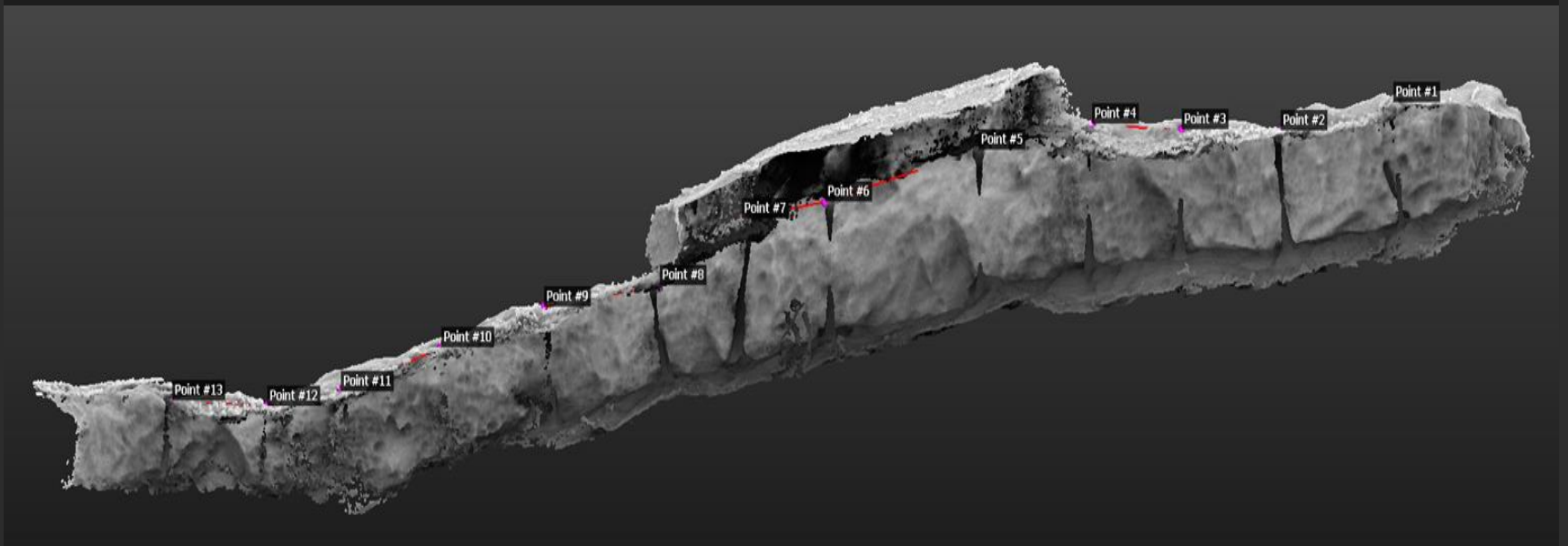


STRATAFY

STRATAFY SEEKER – SUPPORT MEASUREMENTS



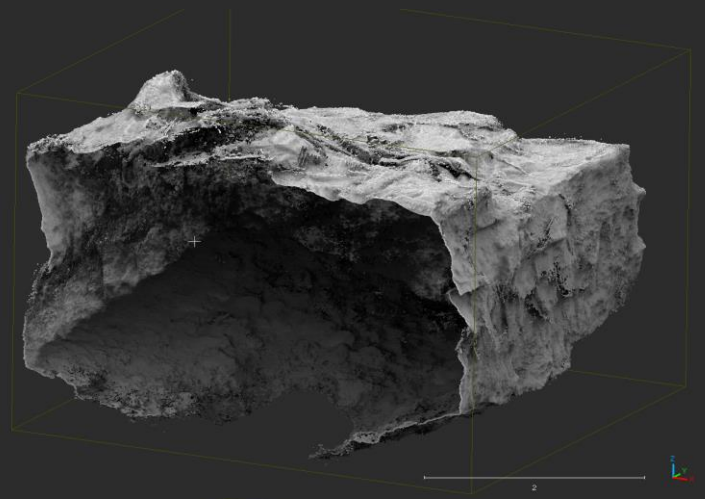


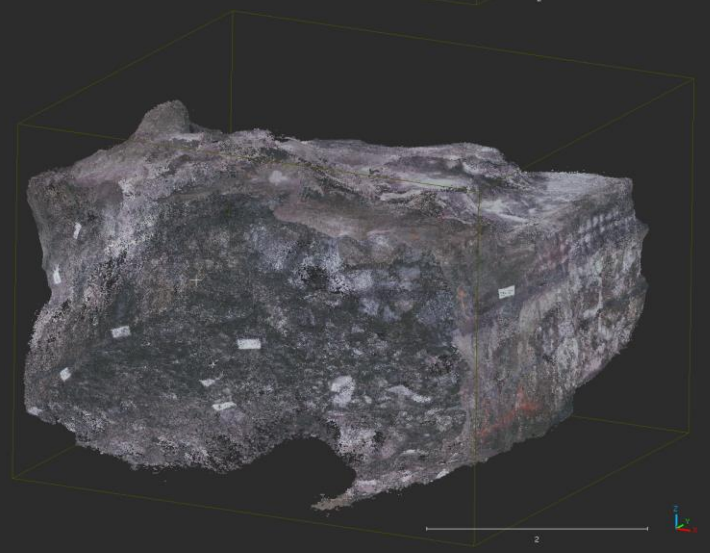


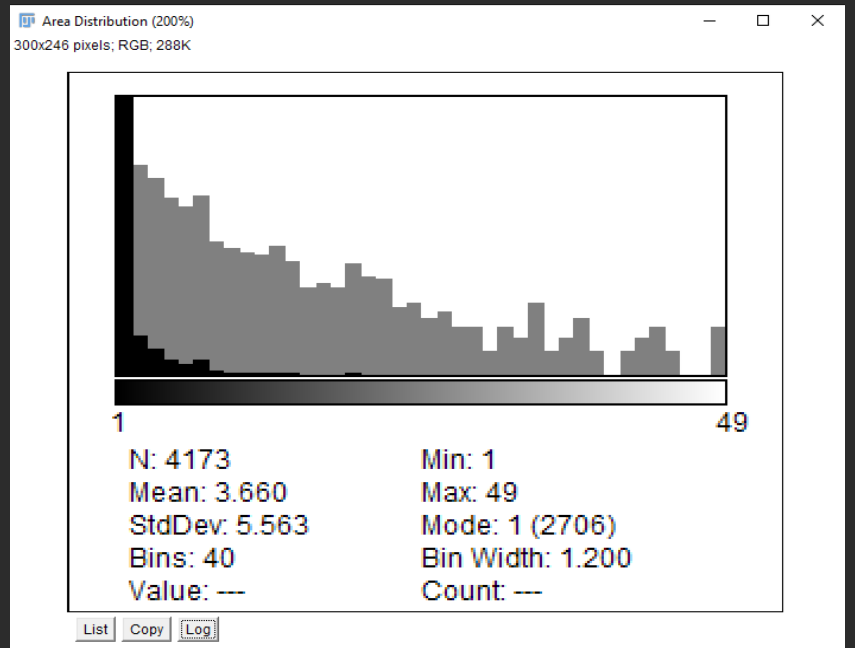
- Total face length can be plotted
- Distance of support can be measured
- Alignment of temporary support can be measured

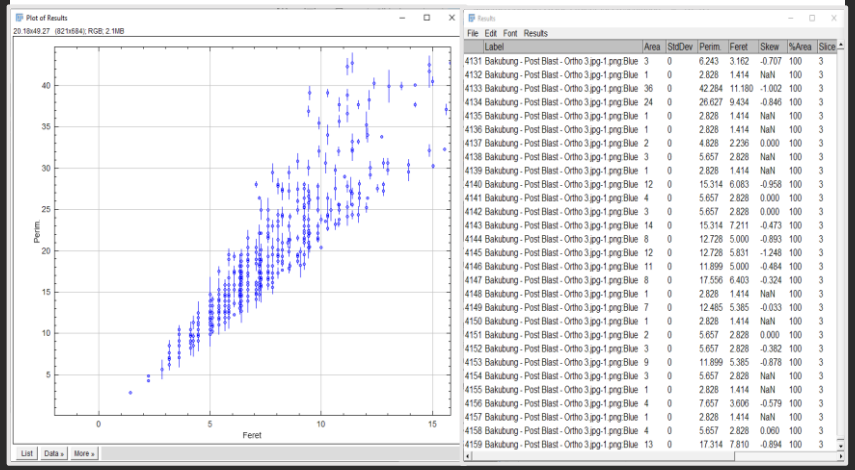
STRATAFY

STRATAFY SEEKER – FRAGMENTATION





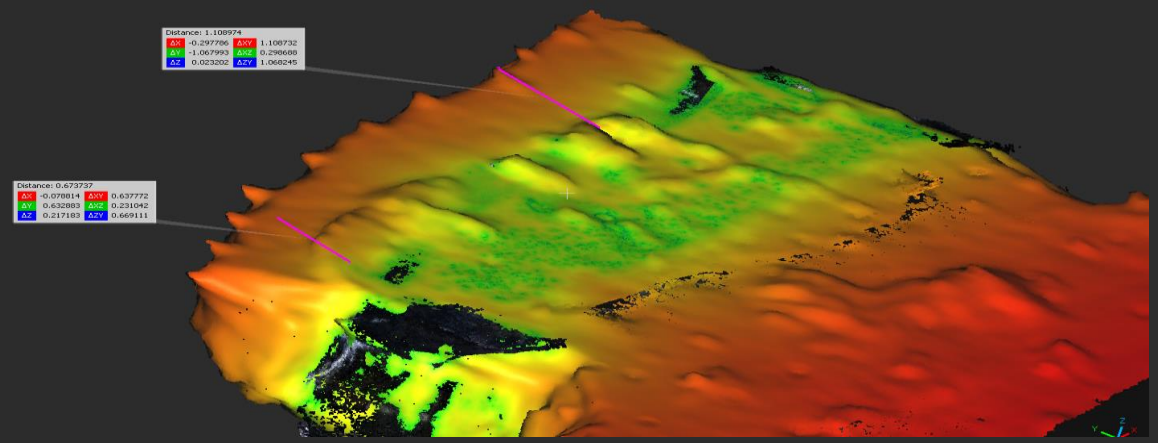


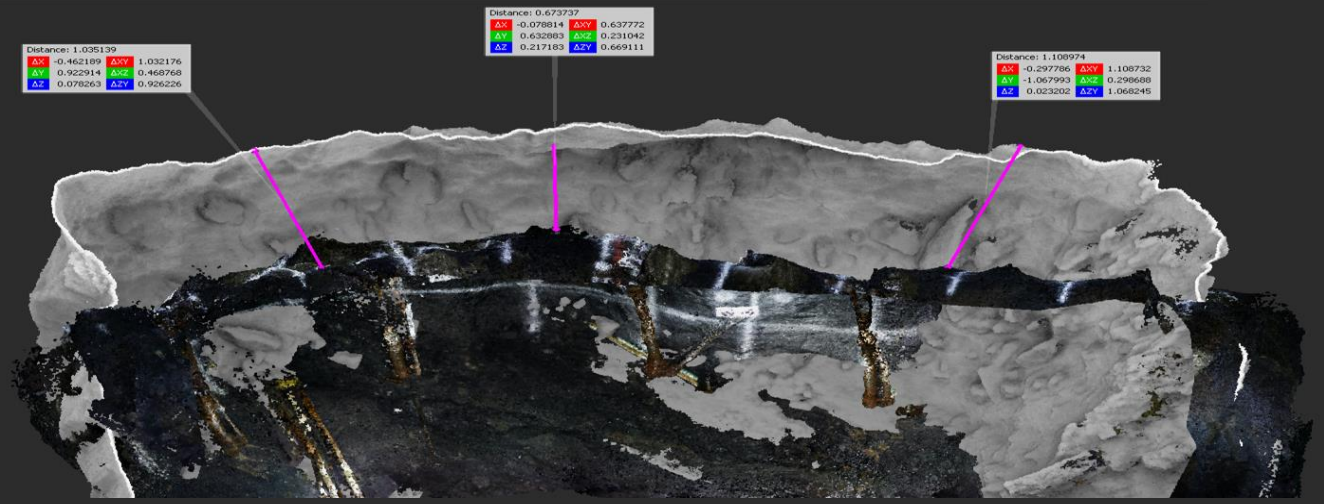


STRATAFY

STRATAFY SEEKER – VOLUMETRIC

- Volumetric difference during pre-and post –Blast study between shifts

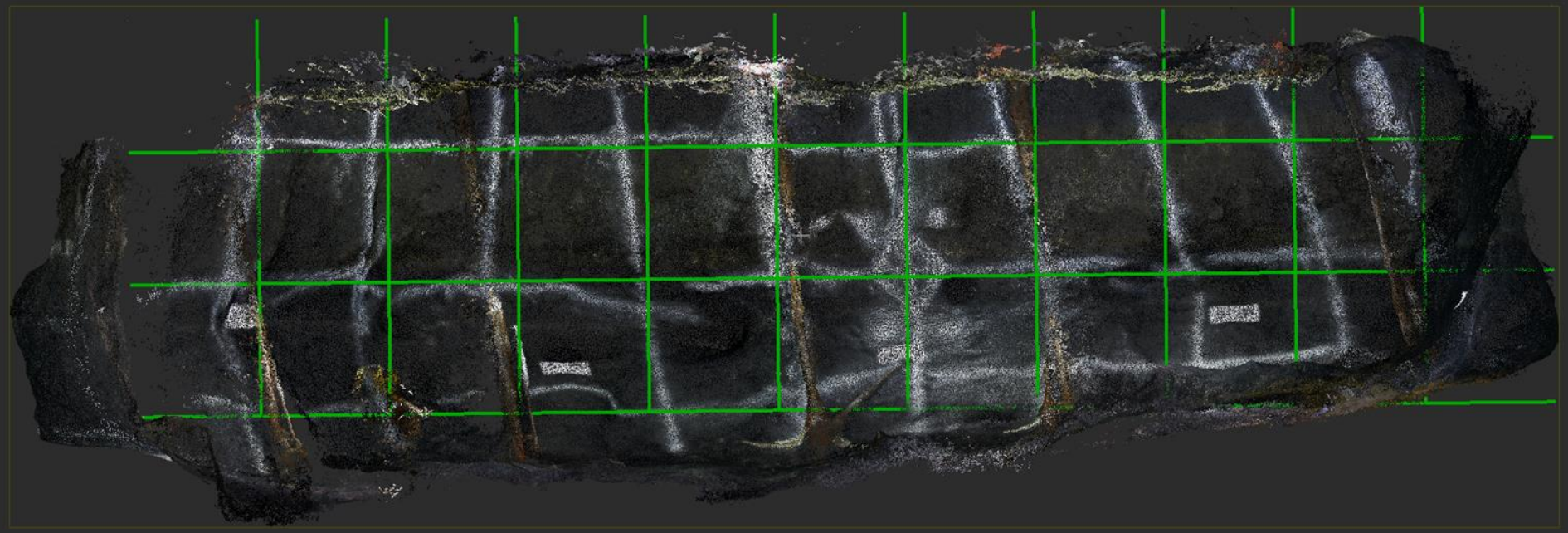


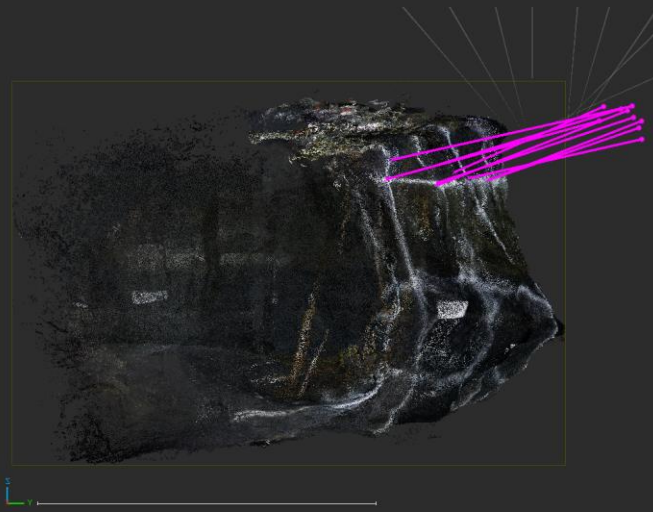


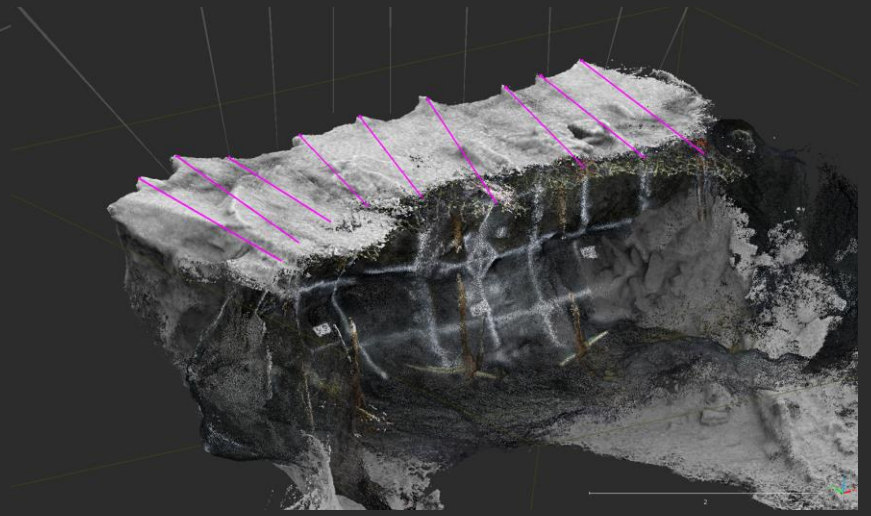
STRATAFY

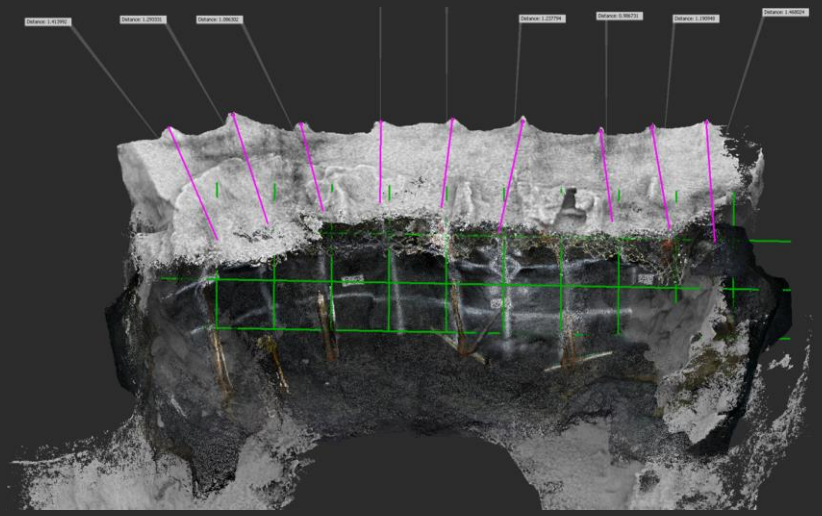
STRATAFY SEEKER – DRILLING PRACTICES

STRATAFY

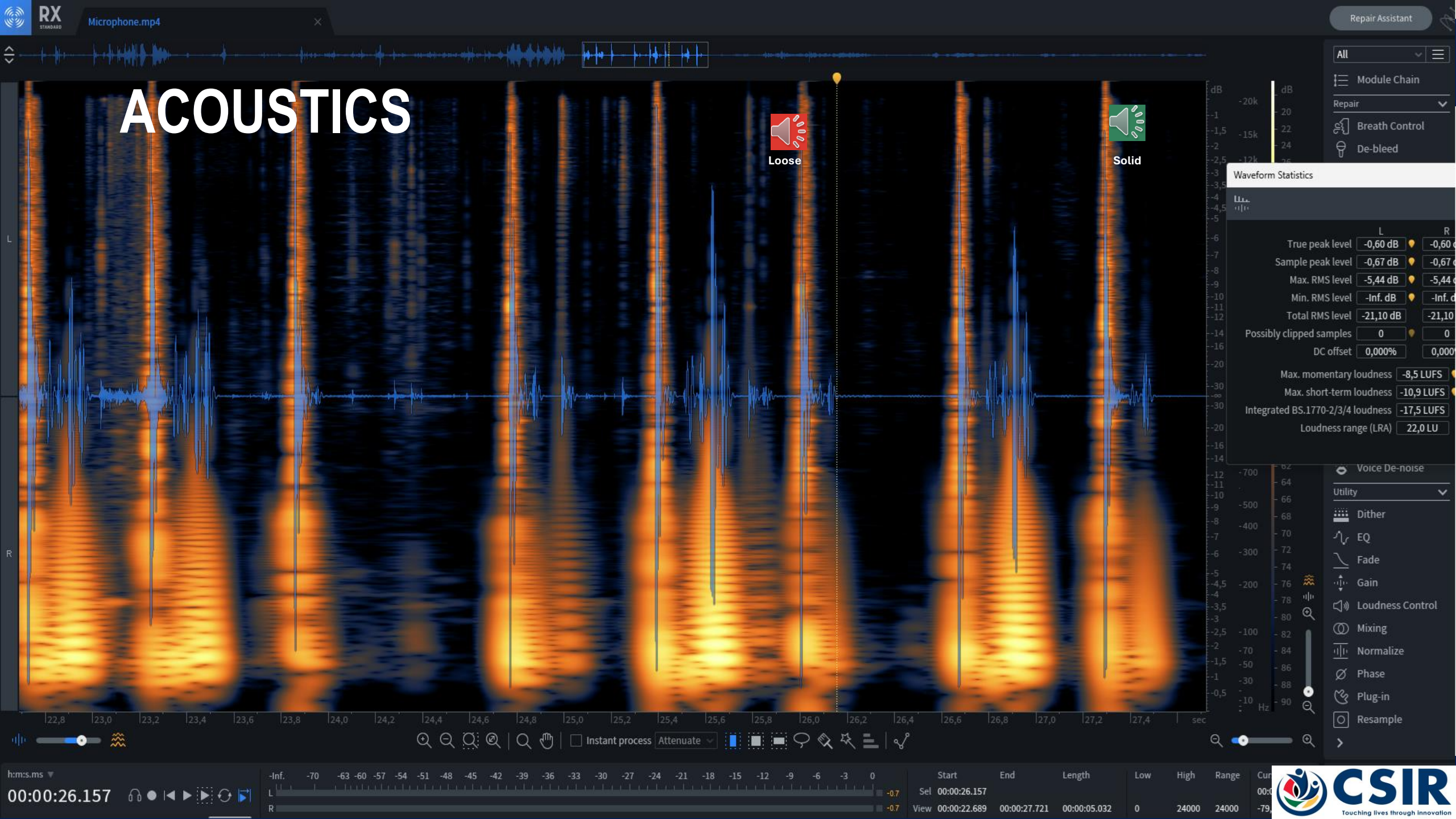








Next steps – Near Real-Time Feedback to User


RX STANDARD
Microphone.mp4
Repair Assistant
ACOUSTICS
Loose
Solid
All
Module Chain
Repair
Breath Control
De-bleed
Waveform Statistics
L
R
True peak level -0,60 dB -0,60
Sample peak level -0,67 dB -0,67
Max. RMS level -5,44 dB -5,44
Min. RMS level -Inf. dB -Inf.
Total RMS level -21,10 dB -21,10
Possibly clipped samples 0 0
DC offset 0,000% 0,000
Max. momentary loudness -8,5 LUFS
Max. short-term loudness -10,9 LUFS
Integrated BS.1770-2/3/4 loudness -17,5 LUFS
Loudness range (LRA) 22,0 LU
Voice De-noise
Utility
Dither
EQ
Fade
Gain
Loudness Control
Mixing
Normalize
Phase
Plug-in
Resample
Instant process
Attenuate
h:m:s.ms
00:00:26.157
Start
End
Length
Low
High
Range
Sel 00:00:26.157
View 00:00:22.689 00:00:27.721 00:00:05.032 0 24000 24000
CSIR
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ACOUSTICS

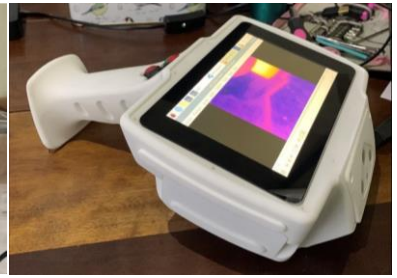
ESD V1.0 – ELECTRONIC SOUNDING DEVICE (ESD)

- Mounted on hardhat
- Lightweight and portable
- Audible beeps communicate with miner
- Not very user-friendly
- Entered license agreement which did not work out.
- Still maintain IP

ITAD V2.0 – INTEGRATED THERMAL ACOUSTIC DEVICE

- Increased haptic feedback and user-friendliness
- Portable handheld device
- Not trialed or tested in a mine
- Hardware specific design
- Limitations on computation

ITAD V3.0 – INTEGRATED THERMAL ACOUSTIC DEVICE



- Larger screen
- More computational capacity
- Increasing field-of-vision for thermal image.
- More interoperable
- Tested underground – focused on PGM environment
- Thermal studies unsuccessful Device unreliable in the underground environment
- General good results

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ACOUSTICS

Acoustics – A branch of physics concerned with the properties of sound

Device: Use a recording device with high quality audio capability, visual media functionality and strike force measurement to record sounding parameters.

iPhone (iOS) vs. Android

Data Collection Environment:

On-reef at the beginning of the shift – low noise

Pinch Bar, Sounding Position and Rock Type as input parameters

Algorithm Development:

Primary focus and desired outcome of this project – new algorithm

Safe versus unsafe data samples – build balanced data set

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ACOUSTICS

DATA COLLECTION

The setup of the iPhone for data collection was configured and tested on surface at CSIR campus. Two iPhones where used underground

TECHNICAL DEVELOPMENT AND TESTING

The data from underground trial is used as it comes for technical development towards refining the algorithm.

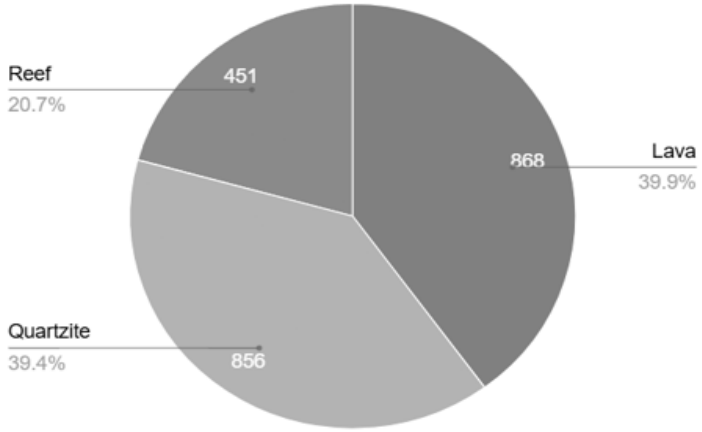
PRELIMINARY DEMONSTRATION

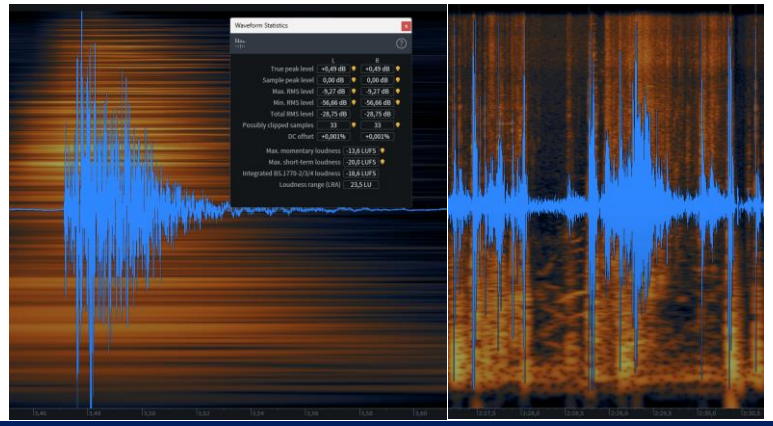
As more data get incorporated into the algorithm, the working algorithm will be demonstrated to the stakeholders

ACOUSTICS

	Lava		Quartzite		Reef	
2024	252 loose	272 solid	105 loose	54 solid	68 loose	105 solid
2025	118 loose	226 solid	401 loose	296 solid	160 loose	118 solid

Dataset distribution by rock type





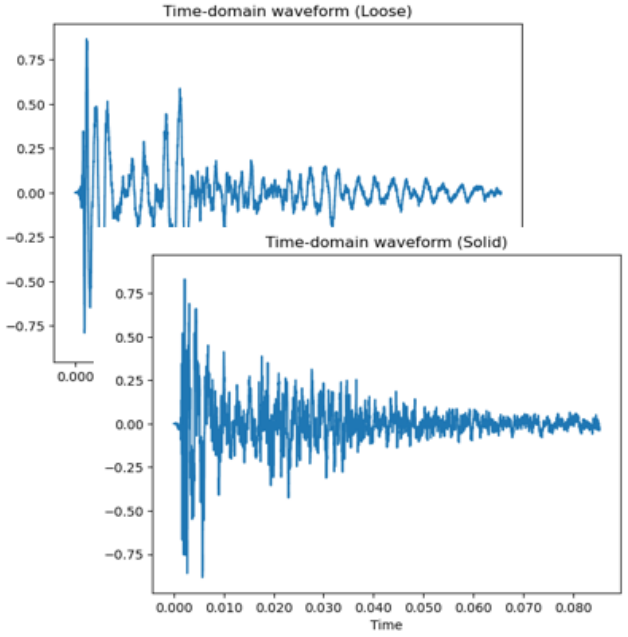
Underground Data Collection & Acoustic Refinement

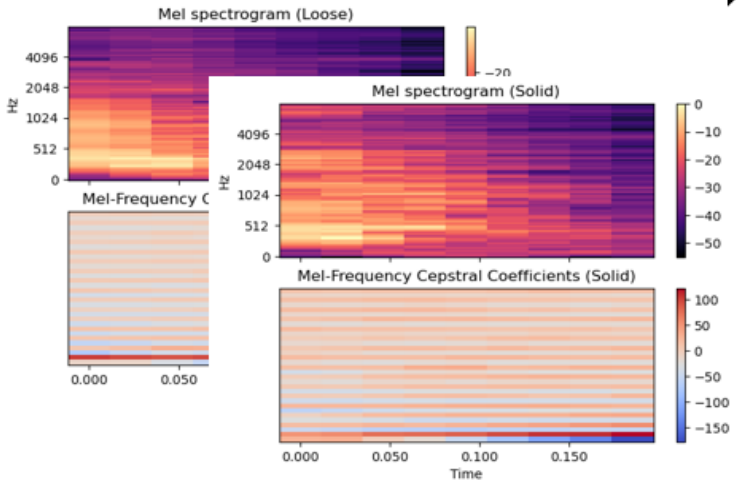
- **Timing & Noise Control:**
  - Data collection was conducted **early in shifts** to minimise production noise.
  - In some cases, crews briefly paused drilling to facilitate **acoustic recording**.
  - Background noises were recorded for **post-processing adjustments**.
- **Optimising Acoustic Data:**
  - Gain settings were adjusted to enhance the **signal-to-noise ratio**.
  - If noise was unavoidable, data was collected in **quieter areas**.
- **Mine & Lithology Selection:**
  - Focused on **gold mines** with suitable lithology (**lava, quartzite, conglomerate**).
  - Mines were briefed in advance to prioritise **on-reef, low-noise environments**.
- **Enhancements for Accuracy:**
  - **iPhone optimised** to focus solely on relevant **rock soundings**.
  - **Noise elimination & sensitivity adjustments** refined acoustic detection.
  - Addressing rock mass changes **during barring**, improving **hazard identification**.

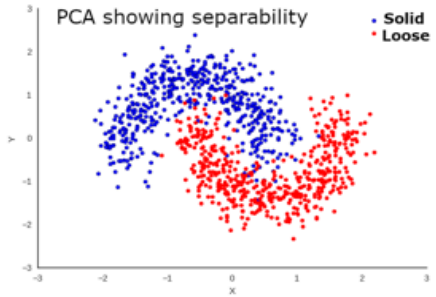
ACOUSTICS

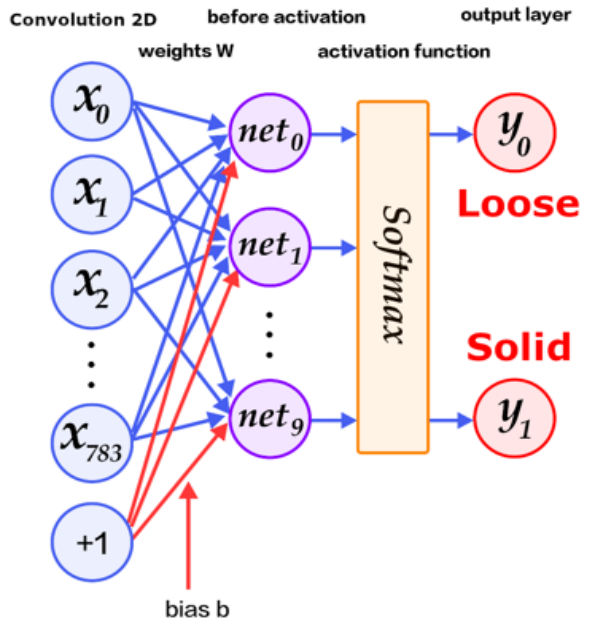
MINDS FOR MINES

RECORD AUDIO → EXTRACT FEATURES → ARTIFICIAL NEURAL NET









STEP 1: Record and Classify Data | **STEP 2: Extract Waveform Features** | **STEP 3: Machine Learning for Algorithm**

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CONCLUSION

AOK aims is to create a **"Glass Rock"** Environment which will enable real-time 3D orebody visualisation, reducing blind mining risks and improving decision-making for mine planners, rock engineers, and geologists.
Technology Integration:

The AOK programme combines **geophysical, geological, and AI-driven solutions** for enhanced subsurface analysis.

AOK transforms mining through **smart, data-driven solutions**, leading to safer and more efficient operations.

The Way Forward:

- Conduct full-scale trials of **Stratafy Seeker**
- Improve **real-time data processing** for enhanced operational responsiveness.
- Develop user-friendly **handheld interfaces** for wider adoption in mining operations.
- Enhance **machine learning models** for geophysical data fusion.
- Improve **AI-based rock hazard identification** for greater predictive accuracy.
- Optimise **real-time decision-making algorithms** for both tactical and strategic planning.
- Engage with the workforce for inputs during testing to ensure **continuous improvement**.
- Foster **collaborations** between industry, researchers, and government to drive **technology adoption**.
- **Share findings** through different platforms to industry

Accelerating Mining RDI

Integrating Research Excellence with Mining Innovation

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