Microseismic based approach to effective ground control management in unstable underground mines

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Abstract

- This paper presents a research project conducted at X Gold Mine. The company seeks to increase production target and this is going to be achieved through secondary stoping and primary stoping in new areas.
- In areas where secondary stoping is going to be considered, ground related challenges can result in fall of ground accidents. This calls for an effective ground control management that minimise the risk of fall of ground and this can be achieved using an effective monitoring system.

Contents

Introduction

- Background of study
- Problem statement
- Aim
- Objectives
- Significance of research

Problem Statement

- Monitoring the hazard is significant and the methods being used at Mine X cannot give information on the state within the rock mass.
- The risk is directly related to the magnitude of the damaged zones and these monitoring techniques does not monitor the extent of the damaged zone or predict what might happen as mining progresses.

Aim and Objectives

- The aim of the research is to design a microseismic monitoring system
- In order to achieve this aim, the following objectives are to be achieved

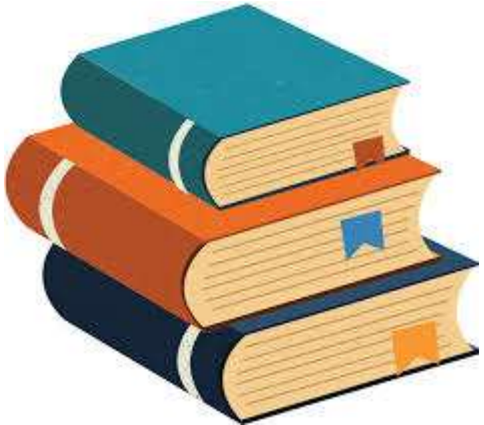
1. To determine the rock mass characteristics
2. To conduct numerical modelling of the area
3. To design the microseismic monitoring system
4. To analyse the designed monitoring system
5. To create a microseismic monitoring based effective ground control management system

Significance of research

- Ground control related decision-making
- detect record and locate when fracturing occurs in the rock mass
- Stope sequencing

Literature Review

- Rock mass characterisation
- Microseismic monitoring
- Ground control management
- Application of microseismic monitoring in ground control



Rock mass characterisation

- Rock Mass Rating (RMR) system by Bieniawski, (1989) and Laubscher, (1990)
- The Rock Quality Designation (RQD) by Deere, (1964) and the Q-index by Barton, et al., (1974).
- the Geological Strength Index (GSI) by Hoek, et al.,(1995),

Numerical modelling

- Numerical simulation is an effective way to examine the stability of a stope (Naung, et al., 2018).
- Numerical software programs commonly used to investigate failure in low confinement areas include Examine 2D and 3D, MAP3D, PHASE2D, FLAC and UDEC (Castro, et al., 2012).

Microseismic monitoring

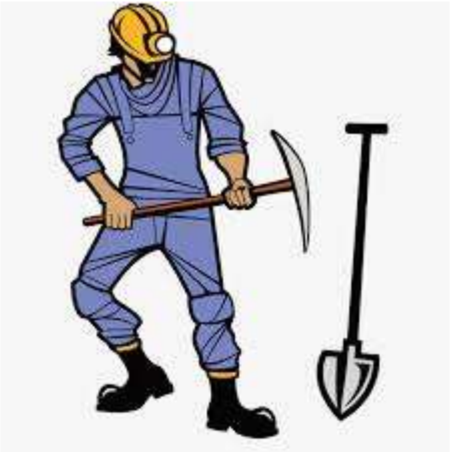
- Microseismic activity related to rock fracture was discussed by Gale et al., (2001).
- The rock mass deformation can be determined based on polarity of wave propagation, leading to identification of tensile failure and compressive failure(Swanson, et al., 2008).
- Le Calvez, et al., (2015) and Ge, (2005) discussed design of microseismic monitoring system

Ground control management

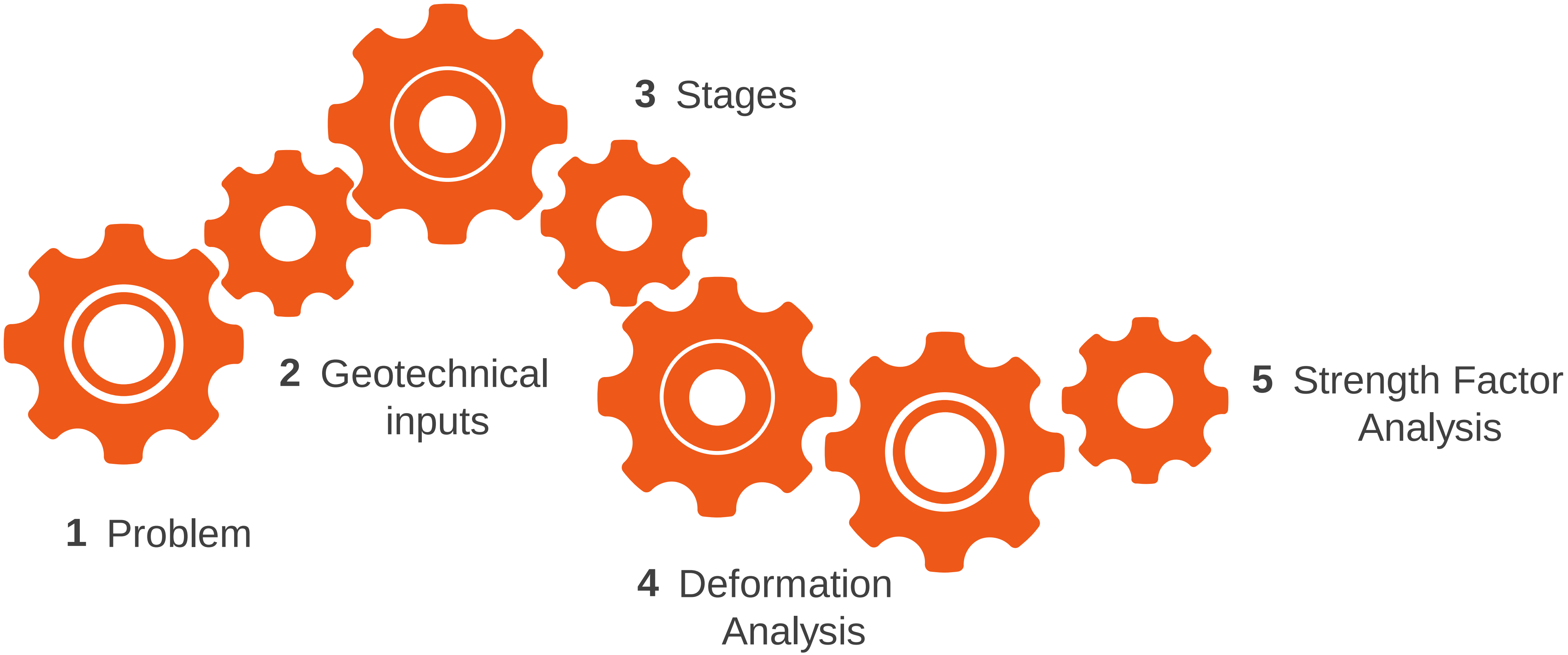
- Ground control management is defined through the ground control management plan (Ran, 2006)
- The essence of a mine wide ground stability is to prevent catastrophic failures of underground structure (Gary, 2018).
- Andrew & Krois, (2005) suggested that an effective ground control management is determined by the ability to recognize the potential for ground control hazards

Methodology

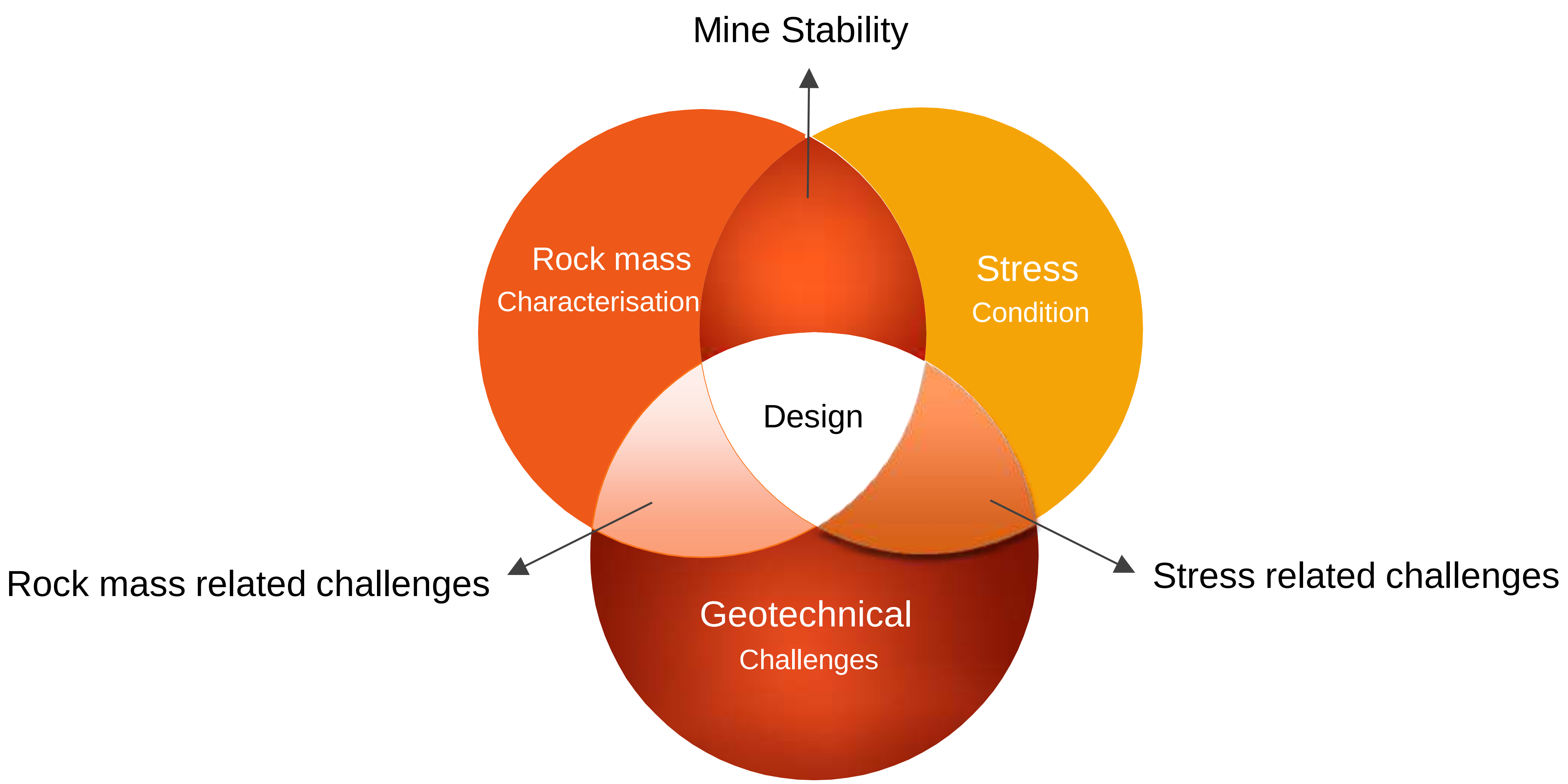
- Rock mass characterisation
- Numerical Modelling
- Microseismic system design
- Financial cost-benefit analysis
- Ground control management



Numerical Modelling



Microseismic System Design



Results and Analysis

- Rock mass characterisation
- Numerical modelling
- Microseismic monitoring system design
- Financial Cost Benefit Analysis
- Microseismic based Ground control management

Rock mass characterisation

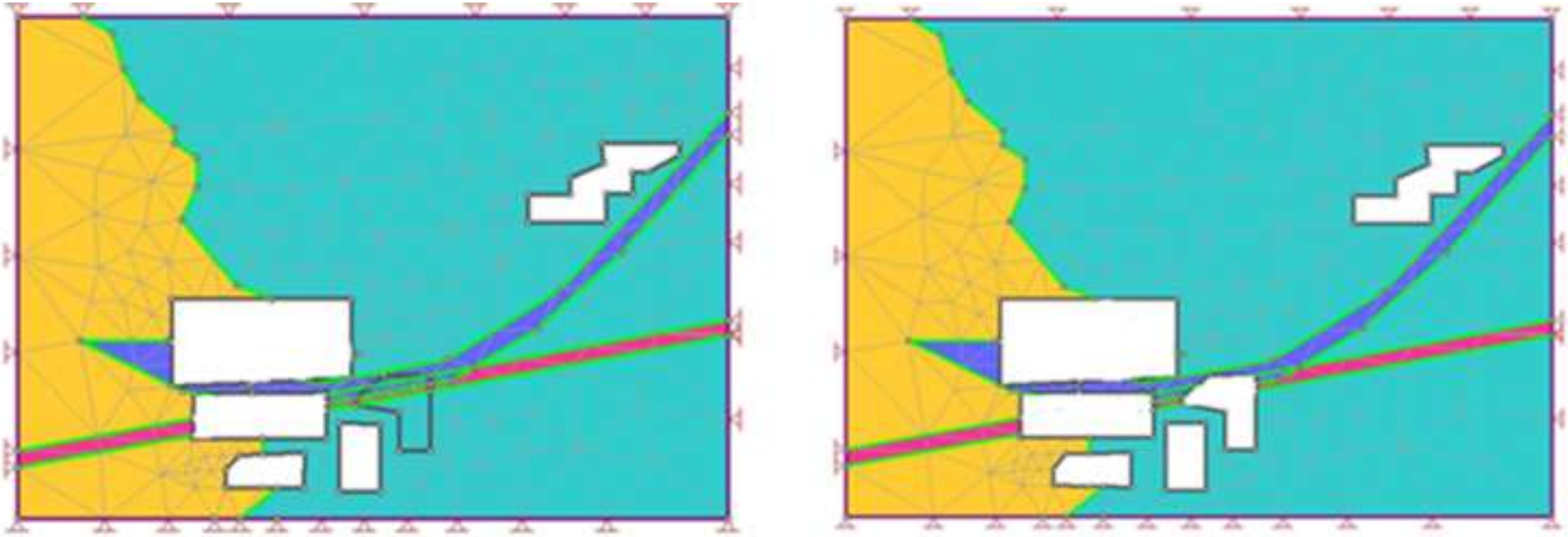
- GSI values for diorite ranges for 50-70
- And GSI values for metasediments ranges from 35-70
- RMR predominantly class II in diorite and class III in metasediment

Table 1.1 Rock formation and RQD

RQD			
Rock formation	Max	Min	Average
Metasediment	85%	21.78%	59.60%
Diorite	90%	36%	66%

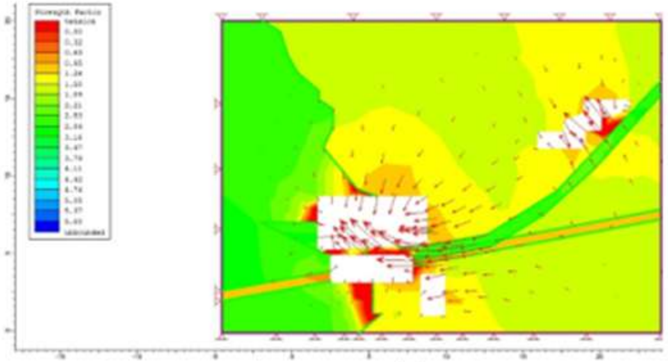
Table 1.2 Geotechnical parameters for diorite and metasediment

Parameter	Metasediment	Diorite	Freda/Rebecca Shear Zone
Intact compressive strength/Mpa	80	100	30
GSI	50	65	40
Friction Angle	33^0	40^0	24^0
Cohesion/Mpa	3.5	10	0.6
Rock mass compressive strength/ Mpa	13	44	2.0
Tensile strength/Mpa	-0.15	-0.75	-0.01
Deformation modulus/Mpa	9000	33000	1500
Dilation angle	4^0	10^0	0

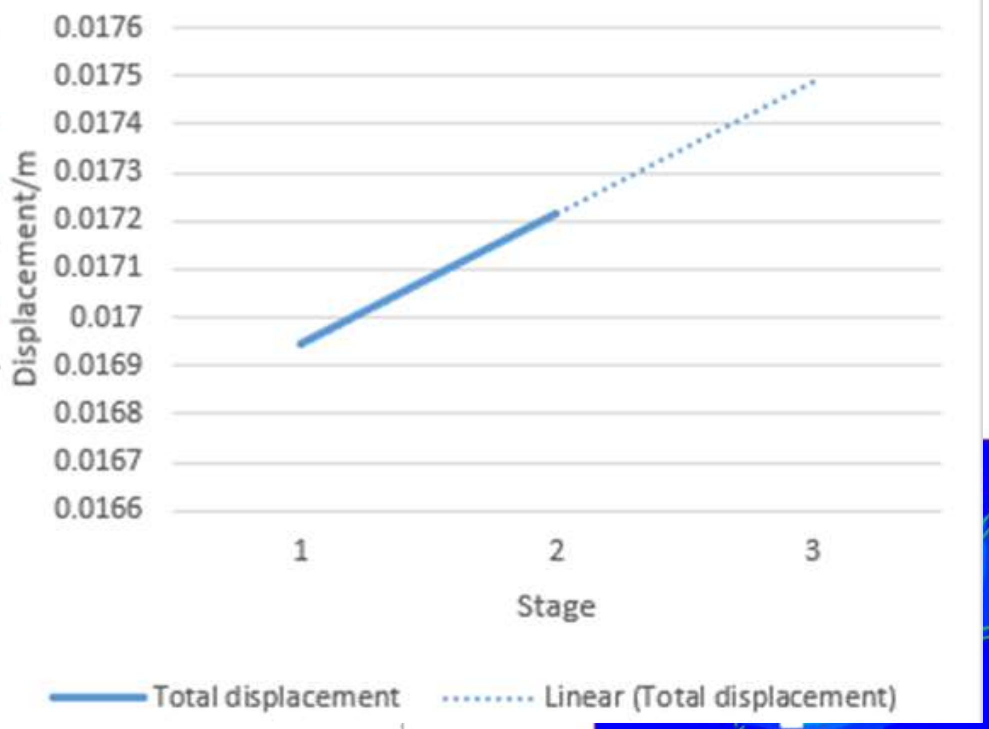


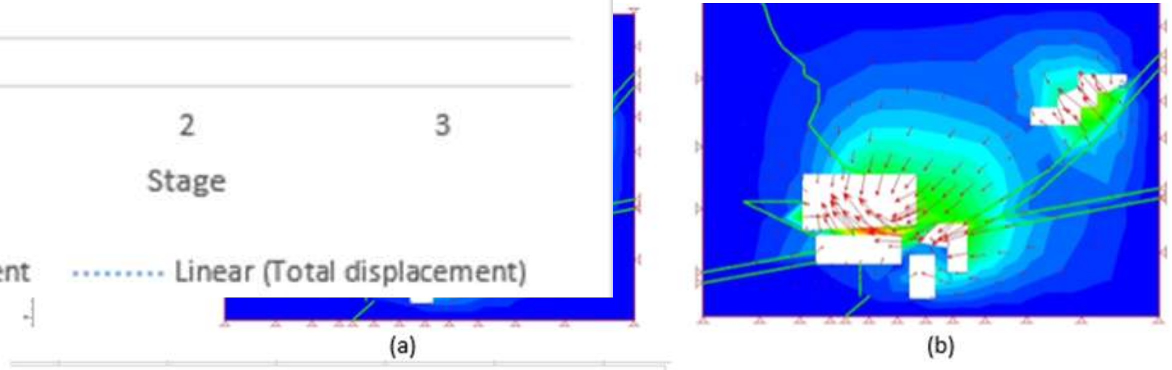
(a) (b)

Numerical Modelling



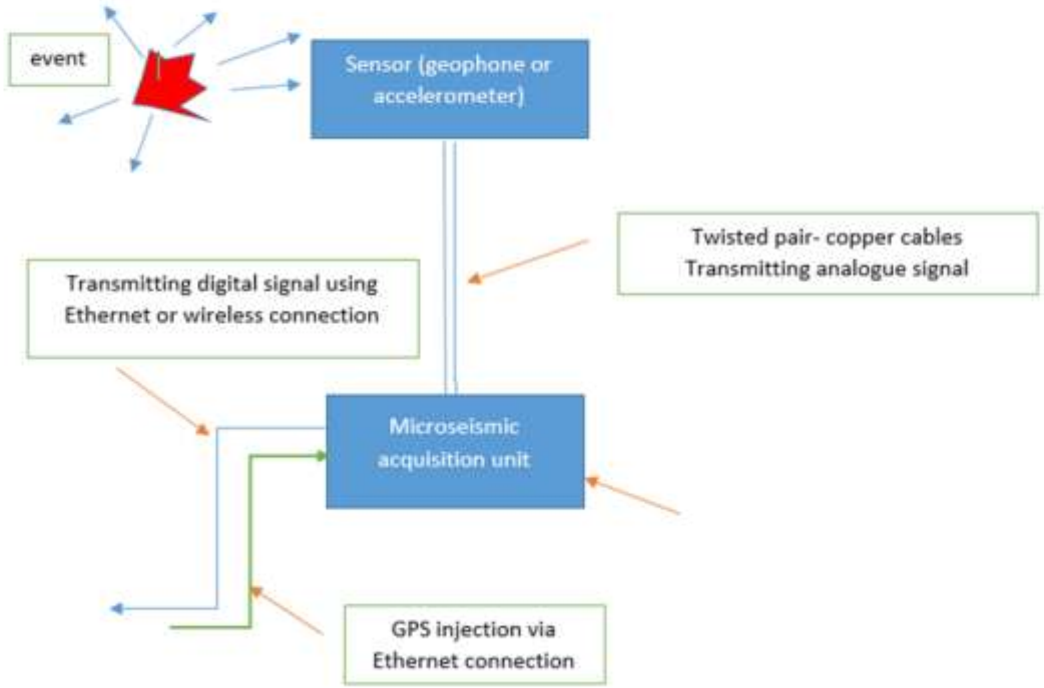
(a)





(a) (b)

Microseismic monitoring design

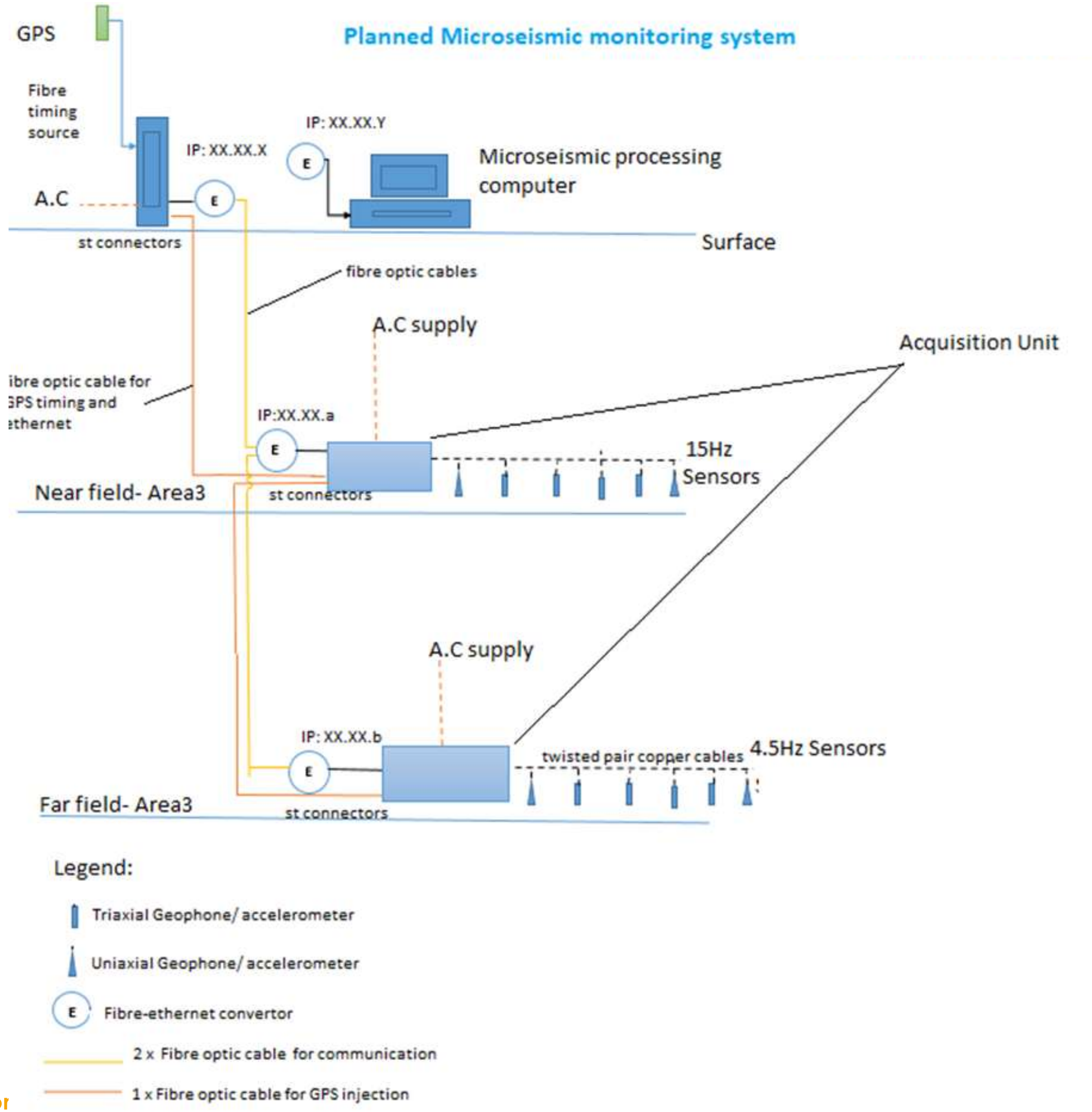


Microseismic system structure

Sensors
4.5 Hz and 16Hz accelerometers and geophones

Data Acquisition
Underground Acquisition units and surface acquisition computer

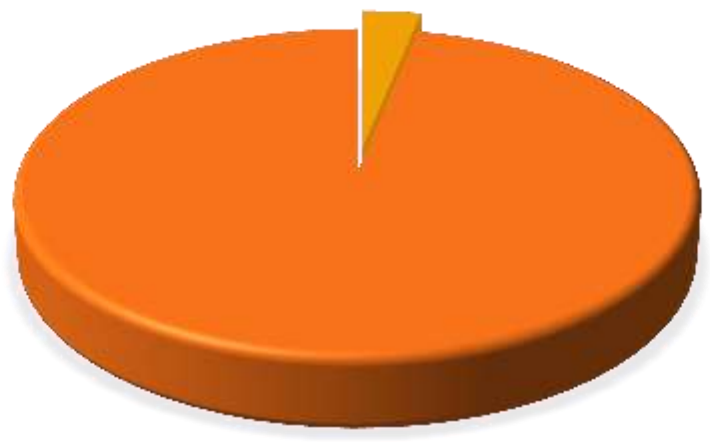
Data Processing
Data processing computer



GPS
Planned Microseismic monitoring system
Fibre timing source
IP: XX.XX.X
IP: XX.XX.Y
Microseismic processing computer
A.C
st connectors
Surface
fibre optic cables
A.C supply
Acquisition Unit
ibre optic cable for
SPS timing and
ethernet
IP:XX.XX.a
15Hz Sensors
Near field- Area3
st connectors
A.C supply
IP: XX.XX.b
twisted pair copper cables
4.5Hz Sensors
Far field- Area3
st connectors
Legend:
Triaxial Geophone/ accelerometer
Uniaxial Geophone/ accelerometer
Fibre-ethernet convertor
2 x Fibre optic cable for communication
1 x Fibre optic cable for GPS injection

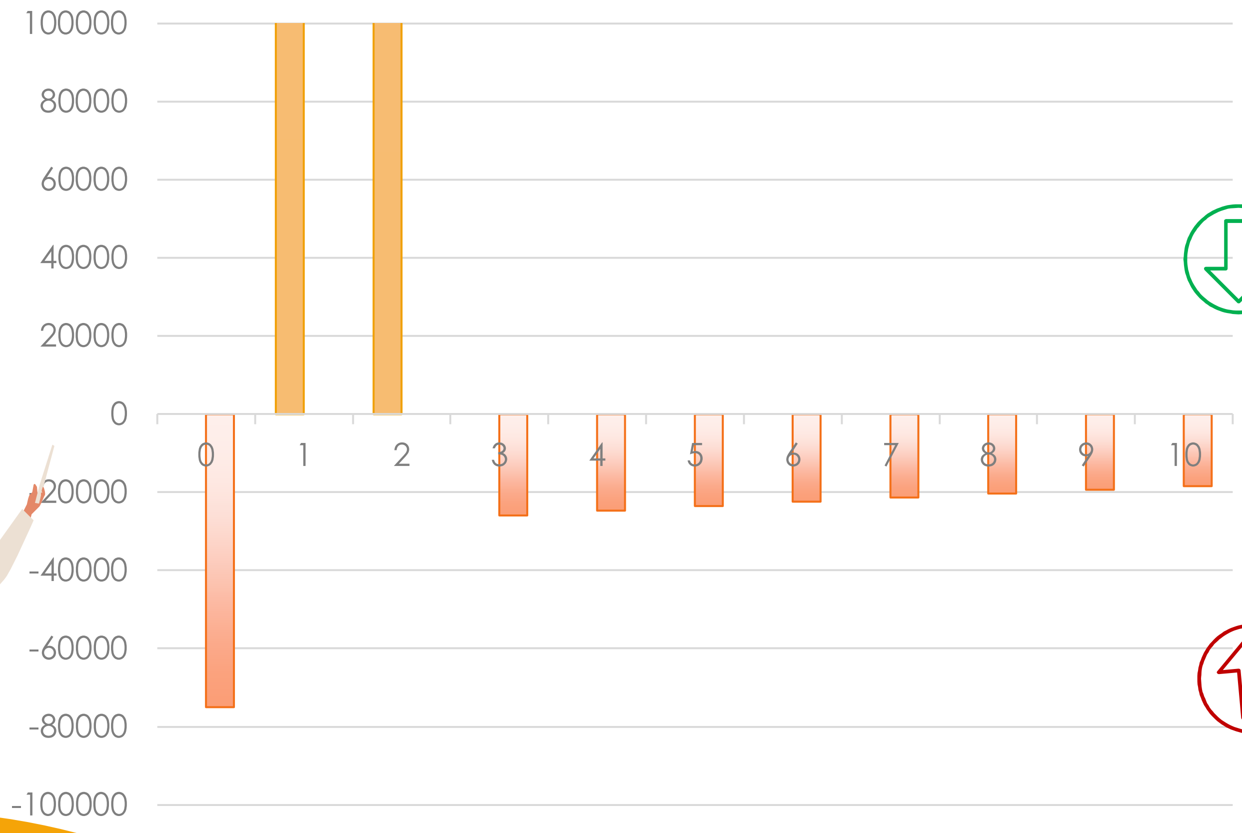
Financial Cost Benefit Analysis

- The cost of option A is estimated at US$75000 and an operational cost of US$35000 operating expense per year
- The benefit of this is US$9,507,762.62
- Cost benefit ratio is 0.0313
- NPV is US$8,532,764.45



The total outflow is US$315,000.00 and total in flow is estimated at US$9,507,762.62

Cashflows



US$9,507,762.62

The total cash inflow from the mining operation

US$315,000.00

The total cash inflow from the mining operation

OPTION B

- Mining recovery of 45% will mean extraction of 467923.635 tonnes
- US$4,278,493.18 from recoverable material
- cost will be US$30 000 per year
- NPV US$3,801,867.69
- cost-benefit ratio is estimated at 0.07

Microseismic based ground control

- Identification of hazards
- Risk assessment
- Eliminate or minimise the risks by implementing effective control measures
- Monitor and review performance of control measures

Conclusions and Recommendations

Conclusions

- The mining area is within DIO and MS with shear ones
- The mining are is unstable around the damage zone
- Secondary stoping can bring a lot of hazards
- A microseismic monitoring system with 6 near field sensors and 6 far field sensors was designed
- A microseismic system is financially viable and is a cost effective investment to safety
- Microseismic monitoring can bring about effective ground control management at Mine X

Recommendation

- A detailed numerical modelling using 3D software to fine tune results
- Fine tune the microseismic monitoring system design by conducting a detailed system design taking into consideration the signal to noise ratios on the mine
- Adoption of a microseismic based ground control management system

Questions