Impala Platinum Limited
Rock Engineering

The Application Of The Q-Tunneling Quality Index To Rock Mass Assessment At Impala Platinum Mine

Wouter Hartman
Snr Rock Engineer – Projects - 2000

1. Introduction

2. Locality Plan

3. Geological Setting

4. Problem
   - *4.1 FOG Analysis*
   - *4.2 Rock Mass Classification Systems*
   - *4.3 Q-System Applicability to Impala*

5. Case Studies
   - *5.1 Q-System Methodology*
   - *5.2 Q-Index Analysis for 10 Level Crosscut & 23 Level Conveyor*
   - *5.3 Bolt Length Design for permanent mine openings*

6. Conclusions

Introduction

Questions remain on how to properly design support in a quasi-static environment using rock mass characteristics as an indicator and design tool

EMPIRICALLY ?

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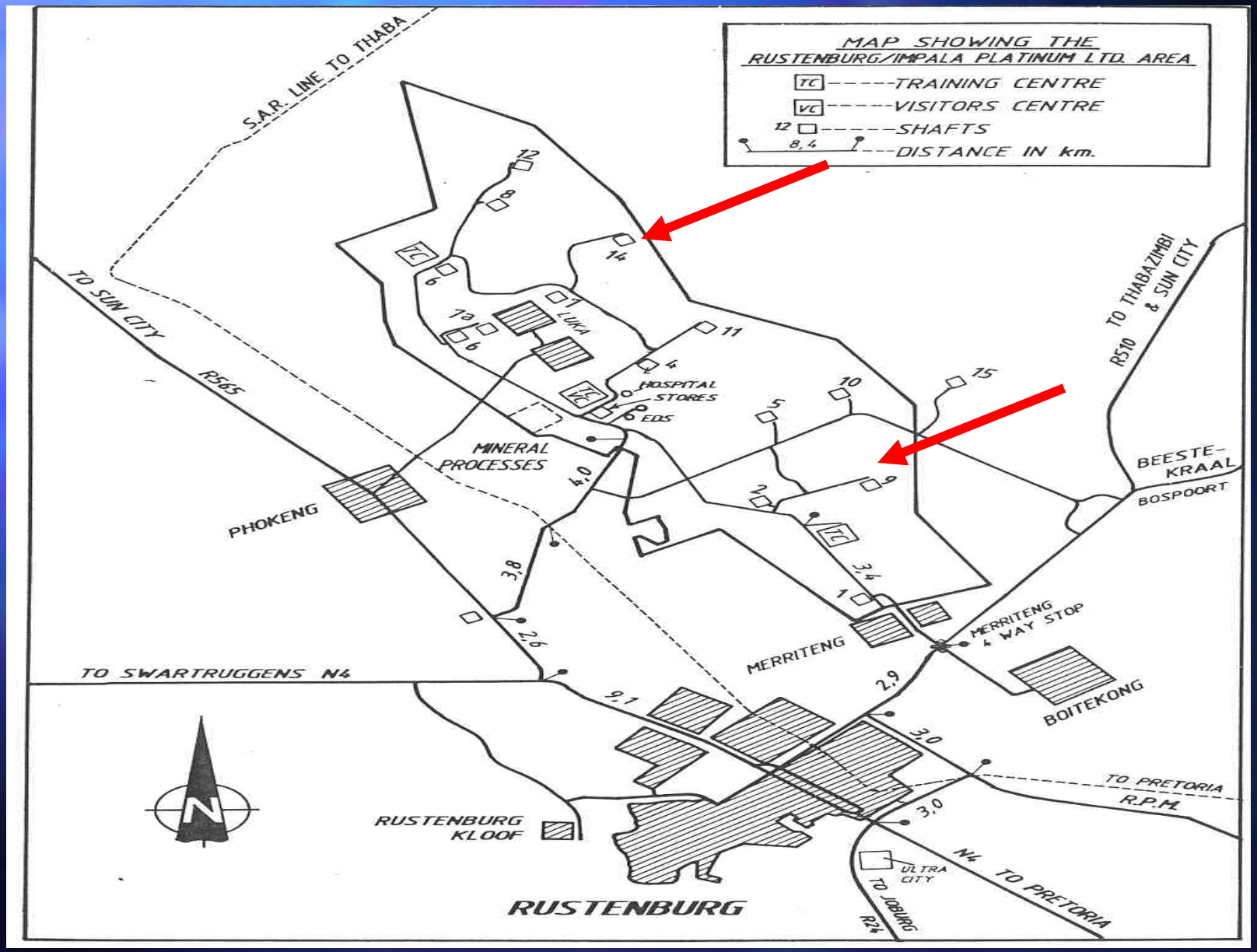
Locality Plan



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Geological Setting

Average Thickness (m)	Unit	Rock Type
34	HW5	Mottled and spotted Anorthosite
3-6	HW4	Spotted Anorthosite (SA)
5-7	HW3	Mottled Anorthosite (MA)
1,5-3	HW2	Spotted Anorthositic Norite
2-6	HW1	Norite
2-3	Bastard Pyroxenite	Pyroxenite, Coarse Grained
2-3	M3	Mottled Anorthosite
3-7	M2	Spotted Anorthositic Norite
0,5	M1	Norite
1-1,5	Merensky Pyroxenite	Medium to Coarse grain Pyroxenite
0,8	Merensky Reef	Chromitite Layer - Pegmatoid
0,4	FW1	Spotted Anorthositic Norite (SAN)
0,2	FW2	Cyclic Unit (Pyroxenite-SAN-MA)
3-5	FW3	Spotted Anorthositic Norite
0,1-0,3	FW4	Mottled Anorthosite
1-3	FW5	Spotted Anorthositic Norite
1-3	FW6	Cyclic Unit (MA-SA-MA)
1-3	FW7	Spotted Anorthositic Norite
0,8-1,2	FW8	Spotted Anorthosite
3-6	FW9	Mottled Anorthosite
3-5	FW10	Spotted Anorthositic Norite
12-15	FW11	Spotted Anorthosite
10-12	FW12	Mottled Anorthosite
5-7		UG2 Pyroxenite with Leader Chromitite Stringers
0,7	UG2 Reef	Chromitite
10-12	FW	UG2 Pegmatoid
5-7	FW13	Spotted Anorthositic Norite

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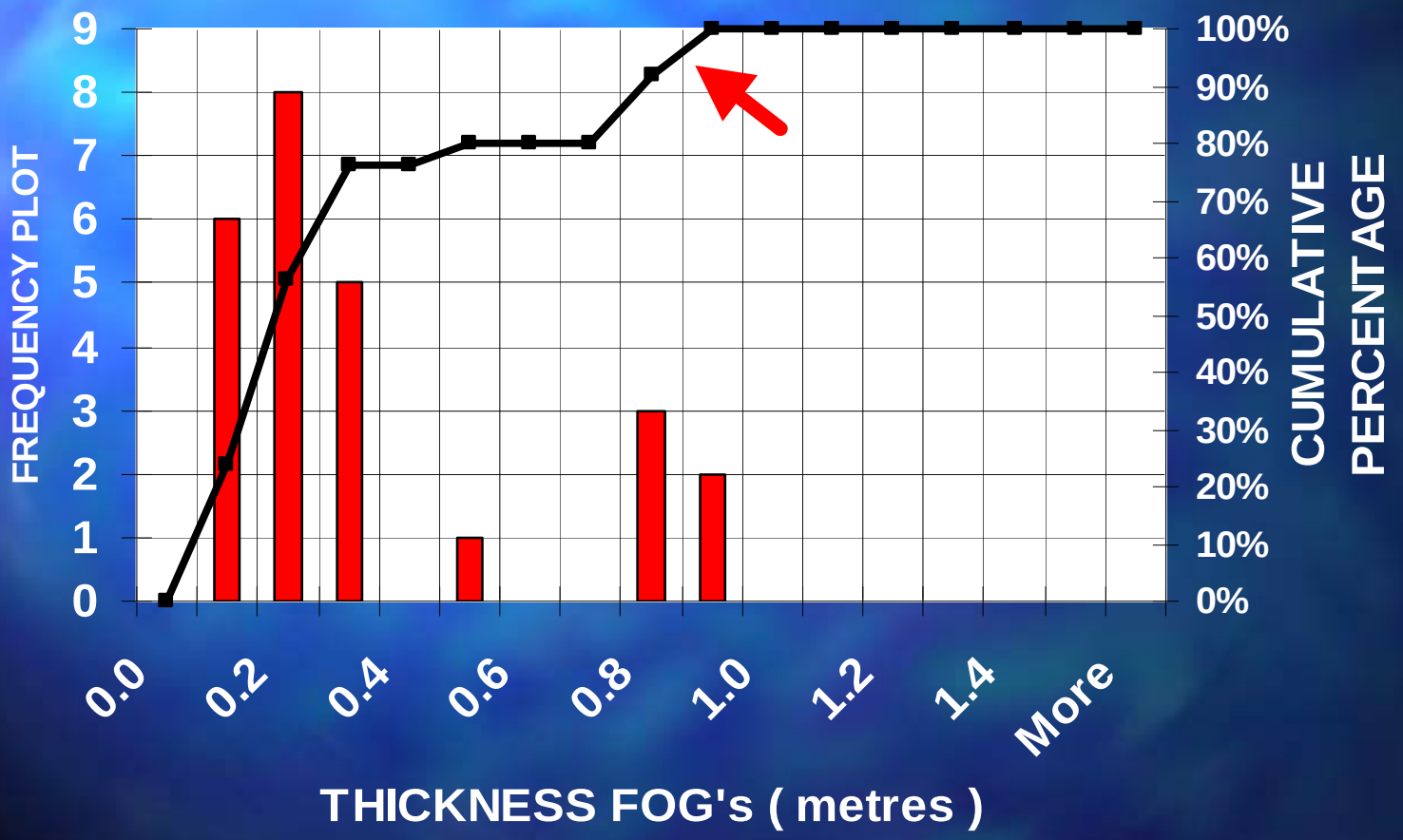
PROBLEM

- Support Design Based On Total Fatality Fall Of Ground 95% Cumulative Analysis
- When Accident Statistics Are Split Into Stoping & Development : The Latter Was Found To Be Limiting To Properly Design Support
- Design Development Support Using 50 kN/m2 Or Use Rock Mass Quality and Excavation Size As Design Criterion

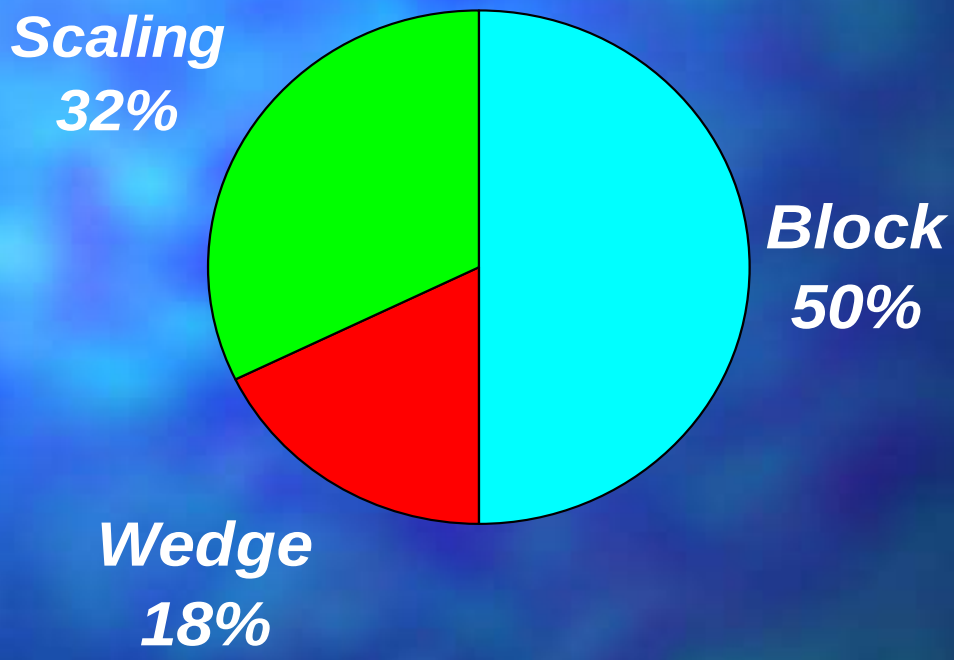
PROBLEM

FOG FATALITY ANALYSIS 95% CUMULATIVE - DEVELOPMENT



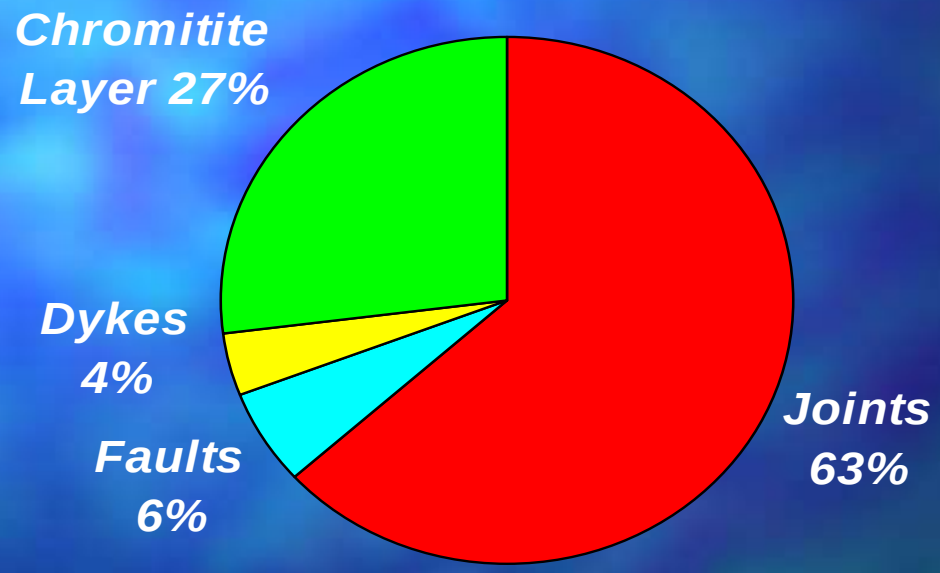
PROBLEM

FOG FATALITY ANALYSIS - GEOMETRIES



PROBLEM

FOG FATALITY ANALYSIS - BOUNDARIES



PROBLEM

ROCK MASS CLASSIFICATION SYSTEMS

1. ***Terzhagi's***
2. ***RQD***
3. ***Rock Structure Rating (RSR)***
4. ***CSIR Geomechanics Classification for jointed rock mass***
5. ***Modifications to RMR for mining***
6. ***Stini & Lauffer Classifications***
7. ***Checklist methodology for hazard identification in tunnels***
8. ***Rockwall Condition Factor (RCF)***
9. ***Rock Tunneling Quality Index, Q***

PROBLEM

Q - SYSTEM APPLICABILITY TO IMPALA

$$Q = \frac{RQD}{Jn} \times \frac{Ja}{Jr} \times \frac{Jw}{SRF}$$

- ***Simplicity as a measure of block size, inter block shear strength, active stress & all critical factors associated with fog's***
- ***Easy to use underground***
- ***Simple relationship between support required, - no support required and tunneling Q-index which can be easily modified to suit changing geotechnical conditions***

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CASE STUDIES

Q – INDEX METHODOLOGY :

- ***Estimating Rock Quality Designation (RQD) From Scan line Measurements***

$$Jd = D + S + V$$

$$RQD = 115 - 3.3 * Jd$$

- ***Jn, Jr, Ja, Jw & SRF Obtained As Described By Barton***
- ***10m Intervals***

CASE STUDIES

Q – INDEX ANALYSIS :

- ***No. 9-Shaft ~ 10 Level Crosscut***
- ***No. 14-Shaft ~ 23 Level Conveyor Decline***

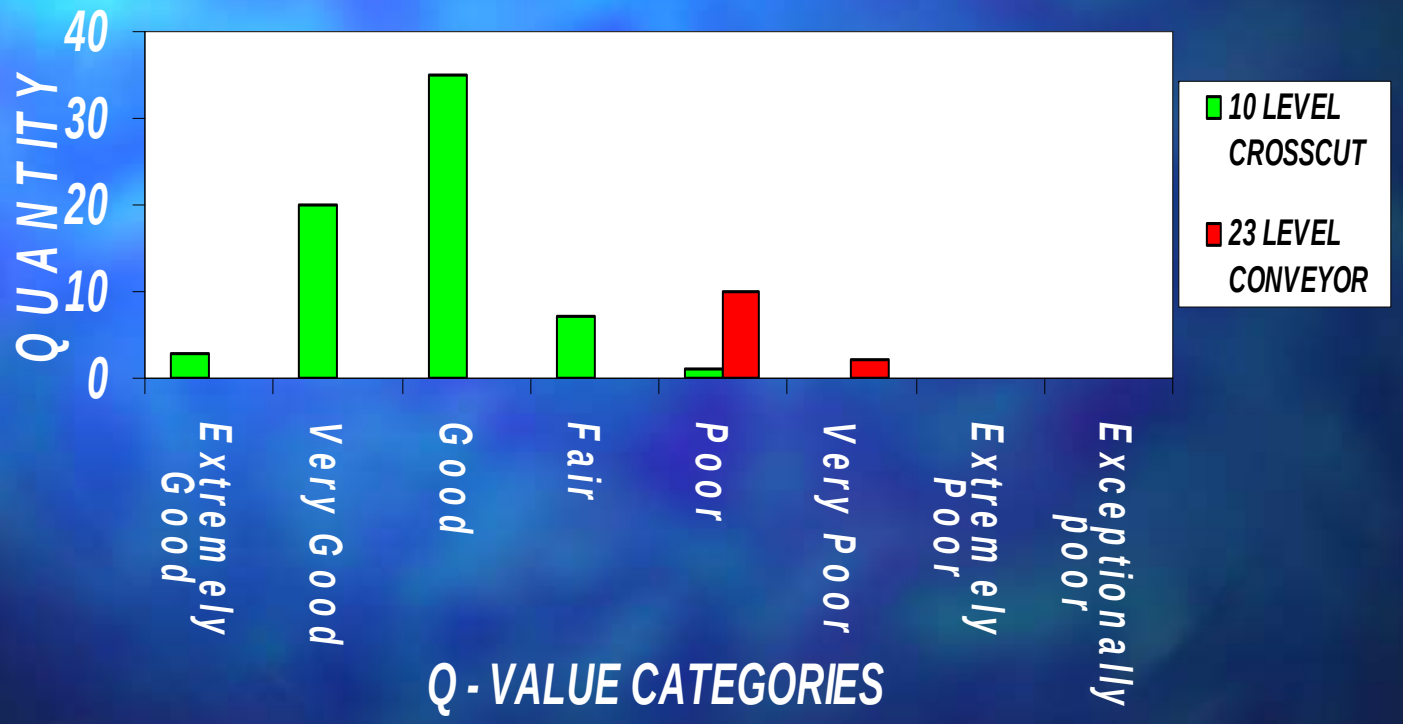
89 Tunneling Quality Index Measurements :

- **77 Along 10 Level Crosscut**
- **12 Along 23 Level Conveyor**

representing 890m of tunnel

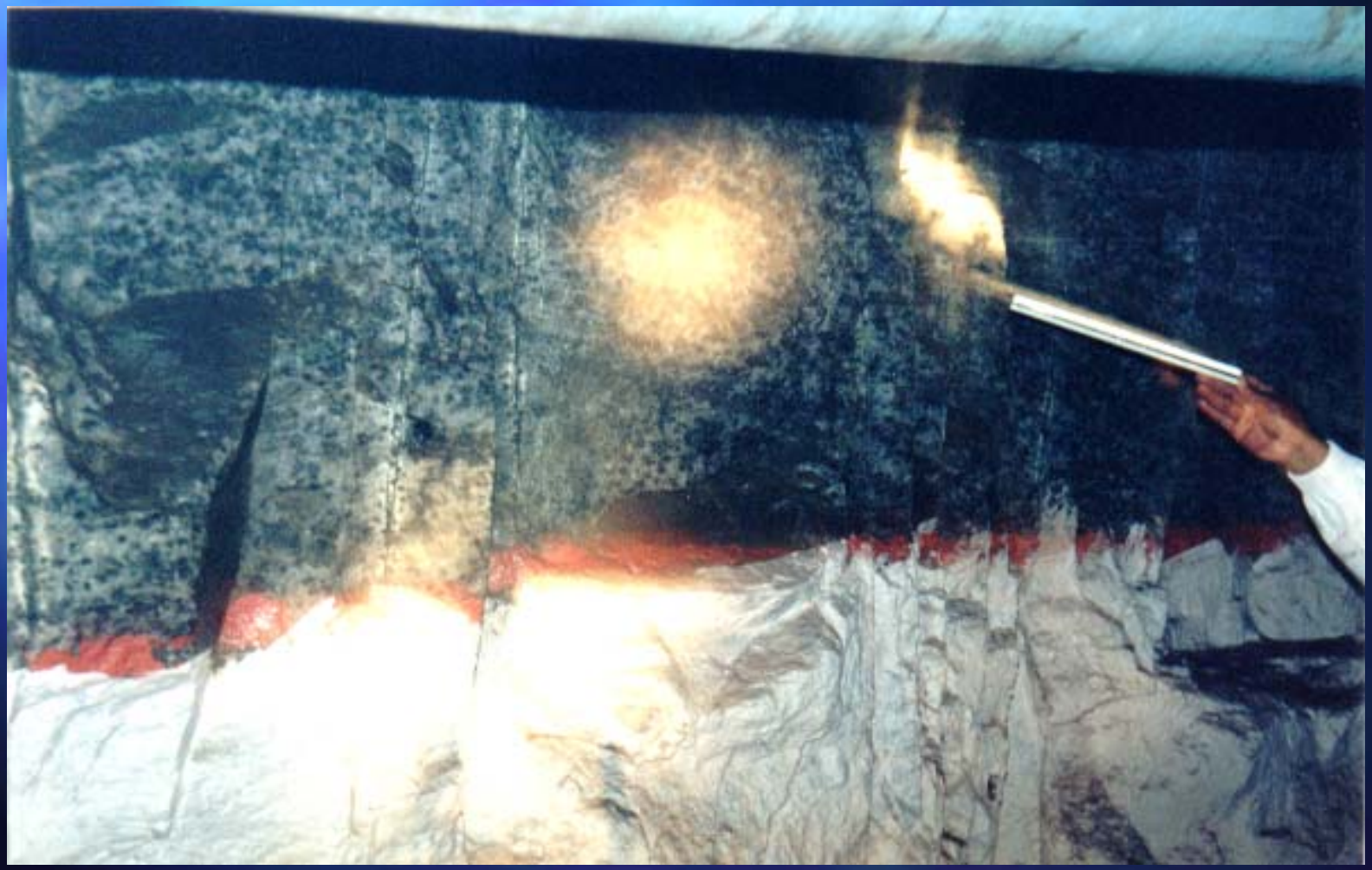
CASE STUDIES

Distribution of Q-Index Values



CASE STUDIES

NO. 9 - SHAFT
10 LEVEL CROSSCUT



CASE STUDIES

NO. 9 - SHAFT
10 LEVEL CROSSCUT

CASE STUDIES

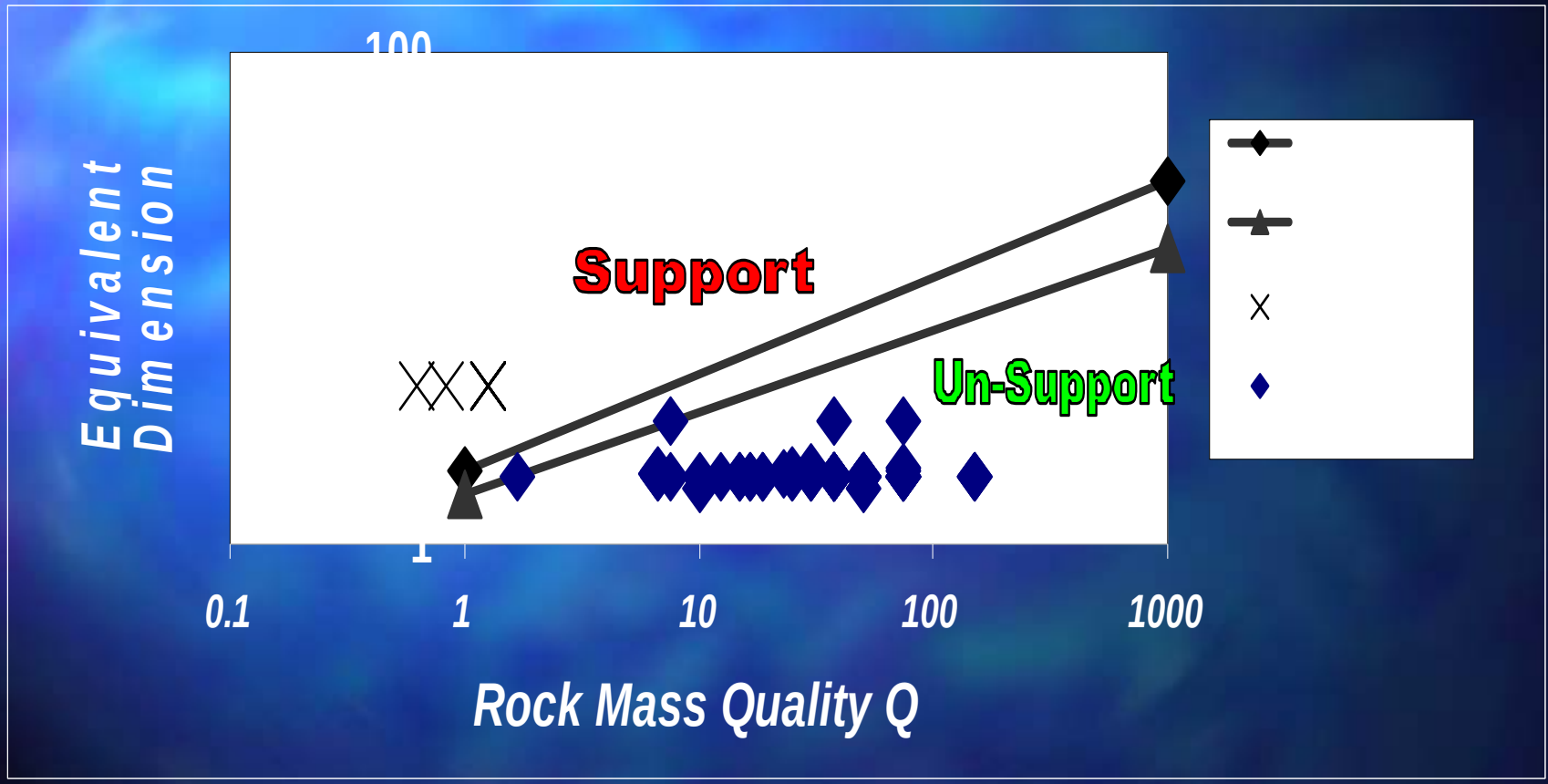
NO. 14 - SHAFT
23 LEVEL CONVEYOR DECLINE

CASE STUDIES

NO. 14 - SHAFT
23 LEVEL CONVEYOR DECLINE

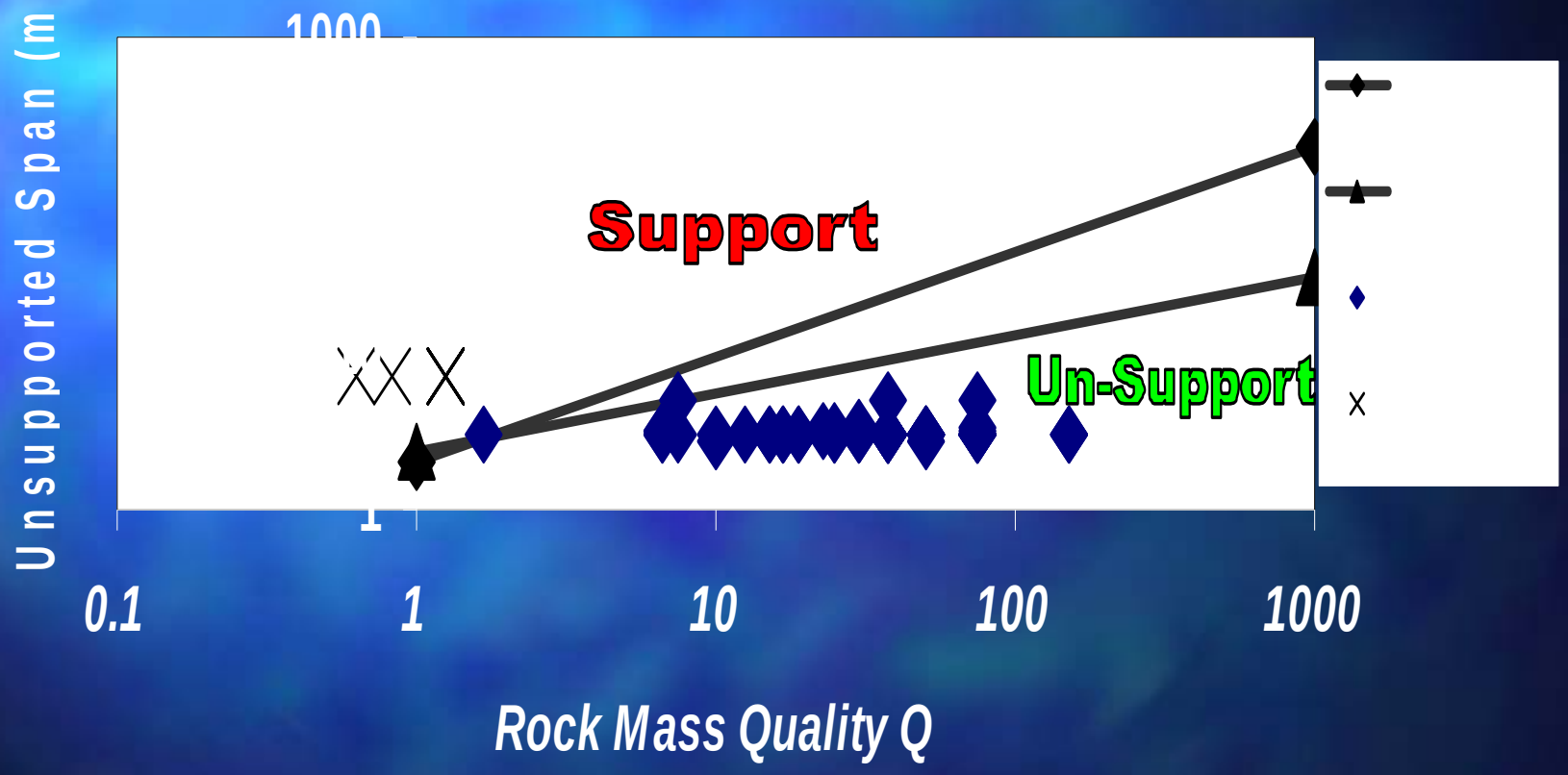
CASE STUDIES

Rock Mass Quality, Q, vs Equivalent Dimension - Plot



CASE STUDIES

Rock Mass Quality, Q, vs Unsupported Span - Plot



CASE STUDIES

Barton Formulas *:*

$$Equivalent\ Dimension = 2 * Q^{0.4}$$

$$Unsupported\ Span = 2 * ESR * Q^{0.4}$$

Hartman Modified Formulas :

$$Equivalent\ Dimension = 1{,}56 * Q^{0.3442}$$

$$Unsupported\ Span = 1{,}56 * ESR * Q^{0.3442}$$

CASE STUDIES

Bolt Length Design for Permanent Mine Openings

From Barton et al :

$$L = \frac{2 + 0.15 * B}{ESR}$$

Where,

L - bolt length;

B - excavation width;

ESR (Excavation Support Ratio) - a value related to the intended use of the excavation and the degree of security, which is demanded of the system - For permanent mine openings the ESR = 1.6.

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Conclusions

FOG Analysis :

- 95% of all falls of ground were 0,9m thick or less
- nearly all falls of ground were related to discontinuities in the rock mass
- large falls of ground are infrequent
- conventional support would have been sufficient to prevent falls of ground

Conclusions (CONT.)

Tunnel Quality Index Application :

- potentially large falls of ground should be prevented by investigations & revealing un-favourable orientations of discontinuities
- support to be introduced into tunnels with spans in excess of the modified prediction
- no rockmass classification systems are general & require some modification in a specific environment