Coal Mine Entry Rating System: A Case Study

Mark Van Dyke

Physical Scientist

NIOSH

Pittsburgh Mining Research Division

Introduction

Researchers at the National Institute for Occupational Safety and Health (NIOSH) have been researching methods to evaluate a mine entry as a system versus analyzing the roof, rib and floor independently.

NIOSH researchers developed a new method to rate coal mine entries through a quantitative process versus the more traditional qualitative data methods.

Many rating systems have been created throughout the years. They were typically created for use at a specific mine or company and don't necessarily fit other coal mines.

Previous rating systems

- 1975 - The US Bureau of Mines (USBM) published a report highlighting the importance of mapping large scale features such as clay veins, coal cleat, faults, sandstone channels, and roof falls. These features can easily be mapped by a geologist, but this does require a trained eye.

- 1994 - The USBM created a method to map the principal horizontal stress direction by determining the direction and type of feature occurred in the roof and floor. Theses features included roof potting, cutters, roof bolt offsets, and orientation of fractures.

- 1998 – LaModel software was utilized to make accurate stress predictions than focused on the amount of pilar damage expected. The software was further enhanced with the introduction of the stability mapping system in 2005.

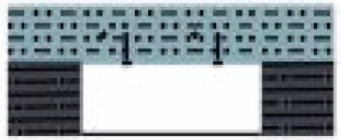
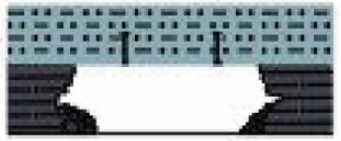
- 2005 – NIOSH published a paper addressing ground condition mapping with new criterion adding measurements and expected signs of damage for each rating for the roof, floor and ribs.

Previous rating systems

- Previous mine mapping systems have proven worthwhile and resulted in enhanced miner safety, health and productivity.
- Most recent systems were developed to verify modeling results, and do not address local geological issues.
- NIOSH researchers needed a new mapping system that could be used by all underground personnel to describe entry damage, verify modeling results and highlight geological issues.
- NIOSH researchers created a hybrid of previous mapping systems address these issues.

Coal mine entry rating system

Rib deterioration index

1	Sloughage of 7.62 cm (3 in) or less. Damage is only on skin of the pillar and rock dust is mostly intact in areas that are outby.	
2	Wide spread skin damage 7.62 to 15.24 cm (3 to 6 in). Small blocks on floor	
3	Ribs are beyond slight skin damage and is observed from 15 to 30 cm (6 in to 1 ft) from the original rib line, larger blocks of sloughage appear on floor.	
4	Obvious rib damage. Damage to pillars extends 0.3 to 0.6 m (1 to 2 ft) on average from the original pillar line.	
5	Significant rib damage. Damage extends 0.6 to 1.2 m (2 to 4 ft) into the pillar from the original rib. Travel is very difficult due to sloughage covering most of the floor.	
6	Severe rib sloughage. Rib damage extends beyond 1.2 m (4 ft). Travel is extremely difficult or impossible. Rib sloughage extends across the floor joining sloughage from the opposite rib.	

Rib rating of 5 (P5) due 3 feet of spalling

Coal mine entry rating system

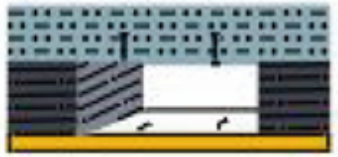
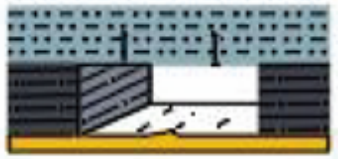
Roof deterioration index

1	Original roof with bit marks mostly visible. Some flaking and scaling is limited to 2.54 cm (1 in) or less.	
2	Flaking and scaling are limited to 2.54 to 7.62 cm (1 to 3 in). Minor closed cracks are possible and no sign of loading of supports is visible.	
3	Flaking and scaling areas are seen between 7.62 to 30.00 cm (3 to 12 in). Small cutters are possible forming less than 0.6 m (2 ft). Some roof deformation observed and possible potting, open minor cracks.	
4	Bolt plate loading observed. Majority of roof beam is intact and cutters are greater than 0.6 m (2 ft) in depth. Standing support shows very little if any loading.	
5	Standing supports are heavily loaded. Large pot-outs between bolts, bolts begin to fail. Majority of the original roofline is gone, multiple open cracks spanning the entry.	
6	Roof fall above primary support.	

Roof rating of 3 (R3) due to cracks and slicks greater than 3 inches.

Coal mine entry rating system

Floor deterioration index

1	Floor has no signs of floor heave, sporadic cracks could be observed, no measurable heave.	
2	Floor has consistent localized cracks. Floor heave is 15 cm (6 in) or less.	
3	Widespread cracks, hollow floor. Floor heave measured between 0.15 to 0.30 m (6 in to 1 ft).	
4	Continuous floor heave measured between 0.3 to 0.6 m (1 to 2 ft), damage to ribs can occur, travel is possible.	
5	Significant displacement of 0.6 to 1.2 m (2 to 4 ft), damage to ribs will occur, pillars, cribs, and post can punch into floor, travel is difficult.	
6	Severe floor displacement 1.2 m (4 ft) or more. Travel is extremely difficult or impossible. Significant damage to ribs, standing support will punch or roll.	

Floor rating of 6 (F6) because floor heave is greater than 4 feet.

Three tier mapping system

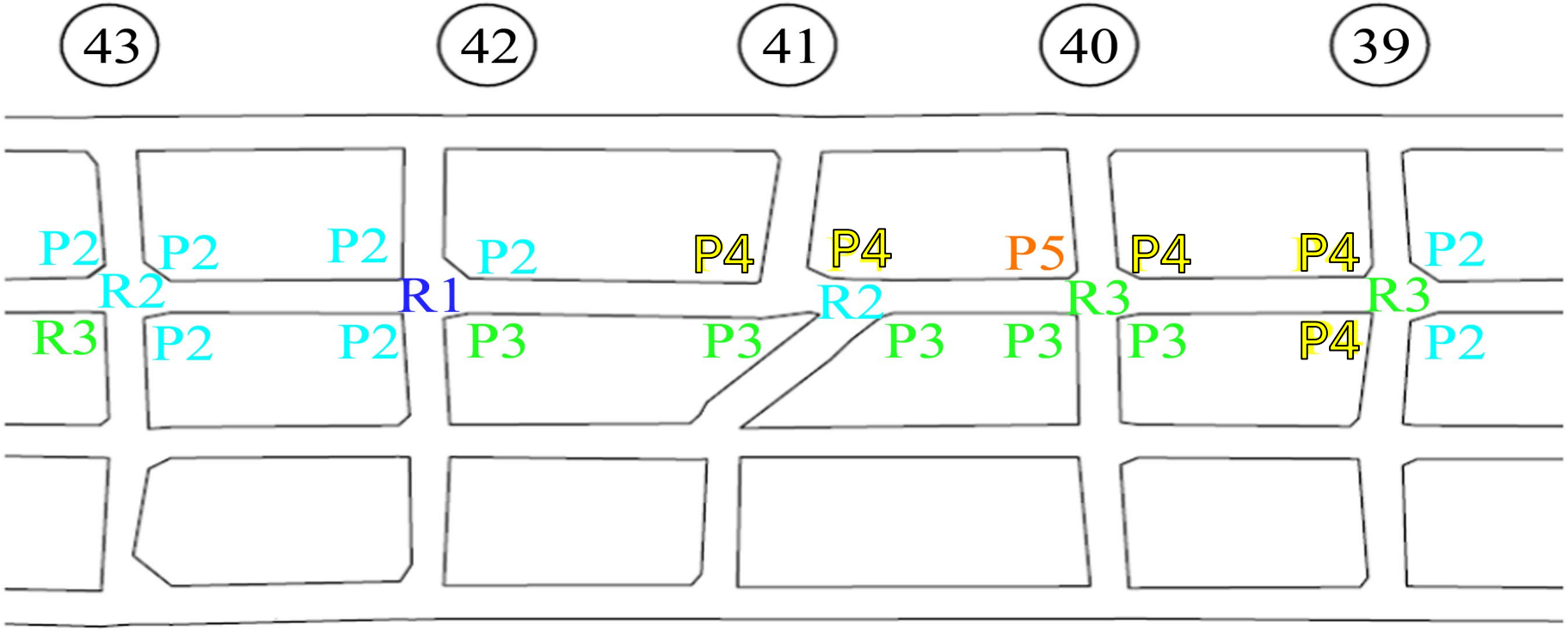
Three tiers of mapping are offered depending on time and skill of employees available.

First tier - utilizes the numerical rating system and focuses on intersections of entries only. Traditionally intersections are known to be more prone to instability because of the greater roof spans. Typically damage to ribs, roof, and floor will start in these areas.

Second tier – straights of entries and crosscuts are rated along with the intersections.

Third tier – incorporates any geological and horizontal stress findings along with ratings associated with the first and second tier mapping. This tier requires the rater to understand basic geological concepts. Mapping of anticlines/synclines, sandstone channels, faults, slips/slicks lithology changes, and more are identified in this step.

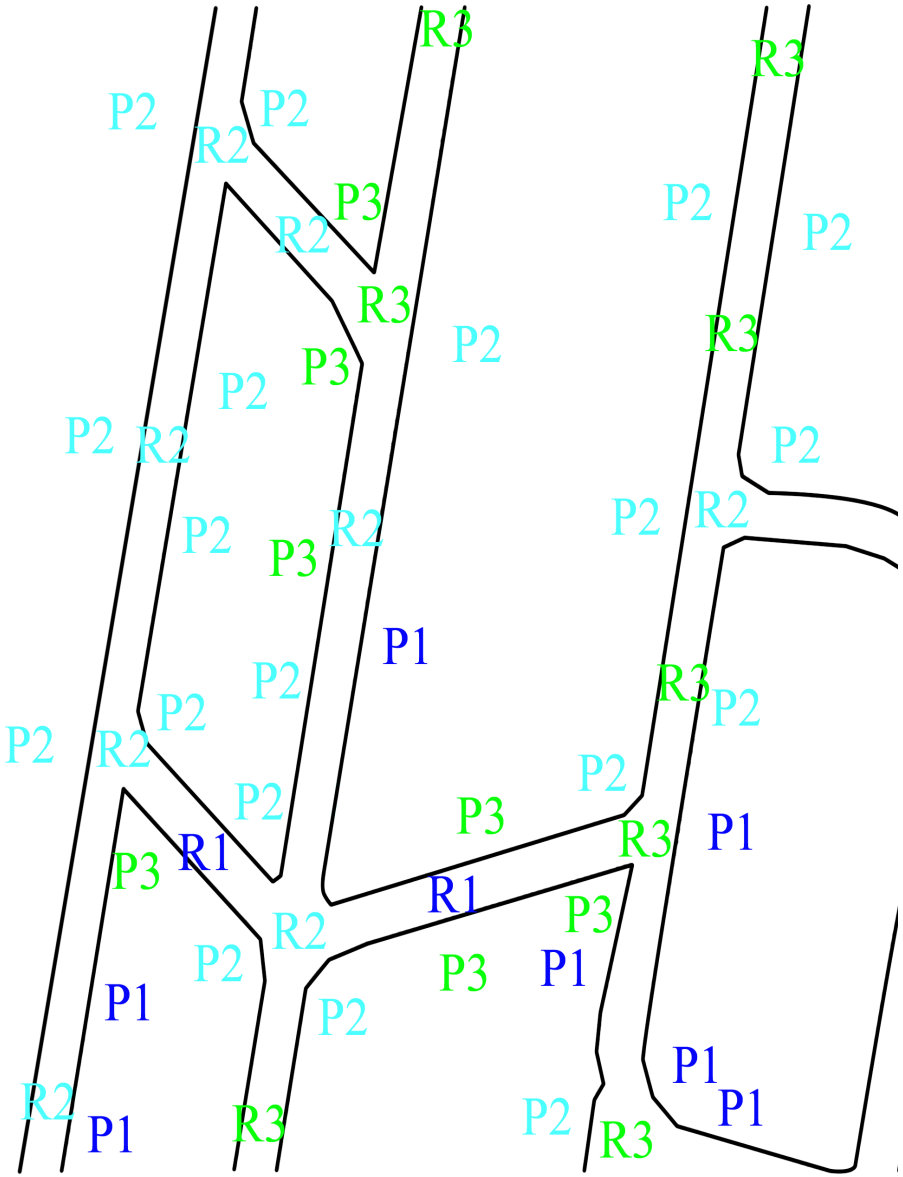
Coal mine entry rating system – Tier 1



Tier 1 ratings are produced quickly by all personnel.

The floor was rated “1” in all locations.

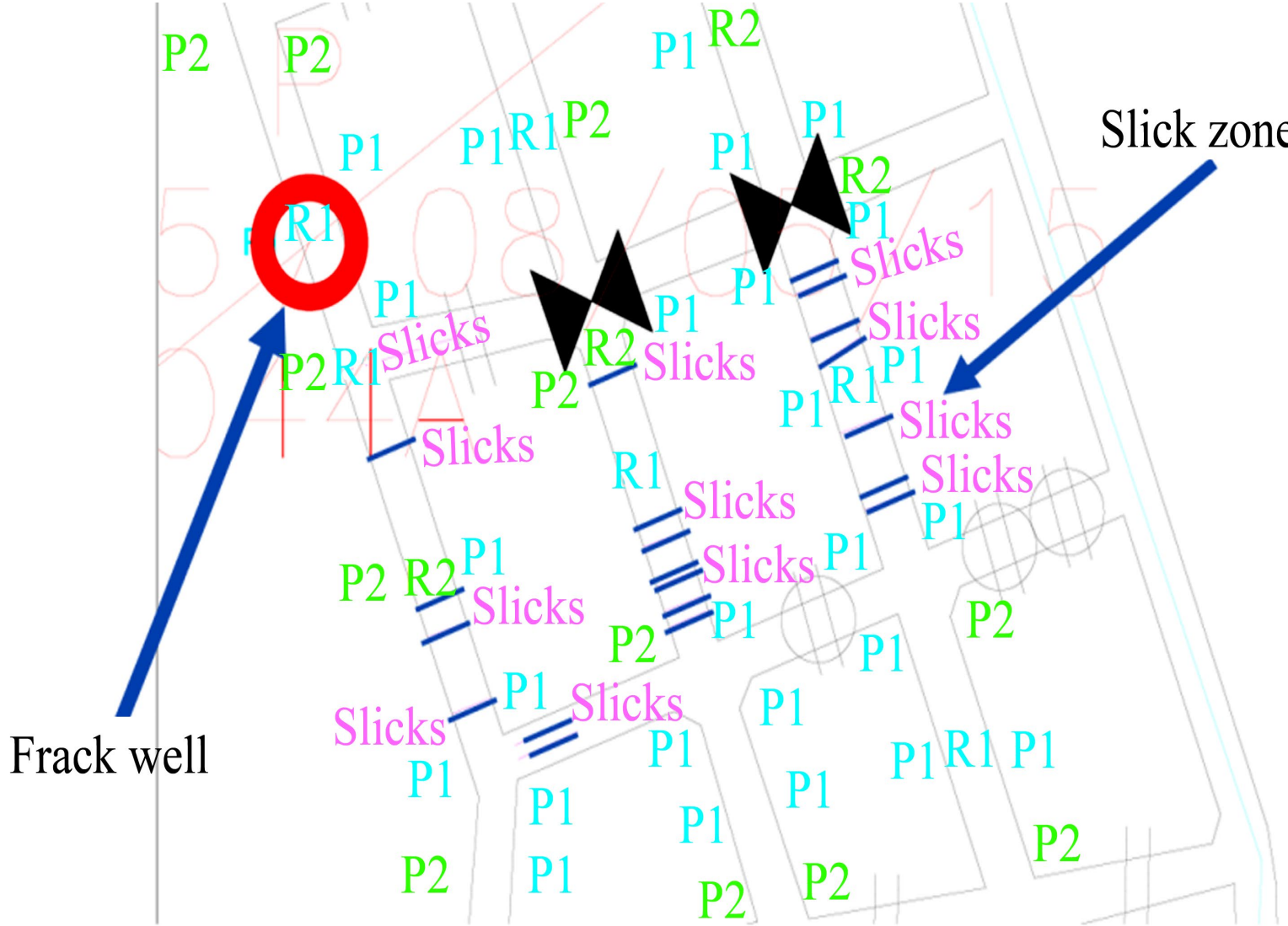
Coal mine entry rating system – Tier 2



Tier 2 requires rating the straights and crosscuts in addition to the intersections.

This tier of mapping can be done by all mine personnel, but will require additional time.

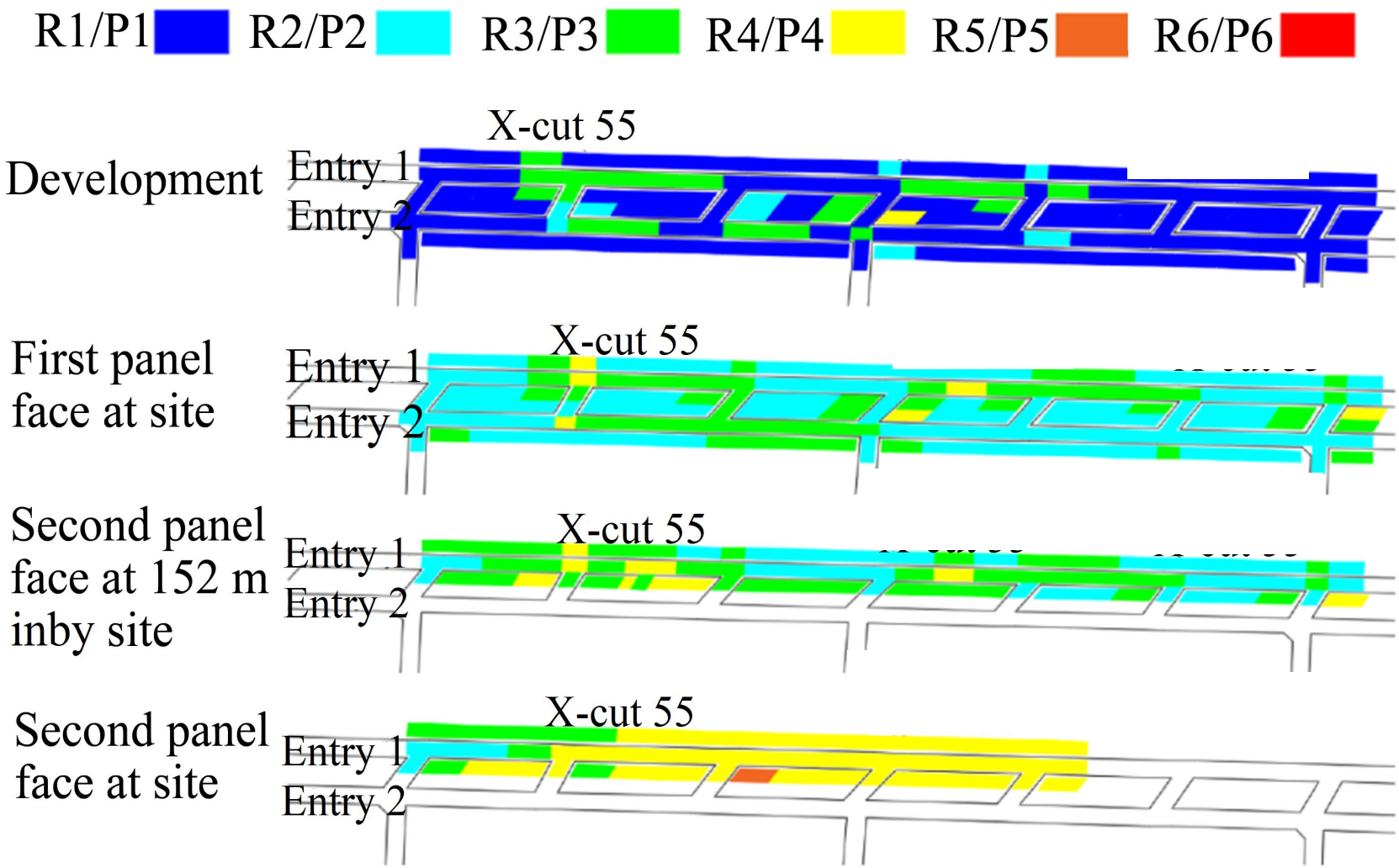
Coal mine entry rating system – Tier 3



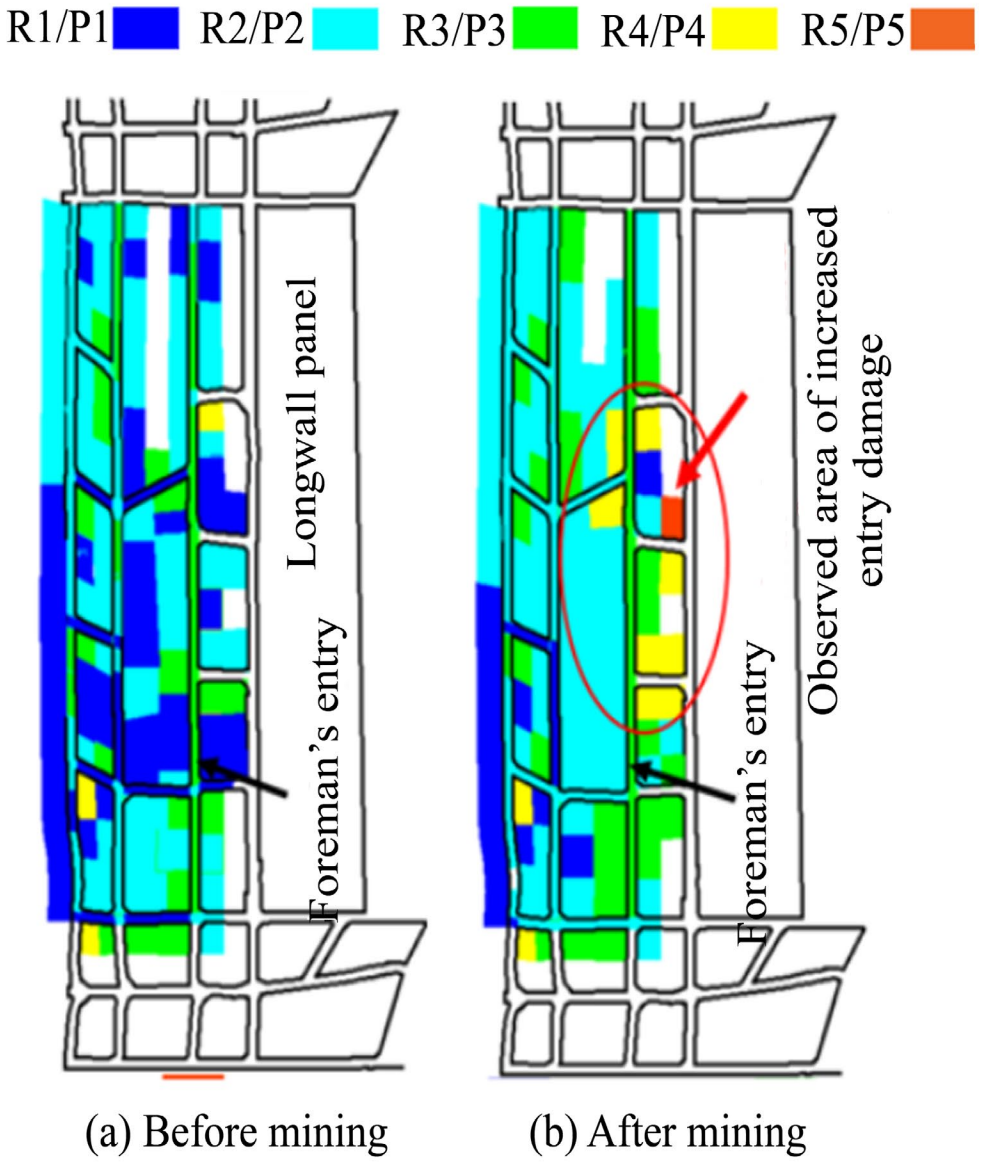
Tier 3 incorporates geology.

In this case a zone with abundant slicks is identified along with the entry ratings.

Case study 1 – Increased gateroad loading

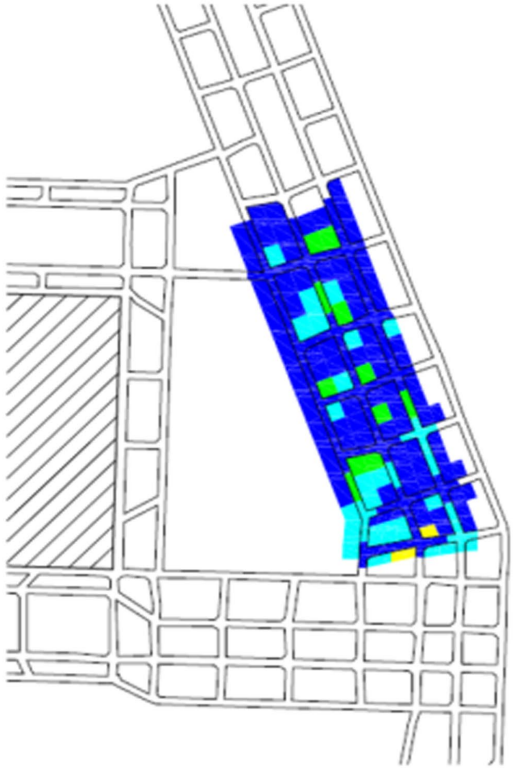


Case study 2 – Bleeder entries before and after mining

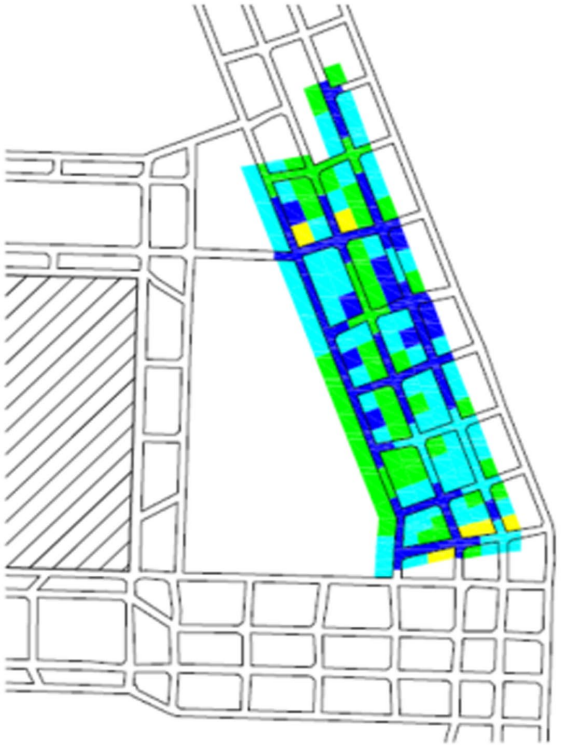


Case study 3 – Bleeder entries after development, after longwall mining 30m, and second panel mining.

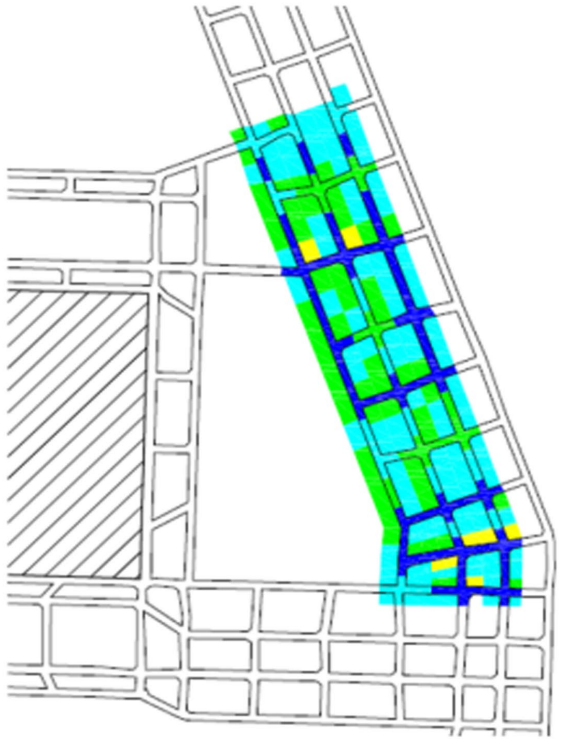
R1/P1 R2/P2 R3/P3 R4/P4 R5/P5



(a) After entry development



(b) After the first panel was mined 30 m



(c) After the first panel completion and the second panel was mined 1463 m

Coal mine entry rating system – Conclusions

- Through multiple case studies the coal mine entry rating system has proven to be a useful research tool. This method assists in understanding the performance of supports on entries over time while delivering a consistent method to rate the entries.

- By offering three mapping options, the rating system provides flexibility if time or the experience of personnel is a concern.

- This mapping system is a bridge between qualitative and quantitative data. The goal is to make a mapping standard that can be used by both researchers and producers to enhance miner safety and health.

Calling All Innovators!

You could **win** the
NIOSH Mine Safety and Health
Technology Innovations Award

For submission info:
go.usa.gov/xKtxe

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Thank you!
Any questions?

Co-authors:
Ted Klemetti
Craig Compton

Contact Information:
Mark Van Dyke
Email: mvandyke@cdc.gov

NIOSH Mining Program
www.cdc.gov/niosh/mining