Hazard Recognition Training Program for Underground Limestone

Instructor's Guide

Prepared by
Pittsburgh Research Laboratory
NIOSH
Pittsburgh, PA.

Table of Contents

Acknowledgments: K.M. Kowalski, L.L. Rethi, E.A. Barrett, R.A. Calhoun, J.J. Haggerty (Pittsburgh Research Laboratory, NIOSH) and J.P. Flick (The Pennsylvania State University).

Introduction

From 1985 through 1994, 78 fatalities occurred in the stone mining industry, sixty at surface operations and eighteen at underground mines. Relative to the quantity of stone produced, the number of fatalities that occurred underground (23%) was disproportionate to the number that occurred on the surface. Five percent of stone production came from underground mines, 95% from surface mines. A review of the injury data during this period for underground limestone mines indicated a high concentration in one area - ground failures. Approximately 68% of the accidents involved roof rock, 20% highwalls, 8% ribs and 4% faces (MSHA Database).

It is hypothesized that the number of injuries to underground limestone miners may be reduced through improved training that focuses on better recognition of the numerous visual cues that are available for evaluating roof and rib conditions. To this end, researchers at NIOSH's Pittsburgh Research Laboratory have merged two proven methods of training miners to recognize hazards, stereoscopic (3-D) slides and the concept of degraded images, into this training program for underground limestone.

Stereoscopic (3-D) slides have been shown in earlier Bureau of Mines research to be an effective training aid for improving the ability of miners to recognize various geologic and mining-induced irregularities that can cause groundfalls[1]. They realistically portray the natural mine environment, and thus are an excellent classroom training aid for teaching miners to recognize visual cues that characterize unstable ground conditions.

The degraded image concept was originally developed and used for military target detection training. Research had shown that flight observers who were trained with less than ideal (or degraded) pictures were more successful in subsequent identification of targets than those trained using ideal (or highlighted) pictures of targets. Degraded image describes scenes where the target is partially hidden by cloud cover, dust, rain, natural barriers, buildings, or other obstructions that can camouflage or confuse the target.

In order to investigate this concept for training miners to recognize hazards, Bureau of Mines researchers developed a prototype hazard recognition training program using degraded mining scenes. A control program based on traditional, highlighted mining scenes was also developed. Both were applied to subjects in a field experiment. Results indicated that miners trained with the degraded images did significantly better on a follow-up test of hazard recognition.[2] The degraded image hazard recognition program teaches trainees to look for hazards in a more realistic manner within the context of the total mine environment.

---

1 (IC 9210) (RI 9527) Bureau of Mines, Dept. of Interior

2 Kowalski, K.M., Fotta, B., & Barrett, E.A. (1995). Modifying Behavior to Improve Miner's Hazard Recognition Skills Thru Training. Proceedings of The 26th Annual Institute on Mining Health. Safety & Research, Virginia Tech, Blacksburg, VA. August 28-30, 1995.

This hazard recognition training program for underground limestone miners was developed by combining the degraded image concept with 3-D slides. It focuses on teaching miners certain techniques for recognizing visual cues in the workplace and using these cues to evaluate mining conditions and hazardous situations. Even though sight is the primary sense used for detecting hazards, it should be stressed that other senses, such as sound can also play an important role in hazard detection to compliment visual acuity.

Learning Objectives

- To introduce hazard recognition techniques and practices that can be used in the workplace
- To identify specific underground limestone mining hazards
- To discuss the appropriate steps to correct hazards
- To work more safely

Classroom Format

The instructor explains to the class:

Using 3-D scenes, you will conduct an evaluation of an underground limestone mine and discuss those cues that alert you to potential hazards.

C The class will work together, following a story line, and look at each scene as a group.

C Each class member will be given four 3-D reels, each containing seven scenes.

C Each class member will be instructed to look at a specific scene and then the class will discuss what potential hazards may be present. Please do not move to the next scene until instructed to do so.

C Hazard recognition techniques and corrective actions will be discussed for each scene.

Key Concepts

Reel A:	Loose rock in roadway/Roof cavities Reduced visibility
Reel B:	Scaling tracks Pillar integrity Slips/Fractures in the roof/rib Different vantage points
Reel C:	Different vantage points (continued) Roof bolts provide important cues Sand channels/Clay veins
Reel D:	Sand channels/Clay veins (continued) Newly exposed face areas Basic physics/Rocks fall fast and hit hard

Materials

Materials included:

a. instructor's notes that discuss the seven scenes on each 3-D reel
b. attachments for making overheads
c. true/false quiz that allows trainees to self-assess the knowledge gained by each person
d. student handout of specific information discussed

Equipment necessary (not included in this package):

Four 3-D reels labeled A, B, C and D. These may be obtained from the NIOSH, Pittsburgh Research Laboratory, phone 412-386-5901, fax 412-386-5902, or email minetraining@cdc.gov

Pencils

Overhead projector

ViewMaster Viewers™ for viewing the 3-D reels. They may be purchased at most toy stores.

Instructional Method

The instructor should read the Instructor's Notes and become thoroughly familiar with the contents. Words in *italics* may be read to the class or the instructor may chose to use your own wording. Overheads may be made from the masters included in the package. The instructor will need to demonstrate how the slide reels are placed in the viewer. The program then begins as the instructor and the class view each scene in sequence, and discuss the key concepts.

Outline of Training Program

a. Introduce the overhead that depicts "Roof and Rib" accident statistics for underground stone mines. (Master 1) Discuss comparisons between stone and other metal/nonmetal mines. This chart can be updated to represent more recent years.

b. Introduce the overhead that shows the objectives and format of the training module. (Master 2) Explain how the exercise will progress and instruct participants how to use the viewer and reels.

c. Pass out the viewers and four 3-D reels (A, B, C and D) to participants.

d. Begin module with reel A and continue through reel B, slide number 13.

e. Reinforce by introducing the overhead of the key concepts covered to this point in the training module. (Masters 3, 4 and 5)

f. Continue module with B number 14 and work through slide D, number 26. Show overheads of formulas for determining physical aspects of rocks and discuss. (Masters 6 and 7)

g. Introduce overhead of key concepts covered in the second half of the exercise and remind students that D numbers 27 and 28 are slides that reference the key concepts and show participants where these concepts can be found on the reels. (Masters 8 and 9)

h. Administer Quiz and discuss answers. (Masters 10, 11 and 12)

i. Pass out the student handout at the end of the class. (Masters 13 – 17)

Instructor's Notes

Insert Reel A:

Slide A1 - Title slide

Stress the importance of the entire class working through the exercise one scene at a time. Remind participants to stay on the scene the instructor is discussing and not to jump ahead until directed to do so. The instructor should lead participants to the next scene by giving participants a general idea of what they are looking at and follow the story line. For instance: *"We are going to be conducting an examination of an underground limestone mine. As we travel through it, we will evaluate and discuss the conditions we observe".*

Slide A2 - Rock in travel way

As we enter the mine, we see some loose rock in the travel way.
What should you ask yourself when you see rock in the roadway?
Where could these rocks have come from?
What hazards do rocks on the roadway pose?

- Loose rock on roadway indicates potential hazards.
- Rocks may have fallen off overloaded trucks.
- Rocks may have fallen from roof or rib.
- Rocks may indicate hazardous roof/rib conditions.
- Rocks may contribute to transportation related accidents.
- Rocks may contribute to trip/fall accidents.
- Rocks may indicate potential for roof failure.

Note: Rocks in the roadway may be the result of pieces falling from the roof/rib or from a haulage truck, may indicate that an area has been scaled or re-scaled, or may indicate that the roof/rib conditions are deteriorating. When rocks are in the roadway, we should ask ourselves where they came from, and recognize that they are potential hazards. Everyone should pay attention to loose rocks and investigate their source. Report any accumulation of rocks in the roadway to your supervisor. Do not work in an area where there is an accumulation of rock until a cause has been determined and corrective action has been taken (if necessary).

Slide A3 - Cavity in roof

You decide to investigate and look at the area directly above the loose rock in the roadway.

What does this scene suggest to you?

- Rocks can fall from existing slip/fractures at any time.
- Fallen rocks may be an indication that the stability of the roof is changing.

Note: It appears that a section of a slip or fracture has become less stable and the loose rocks in the runway are cues that can alert us to changing conditions in the integrity the back/roof. The cavity in the roof may be where the rock in the middle of the roadway fell from. It appears that the roof has been bolted around (on both sides) the slip/fracture for additional stability. However, even when precautionary measures such as roof bolting are taken, the possibility for unsafe conditions might still exist. Roof conditions can change quickly and workers should use all the cues available to them to guard against a rock fall accident. Monitor roof conditions.

Slide A4 - Rock/loose rubble at edge of the roadway

As we continue in the mine, we see another, less obvious, example of loose rock; this time it is on the edge of the travel way and we begin to encounter fog.

How does fog affect our ability to identify hazards?

What other conditions can reduce visibility in the mines?

- Our ability to recognize hazards is reduced because of the fog.
- Blasting can be the source of increased particulate in the mine.
- Equipment exhausts can contribute to reduced visibility.
- Dust from equipment can reduce visibility.
- Poor ventilation can lead to increased dust or particulate levels.
- Equipment windshields can also be affected by these conditions.
- Low light conditions reduce our ability to detect hazards.

Note: Decreased visibility makes it harder to see hazards. It is extremely difficult for workers to detect hazards that they cannot clearly see. However, with practice, some hazards can be detected in these degraded conditions and appropriate actions can be taken. What are some other possibilities that could effect our ability to have a clear view of hazards? Weather conditions can effect visibility. Equipment running on dry roadways can create dust. Blasting can be a source of increased particulate in the mine. Running equipment exhaust can reduce our ability to see. Ventilation that is not adequate can also effect the visibility in underground limestone mines. During the field

test of this training exercise, many participants who operate equipment stated that the windshields of their equipment often fogged up when traveling from outside to inside the mine.

Slide A5 - Rock cavity in roof

We look above the loose rock and through the fog see a cavity in the roof.

What can we determine from looking at the roof above the loose rubble on the runway?

What actions would you take if you saw this scene?

- Do not enter area under cavities with fresh rock on the bottom.
- Cavities in the roof with rock below them require immediate attention.
- Supervisory personnel must evaluate status and attempt to insure safe working environments.
- Communicate what you found to the appropriate person(s).
- It may be necessary to danger off the area to prevent entry by co-workers.
- You might request that the area be re-scaled.

Note: Though it is difficult to see, it appears that a piece of roof has separated. The rubble is an indication that a slab has fallen. The ledge of the cavity provides a cue that a section of roof is missing; notice the absence of scale tracks in the area where the roof has fallen. Now that we see that a section of the roof has fallen, what should be done? Communicate what you found to the appropriate person(s). If you have to leave the area it may be necessary to barricade the area off to prevent someone else from going under bad roof/back.

Slide A6 - Fresh scale tracks in roof

We are looking at a section of roof.

What role do scale tracks play in your safety?

What does the color of scale tracks tell you?

- All working areas and travel ways must be scaled regularly.
- Scale track marks are used when evaluating roof.
- The presence of scale tracks does not guarantee the area is safe.
- Fresh scale tracks are white and indicate that the roof has been recently scaled.
- Older scale tracks are discolored because of diesel exhausts and discoloration indicates that it has been some time since the area has been scaled.

Mine managers should encourage workers to report any area they believe needs to be scaled or re-scaled.

- Scaling is an ongoing process of removing all loose material.

Note: Scale tracks are cues that can tell us certain facts. The color of the scale tracks can tell us approximately how long ago the roof has been scaled. The number and location of the scale tracks tell us that an effort was made to pull down loose pieces of rock. One cannot assume that the roof is safe based solely on tracks left by the mechanical scaler. Conditions can change immediately after corrective actions are taken and roof evaluation should be a continuous effort. Scale tracks, specifically the color and location, can be another cue to use in evaluating a particular section of roof. Moisture and diesel exhaust can darken scale tracks; this indicates that the scaling may have occurred some time ago and re-scaling could be necessary. In addition, a lighter colored section on the roof or rib may indicate the presence of loose rock that has been dried out by circulating air. When you see certain areas that the pick has "worked" you know that this specific area was a concern to the mechanical scaling operator and should be evaluated periodically.

Slide A7 - Fresh scale tracks/ledge or lip

In this slide we see another area that shows fresh scale tracks.

Does the presence of scale tracks mean that an area is safe?

Is there anything in this scene you would question?

- The presence of scale track marks does not guarantee that there is not loose material.
- During scaling, the scaler operator must attempt to remove all loose material.
- It is a common practice for the operator to re-scale the same area on an as needed basis.
- It is vitally important for the worker to look at all areas of the mine roof for areas that may require scaling or re-scaling.
- During scaling, the scaler operator attempts to ascend the mine roof to identify areas that are loose.
- The loose rock in the foreground appears not to have been scaled.
- The ledge in the center is an area that warrants special attention to scaling and frequent inspection to monitor any change.

Note: The mechanical scaler operator and hand scalers play a key role in preparing and maintaining safe conditions in work and travel areas. The scaler operator must try to remove every loose piece of rock in the areas of the mine where work is being performed or where travel occurs. The operator needs support and feedback from all workers to adequately perform his job. Roof safety in the mine is everyone’s responsibility. If you ever see, or even suspect any loose rock, crumbling ledges, or

questionable roof and rib condition, notify your supervisor immediately so that corrective actions can be taken. Never work or travel under or near any questionable areas.

***NOTE: Remove reel A and insert reel B at scene number 8.**

Slide B 8 - Ledge at intersecting pillar and roof

In this slide we are looking at the area where the pillar intersects with the roof.

Why should we pay extra attention to these areas?

How does this area look?

- The areas where the rib meets the roof is inherently weak.
- Stress factors result in loose rock in these areas.
- Report questionable areas immediately to supervisory personnel.
- Use extra caution and examine these apexes closely.

Note: The apex where the rib meets the roof is inherently weak. These areas often are points where rock failures may occur. These areas should be examined closely and often. Report all areas that are suspect to supervisory personnel immediately. Mechanical scaling, re-scaling and hand scaling should be done regularly to ensure these areas are free of loose rock. Underground limestone mines are unique and each one has its own geographical features. Learn the specifics of your mine and be aware of those geological conditions specific to your mine and take appropriate safeguards.

Slide B 9 - Pillar

As we continue our examination, we see a pillar that requires further investigation.

What do you see that may be of concern?

Why should it be a concern?

- The primary purpose of pillars is roof support.
- Natural bedding planes can affect pillar integrity.
- The number and direction of bedding planes can affect both roof and pillar strength.

Note: Pillars support the roof and are the primary defense in roof control. The stresses on the pillar directly affect the integrity of the pillar. Most pillars eventually resemble an hourglass. Employees should constantly evaluate their surroundings, especially the roof, rib and pillar. Both hand scalers and machine scalers should try to maintain pillars by removing loose rock. Bedding planes that occur naturally in the rock introduce additional hazards. Depending on their direction and number, they sometimes weaken the pillar and present additional hazards. They can contribute to those factors that act upon the rock and can lead to failure of pillar support. In this scene, if major stresses from the roof would occur, the pillar could actually slide at the bedding planes where the weakness exists.

Slide B 10 - Bedding planes through a pillar

How many bedding planes do we see in the pillar?

Is there a particular area that should concern you most?

Where is the weakest area?

- There are three natural bedding planes in the pillar. The first runs almost horizontally across the pillar at the top of the area shown. The other 2 are almost parallel and run from the bottom left to the top right of the pillar.
- The pie-shaped area to the left may be the weakest point of the pillar. It could slide out if enough stress acted upon it.

Note: Particular attention should be placed on pillar integrity. As discussed, bedding planes that occur naturally in rock directly affect overall pillar integrity. Discuss how the pie shaped piece of rock would be suspect to being a weak area that may fall when stress is applied to the entire pillar. Constant pillar inspection and maintenance are tools necessary to insure your safety.

Slide B 11 - Patterns of slips/joints/fractures

After evaluating the pillar you continue in the mine and observe the roof condition.

How do slips/joints affect roof conditions?

How many slips or joints do you see?

- Slips or joints in the roof are factors that warrant investigation.
- Slips/joints affect roof integrity.
- There are 3 slips running toward the pillar.
- Depending on their vertical path, they create areas that have the potential for failure.

- It is impossible to determine vertical components of slips.
- Areas where slips occur may require roof bolting for additional support.
- Slips/fractures become more of a concern if they intersect.
- The vertical direction of slips can sometimes be determined by following the slip back to a point where it extends into a pillar or rib.

Note: When slips in the roof intersect or begin to merge together, the potential for loose rock may also increase. Based on the visual cues available to us, this condition should indicate an area of weakness in the roof strata. It may be potentially less dangerous if the slips run parallel instead of intersecting; however, all slips should be evaluated thoroughly and appropriate actions taken. It is less hazardous if the slips intersect above an existing pillar because the pillar provides additional support to the roof. The pillar provides more stability in the event loose rock is present. Stress the fact that it is impossible to determine the vertical components of a slip by looking at it from the mine floor. The crack could run vertically at a 90-degree angle or at a five degree, or lower angle. The direction of the perpendicular crack greatly influences the integrity of the roof. The presence of slips/fractures should be reported to supervisory personnel and should be communicated to the scaler operator.

Slide B 12 - A single slip

When we focus on the single slip/fracture on the left side, we see this scene.

What do the visual cues tell?

What are some of the potential hazards relating to this scene?

- Slips and fractures require special attention.
- The roof on either side of slips/fractures can become less stable.
- In this case, loose rock has fallen and there appear to be several pieces of rock that the mechanical scaler has tried to pull down.
- Bolts have been placed in this area to provide additional support to the roof.

Note: Even when a single slip/fracture is present, it should alert you to conduct a thorough evaluation of that area. Remember that even when an area has been examined and corrective actions have been taken, the area needs continuous re-evaluation to determine any change in its condition. When possible, use sounding techniques, test holes and visual cues when attempting to evaluate roof and rib conditions.

Slide B 13 - Closer look at the slip

When we take a closer look at the area, we see scale tracks from a mechanical scaler.

What do the scale tracks tell you?

Which was done first, scaling or bolting?

- Sequence of events can be determined if the visual cues are available to us.
- Loose rock within the crevice has been scaled down.
- The scaling took place before the bolting.
- Areas where conditions such as this occur should be examined regularly and any changes or concerns brought to the attention of supervisory personnel.

Note: Scale tracks and the visual geological conditions can tell miners the sequence of events. When trying to evaluate roof and rib conditions, we should use all the visual cues available to us. Miners should continuously evaluate the environment where they work. Special examination of areas that trigger a concern are valuable tools and experienced miners should rely on their past experiences with similar conditions. Slips/fractures require close observation and inspection. Conditions that are suspect should be brought to the attention of supervisory personnel immediately.

***NOTE: Show Overheads of Concepts Covered to this Point (Masters 3, 4 & 5)**

Slide B 14 - Rock jutting from roof

After examining the slip/fracture, you continue your evaluation of the roof and observe a piece of rock jutting out from the roof.

Howwould you go about evaluating an area as seen in the slide?

What if you could not reach the roof to sound it?

- Miners should investigate any area they feel is questionable.
- If possible, a scaler should sound the roof from a bucket or platform truck if not able to reach the roof from his/her present location.
- Miners should view the area from several angles. Never position yourself in harm's way when conducting an examination.
- Notify supervisory personnel of any unsafe conditions.

NOTE: Remove reel B and insert reel C at number 15

Slide C15-View of roof line from different (reverse) angle

You walk around the rock projection and look at the same section of roof from the reverse angle of slide B 14.

What are the safety advantages of looking at suspicious sections of roof from more than one angle?

What can be seen in this slide that cannot be seen in the previous slide?

How could a miner be injured by attempting to view sections of roof or rib from different angles?

What action should be taken if a miner observes an actual or suspicious section of roof that may pose a safety hazard?

- The miner, in day to day operations, plays a crucial role in the roof safety program at any mine.
- Cracks or loose sections of rock may be visible from only one vantage point.
- Looking at an actual or suspicious section of roof from more than one vantage point could provide critical safety information to the miner.
- Miners should look ahead and look back often at sections of the roof to evaluate the safety of the roof.
- A miner should never venture under any actual or suspicious section of the roof to try to get a better vantage point.
- Miners should report any actual or suspicious sections of roof/rib to management immediately (as well as co-workers), so that corrective action might be taken.

Note: Looking at a section of roof from several different vantage points may be helpful in spotting actual or suspicious dangerous sections of roof. What a miner sees from one angle may look entirely different from another angle. It is extremely important for miners to look at an area from several vantage points. From one vantage point, the roof may appear to be stable; from a different view, cracks or weak characteristics may be more obvious. When attempting to view any area, a miner should never position himself in an unsafe location. It is possible to be injured by falling rock from the area you are trying to observe. Never position yourself under any actual or suspicious roof when in the process of examining the area. Report any areas that are potentially dangerous to management immediately so that corrective action might be taken. Also advise co-workers of the situation and if necessary, instruct them to avoid the immediate area until it is corrected.

Slide C 16 - View of ledge on roof

We observe what appears to be a ledge line, indicating that a ledge or uneven section of roof lies ahead.

What hazardous conditions may be present on the ledge face that are not visible from this vantage point?

Why is it important for the scaler to make every possible effort to scale all sections of the ledge?

Why is it sometimes difficult to identify a ledge line as seen in this scene?

Why is it important to closely monitor the loose rock activity on ledges?

- Loose rock can be present on ledges.
- Ledges need special attention during the scaling process.
- Ledge lines may be difficult to detect.
- The presence of a ledge should indicate to the miner that the area needs to be monitored continuously for weak, crumbling, or loose materials that pose a falling hazard.
- Any ledge with actual or suspicious loose rock should be reported to management so that corrective action is taken.
- Ledges may be present anywhere on the roof; where the roof meets the rib, or at newly exposed face areas.

Note: Visually identifying ledges is the first step in evaluating any safety hazards that they (ledges) can pose. Ledges are areas where loose or crumbling rock can exist and pose hazards to miners as they work or travel in the mine. Depending on the vantage point, a ledge may be difficult to detect. Ledges are areas of the mine roof that should be observed regularly, due to the potential for falling rock. Any ledge on any part of the roof or face area is an area where loose rock may be present. It is important for every miner to regularly evaluate ledges for any actual or suspicious loose rock. A miner should never go under any ledge area that may pose a safety hazard. Any type of loose rock activity on a ledge should be reported to management and co-workers so that corrective action may be taken.

Slide C17 - View of ledge in roof from reverse angle

We go to the other side and observe the same ledge from the reverse angle.

Why is the ledge, when observed from this angle, easier to recognize than from the opposite angle?

Why is it important to look at both the ledge face from one angle, and the ledge line in the roof from another angle in order to evaluate the ledge's stability, or the presence of loose rock?

What does the presence of a ledge actually indicate?

Where in the mine might ledges be found?

Why is it important to monitor loose rock activity on ledges?

What type(s) of mining activities might have an effect on the stability of ledges?

- Ledges may look different when viewed from several other vantage points.
- Ledges may pose falling rock hazards.
- Ledges indicate a section of layered or laminated rock strata.
- Ledges may be formed by blasting or scaling activities.
- Ledges can exist anywhere on mine roof or rib. The apex can be inherently weak and the potential for failure may be greater at that point

Note: Visually identifying ledges is the first step in evaluating any potential hazards. Ledges can be formed naturally in the strata, or as a result of blasting or scaling. Ledges pose potential safety hazards to miners who work or travel where ledges are present. Ledges indicate layered or laminated strata where the potential for falling rock is increased.

Slide C18 - Roof bolts supporting slips/fractures

Lets go back to the area where we observed several slips running parallel in the roof.

When are roof bolts used in limestone mining?

Why are there roof bolts in this area?

- Usually roof bolts are used on an "as needed, and where needed basis".
- When slips are encountered miners should notify supervisory personnel so a determination can be made for corrective action.
- Roof bolts bind the strata of the roof into a layer that acts like a bridge to support the roof.
- Notice that there are no bolts drilled directly into the slip. It is better to support the areas on both sides of the slip.

Note: Roof bolts are another tool used to protect miners in some underground limestone mines. When roof conditions warrant, bolts are installed to strengthen a layer of roof. Test holes are also drilled to see if the strata above are broken or if there is a

change in the integrity of the roof rock. When you evaluate an area that has been bolted, there are visual cues that can tell you the sequence of events leading to what you see. For example, the area might have been scaled, later a piece of rock came down, and as a result a lip formed which required bolting. Bolting usually indicates the area previously experienced a failure, or a weakness in the stability of the roof. These areas should be inspected carefully to determine if conditions have changed. The area may be safe now, but bolts warrant periodic inspections.

Slide C19 - Closer look at a slip bolting pattern

Lets take a closer look at the bolting pattern around the slip.

Why is it important to bolt the areas around the slip?

- Slips/fractures indicate a weak area in the roof.
- The lip or edge of a slip is the weakest area in this scene.
- Forces acting on the roof will cause the edge of the lip to break and fall.
- Roof bolts bind the rock around the slip and offer additional support.

Slide C20 - Face area that is bolted

As we continue our evaluation, we see an area of the face that has been bolted.

What are some conditions that could require an area where no slips/fractures are present to be bolted?

- A test hole could have identified a break in the strata above the immediate roof.
- An existing condition could have been detected that continues in the direction of where mining will continue.
- The roof may have been sounded and was drummy therefore, a the decision was made to bolt the area.
- Sand channels or clay veins may have been discovered above the immediate roof.

Note: Face areas sometimes require additional bolting for roof support. There are several conditions that warrant bolting at the face. An existing geological condition that affects general roof and rib stability may require that roof bolting take place. If an area is questionable and test holes reveal that the strata above the immediate roof is broken, roof bolts should be installed to bind a layer of strata for better support. The mechanical scaler operator may have tested the roof and, when sounding it, discovered that it was drummy and decided to bolt the area. The point being, roof bolting is an indication that something has or is occurring to the condition of the roof or rib. Extra examination and evaluation may be required.

Slide C21 - Sand channel running through the rock

Outby the bolted face area that we just looked at, we see the reasoning behind the decision to bolt the face area.

Why are sand channels/clay veins signals for weakened strata?

How would a sand channel or clay vein weaken rock strata?

What hazards are associated with sand channel or clay veins?

Why should scalers be extra cautious when removing loose rock in these areas?

- Sand channels/clay veins indicate a weakness in the rock.
- The integrity of the rock is lost when sand channels/clay veins are present.
- Special attention in examining these areas is crucial.
- Scalers should pay particular attention to these areas and should ensure all loose areas are pulled down and/or secured by bolting.
- Large sand channels are extremely dangerous and should be brought to the attention of management.

Note: Sand channels and clay veins are a concern to limestone miners. They usually indicate the potential for loose rock is greater. The stability of the rock is compromised when these conditions are present. Sand and clay mixed in or through the rock strata increases the potential for roof and rib falls. Use extra caution when working in areas that have these conditions and communicate to co-workers and management any concerns so that the potential problem could be corrected and monitored.

***NOTE: Remove reel C and insert reel D at number 22**

Slide D 22 - Effects of sand channels running through rock

Why should everyone pay attention to sand channels?

- Sand channels/ clay veins indicate a weakness in the integrity of the rock.
- Notice the large stone that has fallen from the channel.
- Areas where large sand channels appear may need to be dangered off.
- Report these conditions to management immediately.
- Both hand scalers and machine scalers must use caution when scaling under these conditions.

Note: Anytime a condition exists that affects the integrity of the rock, extra caution must be used. Use visual cues, test holes, bolting and constant evaluation of these conditions to protect yourself and fellow workers. In extreme cases, certain areas are

by-passed in the mining process to reduce the potential for incidents resulting from hazardous conditions like large sand channels and clay veins.

Slide D 23 - Left rib of a face area

Why is a newly exposed face area a potential hazard?

What precautions are taken to reduce these hazards?

How would the mechanical scaler scale a newly exposed face; where would you start and how would you proceed?

In this scene where would be the greatest potential for roof/rib fall?

- Newly exposed face areas have an increased potential for roof/rib fall.
- Never travel inby (past) scale tracks when approaching new face area. Many miners recommend that a safety cushion of twenty feet be added at newly blasted face areas.
- In this scene, the face and left corner may have the greatest potential for roof/rib fall or roll.
- Mechanical operators should address the immediate roof and work inby to the face paying particular attention to the rib. If the rib appears to present a hazard, it should be scaled as progress is made.

Note: Newly exposed face areas are most dangerous. Prior to being scaled, these areas can have great potential for loose rock at the roof, rib and face. Never approach the face area until it has been scaled. Most machine scalers attack the immediate roof first as they enter new face areas. They work a short distance on the roof and then scale each rib the distance the roof has been scaled. Never enter a face area where machine scaling is in progress. Many operations wet down the face area after a blast has occurred and those rocks that are loose dry faster and can be seen. In many cases, the lighter color of the rock indicates the rock may be loose; air circulates behind loose rock and dries it more quickly.

Slide D24 - Newly exposed face

Slide D25 - Right rib of newly exposed face area

Lets look at the next slide (24; it shows the face looking head on. Slide 25 shows the right rib.)

What should you look for when you evaluate a face area that has just been scaled?

What should you do if you find an area that is questionable?

- Look for fresh scale tracks.
- Examine freshly scaled face areas for loose rock, ledges, clay/sand channels.
- Check the roof/rib for any signs of slips/fractures.
- Check the bottom for any signs of rocks or loose material that may have fallen from the roof/rib.
- Carefully examine the outby pillar and corner to determine stability.
- View areas from different angles.
- Notify co-workers and management of any suspicious areas.
- Ask scaler operator to re-scale questionable areas.
- Check for ledges.

Note: Newly exposed face areas should be scaled by mechanical scalers as soon as possible. By working inby attacking the immediate roof and then each side of the rib line, the operator protects both himself and co-workers. The operator will evaluate the area and look for loose rock, ledges, sand channels/clay veins and slips/fractures. The mechanical operator can also sound the roof and rib to determine stability. In field tests, many miners recommended that you stay back at least twenty feet outby the last visible scaling tracks. They stated that many times the roof and rib are affected by blasting and extra caution is warranted.

Slide 26 - Men standing in an entry with roof height shown

Look at the slide. Let's talk about how rocks falling from the roof can affect us. We are going to discuss this.

Note: Show overheads of formulas. Stress importance of roof evaluation and the fact that you will **never** outrun a falling piece of rock. In the formulas:

t = time in seconds
s = distance in feet
g = gravity in meters per second squared
a = acceleration in feet per second squared
v = velocity in feet per second
f = force in feet per second
m = mass in pounds

How long does it take a rock to fall?

How hard will it hit you?

***NOTE: Refer to two overheads that contain formulas and depict the physical characteristics of falling rock (Masters 6 & 7).**

***NOTE: Show masters of concepts covered in second half of module (8 &9).**

Slides D27, 28 - Review of key concepts that were covered

Participants should be given the opportunity to look at slides and concepts. Ask if there are any questions or comments on particular scenes. The following is a guide to where the key concepts are illustrated on the reel.

Loose rock in roadway. A: 2, 3

Fog/Haze degrades perceptions. A: 4, 5

Scaling tracks. A: 6, 7

Pillar integrity. B: 8, 9, 10

Slips/fractures in back/rib. B: 11, 12, 13

View area from different angles. B: 14, C: 15, 16, 17

Roof bolts. C: 18, 19, 20

Clay/sand veins. C: 21, D: 22

Newly exposed face areas. D: 23, 24, 25

Rock Physics. D: 26

Administer quiz. (Masters 10, 11 and 12)

After the class has completed the quiz, discuss the answers and comment on the specifics of the subject matter, referring as necessary to the information included in the Instructor's Guide.

Answers to true/false quiz:

1	False	10	True	19	True
2	False	11	True	20	False
3	False	12	True	21	True
4	True	13	True	22	True
5	True	14	True	23	True
6	True	15	True	24	True
7	True	16	False	25	True
8	True	17	True	26	True
9	False	18	False		

Attachments

A Look at Roof/Rib Accident Numbers
Underground Stone, 1989 - 1995*

Fatality Data

	1989	1990	1991	1992	1993	1994	1995
Operator falling, sliding, or rolling material	0	0	0	0	0	0	0
Operator fall of face, rib, side, or highwall	0	0	0	0	1	0	0
Operator fall of roof	0	0	1	2	5	1	0
Contractor falling, sliding, or rolling material	0	0	0	0	0	0	0
Contractor fall of face, rib, side, or highwall	0	0	0	0	0	0	0
Contractor fall of roof	0	0	0	0	0	0	0
Total fatals for year UG stone	0	0	1	3	8	2	0
Total fatals for year all other UG MNM	10	10	9	4	9	7	6
Total fatals for year all UG MNM	10	10	10	7	17	10	6

Lost Time Accident Data

	1989	1990	1991	1992	1993	1994	1995
Operator falling, sliding, or rolling material	1	0	0	0	0	0	0
Operator fall of face, rib, side, or highwall	1	0	2	2	1	4	0
Operator fall of roof	10	10	0	12	5	6	5
Contractor falling, sliding, or rolling material	0	0	0	0	0	0	0
Contractor fall of face, rib, side, or highwall	0	0	0	1	0	0	0
Contractor fall of roof	0	0	0	0	0	0	0
Total injuries for year UG stone	136	123	95	104	81	96	66
Total injuries for year all other UG MNM	947	907	735	558	547	639	555
Total injuries for year all UG MNM	1083	1030	830	662	628	735	621

* Reference: *MSHA Mine Injuries and Worktime Quarterly.* Preliminary and Final Editions, 1989 – 1995

OBJECTIVES

To introduce hazard recognition techniques and practices that you can use in your workplace to help you work more safely.

- Participant will be able to identify hazards
- Participant will be able to take appropriate steps to correct hazard
- Participant will work more safely

FORMAT

Using 3-D scenes, you will conduct an evaluation of an underground limestone mine and discuss those cues that alert you to potential hazards.

- Participants will work together and look at the slide as a group.
- There are seven scenes on each of the four reels.
- You will be instructed to look at a specific scene and then discuss what potential hazards may be present.
- Hazard recognition techniques and corrective actions will be discussed for each scene.

Key Concepts Covered in Module One

Loose rock in roadway/roof cavities:

- Ask yourself where rock(s) came from and investigate their source.
- Carefully examine and evaluate cavities and slips/fractures.
- Rocks in roadway may indicate unstable roof/rib conditions.
- Do not enter areas where fresh rock is on the bottom and a cavity in the roof exists.
- Take appropriate actions based on your evaluation.
- Communicate any unsafe condition to co-workers and management.

Reduced visibility limits our ability to detect hazards:

- Our ability to recognize hazards is reduced due to fog, dust, poor lighting, equipment exhaust and poor ventilation.
- Take time to examine areas more carefully in these conditions.
- With practice, some hazards can be detected in these degraded conditions.
- When in doubt, ask for assistance.

Scaling tracks:

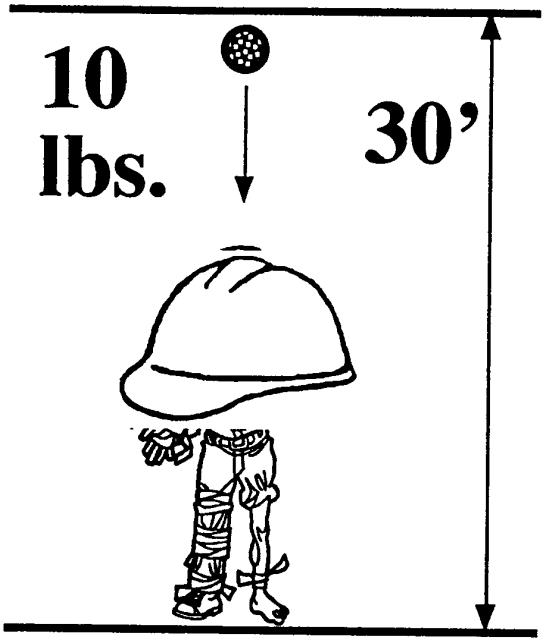
- All working areas and travelways must be scaled regularly.
- Use scaling tracks when evaluating roof and rib/conditions.
- Scaling tracks do not guarantee that the area is safe.
- Report any area you feel needs to be re-scaled.
- The color of scaling tracks changes over time.
- Pay particular attention to ledges or uneven roof.
- Communicate concerns to fellow workers and management.

Pillar integrity:

- Pillars provide primary support for the roof.
- Ledges where the rib meets the roof are key areas to examine.
- Natural bedding planes can affect pillar strength and provide the potential for loose rock.
- Notify management immediately when unsafe conditions are observed.
- Pillar maintenance is vital to safe working conditions.

Slips/fractures in the roof/rib:

- The presence of slips/fractures in roof warrants investigation.
- Directly affect integrity of roof.
- Danger increases if they intersect each other.
- Requires immediate attention.
- You can't determine vertical components of slip by sight alone.
- Communicate suspicious areas immediately to management and fellow workers.



Given:

Floor to roof = 30'

Man = 5'11''(5.92')tall

Roof to head = 24.1'

Rock weighs 10 lbs.

1. How long will it take the rock to fall?

$$t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2\,(24.1)}{32.2}} = 1.22 \text{ seconds!!!}$$

2. How fast is the rock falling?

$$v = \sqrt{2as} = \sqrt{2(32.2)\,(24.1)} = 39.39 \text{ fps}$$

3. How fast is the rock accelerating?

$$a = \frac{v}{t} = \frac{39.39 \text{ fps}}{1.22 \text{ sec}} = 32.2 \text{ fps}^2$$

4. How hard will it hit his head?

f = ma = (10) (32.2) = 322 lbs. of force!!!

5. What's the moral of the story?

A. Look up--look around--If it doesn't look right, it probably isn't--believe yourself! Looks like dog...Acts like dog...Barks like dog... = DOG!!! AVOID THE DOG!

B. You would NEVER, EVER have time to outrun a falling rock!

C. One small rock could hit you like you've never been hit before!!!

D. If even the slightest bit doubtful--back off, call the supervisor, get the scaler, advise others!

Key Concepts Covered in Module Two:

Examine area from different vantage points:

- You should carefully examine any area you feel is questionable.
- View the area from several vantage points.
- Never position yourself in a dangerous place when conducting an examination.
- Miners should look ahead and look back often to evaluate roof and rib conditions.
- Look for cues such as ledges or off sets that alert you to potential hazards.
- When you look at an area from several different angles, you get a better picture.
- Miners should alert machine and hand scalers of those areas that are of concern.
- Communicate what you see to management.

Roof bolts provide important cues:

- Usually, roof bolts are used on an "As needed, where needed" basis.
- Roof bolts bind the strata of the roof and provide additional support.
- Test holes can help identify the characteristics of the roof.
- Slips and fracture edges are bolted to provide support to the lip of the fault.
- The presence of roof bolts alerts you to the fact that something has happened to the area and that extra caution and examination are required.

Sand channels/clay veins:

- The presence of sand channels/clay veins indicates weakness in the roof or rib.
- You should use special care and closely examine these areas for stability.
- Scalers should pay particular attention to these areas and ensure that all loose material is pulled down.
- These areas should be monitored frequently to detect any change in conditions.
- Notify your co-workers and management of these conditions so that corrective action can be taken.

Newly exposed face areas:

- Newly exposed face areas have a greater potential for roof/rib fall.
- Never travel past the scaling tracks toward a face.
- Blasting sometimes leaves dangerous roof and rib conditions.
- Mechanical scale operators should address the immediate roof of a newly exposed face and work systematically to remove all loose material.
- Be extra alert when working at or near at newly exposed face areas.

Rocks fall fast and hit hard:

- A small rock has the potential to cause great injury.
- You can't outrun a falling rock.
- Use all the tools available to you to reduce the possibility of injury.

Underground Limestone Roof/Scaling Hazard Recognition Review

The following True/False questions are meant to review the major points of this underground limestone roof/rib scaling training exercise. The questions below are either TRUE or FALSE. Please read each question carefully, and place a T for True, or F for False in the space at the beginning of each question.
Note: When this review is discussed in the training class, please explain why you believe a false answer is really false. How would you re-word the statement to make it a true statement. This exercise is meant to stimulate discussion.
PLEASE HELP MAKE IT WORK! ! Thank you.

_____ 1. Loose rock seen on travelways most likely indicates spillage from a haulage truck.

_____ 2. Once a rock/rocks have fallen from a slip or fracture in the roof, it is unlikely that future rock falls will occur.

_____ 3. There are only two known causes for reduced visibility underground stone mines: fog and equipment exhaust.

_____ 4. Cavities in the roof, with fallen rock below them, require immediate attention.

_____ 5. An area of the roof or rib that may initially appear stable may, upon closer examination, have loose rock visible, further emphasizing the need to look closely at all areas in which you work or travel.

_____ 6. Scale marks can become discolored over time.

_____ 7. A lighter colored section on the roof or rib may indicate the presence of loose rock, because air has circulated in and behind the loose rock, and dried it out.

_____ 8. Scaling is an on going, never ending process

_____ 9. The presence of scaling marks is a virtual guarantee that the scaled area is safe from falling rock.

_____ 10. The area where the rib meets the roof is a likely spot to suspect as being weak, or to look for loose material.

_____ 11. The visual cues that you use to determine the condition of the roof/rib provides you with extremely important safety information.

_____ 12. The natural layers of the limestone in the earth are called "bedding planes, and can affect both roof and pillar strength.

_____ 13. When slips or cracks in the roof begin to merge together, or intersect, the potential for loose material increases.

_____ 14. The mere presence of a slip or crack in the roof should alert you to the possibility of falling rock. You should advise your supervisor immediately about any area that alarms or concerns you.

_____ 15. What you see from one angle when looking at the roof or rib may look entirely different from another angle. Never venture into an unstable area to make an observation.

_____ 16. Ledges are always easy to recognize and generally look the same when viewed from any angle.

_____ 17. Ledges can be formed by blasting or scaling and pose falling rock hazards. Ledges need continual scaling.

_____ 18. Roof bolts have very little value in underground limestone mining.

_____ 19. Roof bolts are usually placed on an “as needed, where needed” basis throughout the mine unless mine management has a special directive from MSHA or the State to do otherwise.

_____ 20. Roof bolts are usually placed directly into slips and cracks in the roof or rib.

_____ 21. Test drilling usually precedes roof bolting to see if the strata above the roof is solid. If not, roof bolts are placed, or other precautions are taken.

_____ 22. The mere presence of roof bolts in an area should be a visual signal to you to
observe the area carefully before working or traveling in that area.

_____ 23. Sand channels or clay veins literally separate solid stone, and can cause loose rock. You should be extremely observant when working in any such areas because these areas are naturally weak.

_____ 24. You should never, under any circumstances, advance any further toward a developing working face than what has been scaled or roof bolted.

_____ 25. It is extremely important to be visually “tuned in" to your work and travel areas, because many (but not all) hazards can be visually identified.

_____ 26. You should notify mine management immediately it you see, or even suspect, any type of obvious hazard or even if you are not sure how to read an area.

Student Handout

Duplicate the following pages to be used as a handout for the trainees at the end of the session.

Underground Limestone Hazard Training

Loose rock in roadway/cavities in roof

- Loose rock on roadway indicates potential hazards.
- Rocks may have fallen off overloaded trucks
- Rocks may have fallen from roof or rib
- Rocks may indicate hazardous roof/rib conditions
- Rocks may contribute to transportation type accidents
- Rocks may contribute to trip/fall accidents
- Rocks may indicate potential for roof failure
- Rocks can fall from existing slip/ fractures at any time.
- Fallen rocks may be an indication that the stability of the roof is chancing.

Fog/haze reduces visibility

- Our ability to recognize hazards is reduced because of the fog.
- Blasting can be the source of increased particulate in the mine.
- Equipment exhausts can contribute to reduced visibility.
- Dust from equipment can reduce visibility.
- Poor ventilation can lead to increased dust or particulate levels.
- Do not enter area with fresh rock on the bottom under cavities.
- Cavities in the roof with rock below them require immediate attention.
- Supervisory personnel must evaluate status and insure safe working conditions.
- Communicate what you found to the appropriate person(s).
- It may be necessary to danger off the area to prevent entry by co-workers.

Scaling tracks tell a story

- All working areas and travelways must be scaled regularly
- Scale tracks marks are used when evaluating roof.
- The presence of scale tracks does not guarantee the area is safe.
- Fresh scale tracks are white and indicate that the roof has been recently scaled.
- Older scale tracks are discolored because of diesel exhausts and discoloration indicates that it has been some time since the area has been scaled.
- Mine managers should encourage workers to report any area they believe needs scaled.

[7]Hazard Recognition Training Program for Underground Limestone - Master 13

- Scaling is an ongoing process of removing all loose material.
- The presence of scale track marks does not guarantee that there is nor loose material.
- During scaling, the scaler operator must attempt to remove all loose material.
- It is a common practice for the operator to re-scale the same area on an as needed basis.
- It is vitally important for the worker to look at all areas of the mine roof for areas that may require scaling or re-scaling.
- During scaling, the scaler operator attempts to assess the mine roof to identify areas that are loose.
- The loose rock in the foreground appears not to have been scaled.
- The ledge in the center is an area that warrants special attention to scaling and frequent inspection to monitor any change.
- The area where the rib meets the roof is inherently weak.
- Stress factors result in loose rock in these areas.
- Report questionable areas immediately to supervisory personnel.
- Use extra caution and examine these apexes closely.

Pillar integrity

- The primary purpose of pillars is roof support.
- Natural bedding planes can affect pillar integrity.
- Depending on number and direction of bedding planes, they can affect both roof and pillar strength.
- There are three natural bedding planes in the pillar.
- The pie shaped area to the left may be the weakest point of the pillar.
- It could slide out if enough stress acted upon it.

Slips/fractures affect roof strength

- Slips or joints in the roof are factors that warrant investigation
- Slips/joints affect roof integrity.
- Depending on their vertical path, they create areas that have the potential for failure.
- It is impossible to determine vertical components of slips.
- Areas where slips occur may require roof bolting for additional support.
- Slips/fractures become more of a concern if they intersect.
- Slips and fractures require special attention.
- The roof on either side of slips/fractures can become less stable.
- In this case, loose rock has fallen and there appears to be several pieces of rock that the mechanical scaler has tried to pull down.

- Bolts have been placed in this area to provide additional support to the roof.
- Sequence of events can be determined if the visual cues are available to us.
- Loose rock within the crevasse has been scaled down.
- The scaling took place before the bolting.
- Areas where conditions such as this occur should be examined regular, and any changes or concerns brought to the attention of supervisory personnel.

Evaluate roof/rib from different vantage points

- Miners should investigate any area they feel is questionable.
- If possible, a scaler should "sound" the roof from a bucket or platform truck.
- Miners should view the area from several angles.
- Never position yourself in harms way when conducting an examination.
- Notify supervisory personnel of any unsafe conditions.
- The miner, in day to day operations, plays a crucial role in the roof safety program at any mine.
- Cracks or loose sections of rock may not be visible from only one vantage point.
- Looking at an actual or suspicious section of roof from more than one vantage point could provide critical safety information to the miner.
- Miners should look ahead and look back often at sections of the roof to evaluate the safety of the roof.
- A miner should never venture under any actual or suspicious section of the roof to try to get a better vantage point.
- Miners should report any actual or suspicious sections of roof/rib to management immediately(as well as co-workers), so that corrective action might be taken.
- Loose rock can be present on ledges.
- Ledges need special attention during the scaling process.
- Ledge lines may be difficult to detect.
- The presence of a ledge should indicate to the miner that the area needs to be monitored continuously for weak, crumbling, or loose materials that pose a falling hazard.
- Any ledge with actual or suspicious loose rock should be reported to management so that corrective action is taken.
- Ledges may be present anywhere on the roof; where the roof meets the rib, or at newly exposed face areas.
- Ledges may look different when viewed from several other vantage points.
- Ledges may pose falling rock hazards.
- Ledges indicate a section of layered or laminated rock strata.
- Ledges may be formed by blasting or scaling activities.

- Ledges can exist anywhere on mine roof or rib. The apex can be inherently weak and the potential for failure may be greater.

Roof bolting

- Roof bolts are used on an “as needed” and “where needed” basis.
- When slips are encountered miners should notify supervisory personnel so a determination can be made for corrective action.
- Roof bolts "bind" the strata of the roof into a layer that acts like a bridge to support the roof.
- Notice that there are no bolts drilled directly into the slip It is better to support the areas on both sides of the slip.
- Slips/fractures indicate a weak area in the roof.
- The lip or edge of a slip is the weakest area in this scene.
- Forces acting on the roof will cause the edge of the lip to be break and fall.
- Roof bolts bind the rock around the slip and offers addition support.
- A test hole could have identified a break in the strata above the immediate roof.
- An existing condition could have been detected that continues in the direction of where mining will continue.
- The roof may have been sounded and was drummy and the decision was made to bolt the area.
- Sand channels or clay veins may have been discovered above the immediate roof.

Sand channels/clay veins

- Sand channels/clay veins indicate a weakness in the rock.
- The integrity of the rock is lost when sand channels/clay veins arc present.
- Special attention in examining these areas is crucial.
- Scalers should pay particular attention to these areas and should ensure all loose areas are pulled down and/or secured by bolting.
- Large sand channels are extremely dangerous and should be brought to the attention of management.
- Sand channels/ clay veins indicate a weakness in the integrity of the rock.
- Notice the large stone that has fallen from the channel.
- Areas where large sand channels appear may need to dangered off.
- Report these conditions to management immediately.
- Both hand scalers and machine scalers must use caution when scaling under these conditions.

Newly exposed face areas

- Newly exposed face areas have an increased potential for roof/rib fall.
- Never travel inby (past) scale tracks when approaching new face area.
- In this scene, the face and led corner may have the greatest potential for roof/rib fall or roll.
- Mechanical operators should address the immediate roof and work inby the face, paying particular attention to the rib.
- If the rib appears to present a hazard, it should be scaled as progress is made
- Look for fresh scale tracks.
- Examine freshly scaled face areas for loose rock, ledges, and clay/sand channels.
- Check the roof/rib for any signs of slips/fractures.
- Check the bottom for any signs of rocks or loose material that may have fallen from the roof/rib.
- Carefully examine the outby pillar and corner to determine stability
- View areas from different angles.
- Notify co-workers and management of any suspicious areas
- Ask scaler operator to re-scale questionable areas.
- Check for ledges.