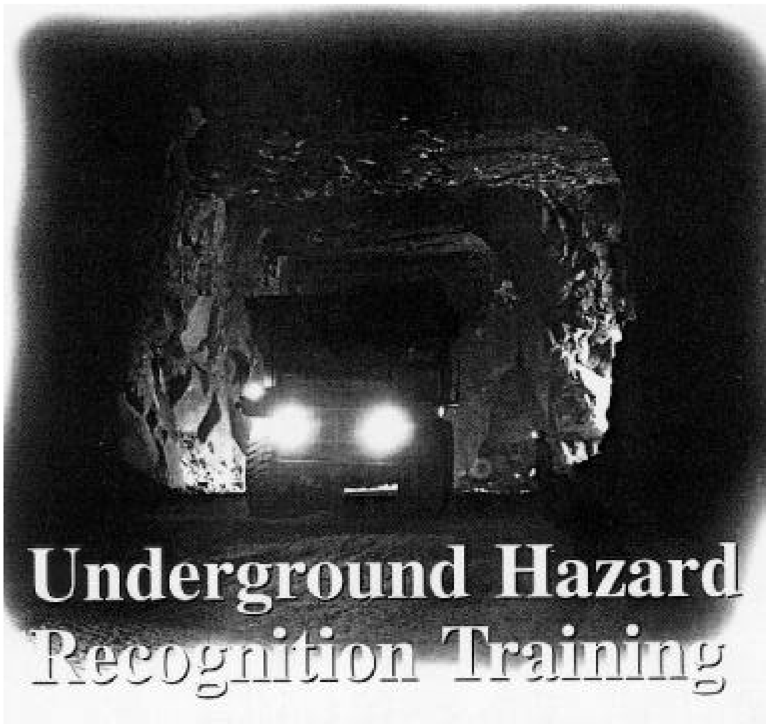

Mined limestone can be hauled to the surface using trucks or underground conveyors (left). Entries are often more than 50 ft high.

Underground Hazard Recognition Training

BY EDWARD A. BARRETT AND LYNN L. RETHI

From 1987 through 1996, 13 fatalities occurred at underground operations in the U.S. stone mining industry. A review of the underground limestone mine injury data for this 10-year period indicated a high fatality concentration in one area: ground failures. As shown in Table 1, approximately 92 percent (12 of 13) of the operator fatalities involved falls of face, rib, pillar, side, highwall, roof or back. Further, more than 11 percent (84 of 771) of the operator non-fatal days lost incidents reported during this period were classified as ground control accidents.

Because underground limestone mining operations are becoming more common, particularly in the central and eastern states, this fatality and accident trend could continue or perhaps even worsen.[1]

It is hypothesized that the number of injuries to underground limestone miners can be reduced through improved training that focuses on greater recognition of visual cues for evaluating roof and rib conditions. To this end, investigators at the National Institute for Occupational Safety and Health's (NIOSH) Pittsburgh Research Laboratory have developed a training module specifically designed for improving the hazard recognition skills of miners in this segment of the industry. The instructional materials combine two training aids, 3-D slides and the concept of degraded images that have been shown to be very effective mine training instruments.

Stereoscopic slides have been reported in studies by the former U.S. Bureau of Mines (USBM) to be effective for teaching miners to recognize various geologic and mining-induced irregularities that may cause ground failures.[2, 3] During safety training classes, miners can vicariously experience workplace conditions because the slides realistically portray the natural mine environment. As such, they serve as an excellent proxy for training miners to recognize cues that distinguish various types of hazards.

The "degraded image" concept was originally developed and used for military target detection training. Military research has shown that pilots 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 images are scenes where the subjects are partially hidden from view, observed from an eccentric angle, viewed through haze or dust, inadequately illuminated or otherwise obstructed so as to camouflage the target.

To investigate this concept for training miners, USBM researchers developed a prototype hazard recognition training module using traditional (two-dimensional) slides of 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 slides performed significantly better on a follow-up test of hazard recognition.[4] In effect, the degraded image hazard recognition program teaches subjects to look for hazards in a more holistic manner within the immediate mine environment.

NIOSH's training module (above) describes hazard recognition techniques and practices, identifies specific underground limestone ground and discusses appropriate steps to correct hazards.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Operator, NFDL										
Fall of Face, Rib, Pillar, Side or Highwall	3	2	1	0	2	2	1	4	0	0
Fall of Roof or Back	5	12	10	10	0	12	5	6	5	4
Other	64	78	93	78	65	60	64	60	52	73
Total Injuries, NFDL	72	92	104	88	67	74	70	70	57	77
Operator, F										
Fall of Face, Rib, Pillar, Side or Highwall	0	0	0	0	0	0	1	0	0	0
Fall of Roof or Back	0	0	0	0	1	2	5	1	0	2
Other	0	0	0	0	0	0	1	0	0	0
Total Injuries, NFDL	0	0	0	0	1	2	7	1	0	2
Contractor, NFDL										
Fall of Face, Rib, Pillar, Side or Highwall	0	0	0	0	0	1	0	0	0	0
Fall of Roof or Back	0	0	0	0	0	0	1	0	0	0
Other	0	0	0	0	0	0	1	1	0	1
Total Injuries, NFDL	0	0	0	0	0	1	2	1	0	1

Contractor, There were zero contractor fatalities in the 10 year period.

Note: MSHA's accident classifications **Fall of Face, Rib, Pillar, Side or Highwall** and **Fall of Roof or Back** also include falls of material while barring down or placing props.

Source: MSHA Database

TRAINING REQUIREMENTS

The Federal Mine Safety and Health Act of 1977 (Public Law 95-164) mandates that mine operators provide health and safety training for their employees. This regulation applies to all segments of the mining industry, including underground limestone mines. The purpose, subject and content of the required training are detailed in 30 CFR Part 48.[5]

The standard includes specific instructional guidelines for topics such as escape, ground control, work environment, explosives, health, electrical, first aid, hazard recognition and other areas "as may be required by the district manager based on circumstances and conditions at the mine." These are required components in the training programs advocated for all coal and noncoal miners, both underground and surface; for new miners; newly employed, but experienced miners; and those required to have eight hours of annual refresher training. Hazard recognition training, in addition to being broken out as a separate instructional area, is also included in the electrical, ground control and explosives courses noted above.

This highlighted training slide, Slide A2, shows rock in the travelway and stimulates conversation on its causes and potential hazards.

Hazard recognition training is defined by the Mine Safety and Health Administration (MSHA), simply, as training for the recognition and avoidance of hazards present in the mine. This instruction is typically delivered either by having a verbal exchange regarding specific, known hazards or by showing traditional (2-D) visuals of potential hazards. Then, discussions of their locations in the mine and, perhaps, what to do if an employee encounters a similar hazardous condition or situation may follow. It is assumed that this approach will have a positive safety impact days or weeks later if the worker happens to see a particular hazard and reacts as trained.

The visuals used in these classes are generally two dimensional highlighted scenes that reveal only important details of the actual hazards. However, related cues that may be associated with, or a consequence of, the hazard are usually not apparent. This, in turn, may diminish the effectiveness of this type of hazard recognition training. The Underground Limestone Hazard Recognition Training Module advances this traditional approach by including 3-D/degraded visuals and instructor's notes that, along with a review exercise, provide an opportunity for a much more in-depth and comprehensive discussion of mine hazards.

UNDERGROUND LIMESTONE HAZARD RECOGNITION TRAINING MODULE

The training module was designed to accomplish three learning objectives: (1) to describe hazard recognition techniques and practices that can be used in the workplace, (2) to identify specific underground limestone ground hazards and (3) to discuss appropriate steps to correct the hazards. These objectives are collectively addressed as both the instructor and the entire class, interactively, proceed through an underground limestone mine. The latter is accomplished as participants view 3-D slides of roof and rib conditions while "traveling through" the entries and crosscuts.

The instructor leads the participants in discussions as they consider the key points depicted in each slide scene. The trainer, of course, has the option of following the descriptive data provided in the instructors' notes as well as incorporating his/her own information into the exchanges. The time required to complete the exercise is approximately one hour, depending on the amount of discussion generated. The authors' experiences in field evaluations of the module have shown that the level of enthusiasm from the participants is extremely high, and a class could easily be extended for well over one hour.

Slide C21, which is degraded, illustrates a sand channel running through rock and promotes discussion about the associated dangers.

The instructor initiates the training session by explaining to the class:

- We will conduct an evaluation of an underground limestone mine by looking at 3-D slide reels and discussing those cues that alert you to potential hazards.
- We will work together by following a story line and looking at each scene as a group.
- You will receive four 3-D reels (a total of 28 slides) and a viewer.
- You are to look at a particular scene and the class will discuss what potential hazards may be present. Do not advance to the next scene until instructed to do so.
- Together, we will discuss hazard recognition techniques and corrective actions.

Ten key ground control concepts are presented in the four 3-D slide reels. Some of these concepts are presented in a degraded format; others are highlighted. The topics are:

TRAINING MODULE COMPONENTS

The following five components comprise the training module:

Stereoscopic (3-D) slide reels. The four reels are labeled A, B, C and D. Each reel contains seven 3-D slides. The slides must be viewed through a ViewMaster Viewer or similar viewer. Viewers are not included in the module package; they may be purchased at discount toy stores.

Instructor's notes. This segment of the module contains 16 pages of subject information about each scene on the 3-D reels. Also included in the notes are questions designed to prompt discussion among the participants in the training class.

Master sheets from which overheads can be made. These are attached to the module package as appendices. They include fatality and lost time data for underground limestone mines from 1989 to 1995 and a summary/review of key concepts discussed in the class.

Review exercise consisting of 26 true/false questions. Participants can self-assess knowledge gained in the training class. Answers are also provided. (Author's Note: This review exercise generated significant discussion in field evaluation classes.)

Student handouts. This segment of the module is a summary of specific information discussed. Trainees can use them as reminders in the future.

	Reel ID
(1) Loose rock in roadway/roof cavities	A
(2) Reduced visibility	A
(3) Scaling tracks	B
(4) Pillar integrity	B
(5) Slips/fractures in the roof/rib	B
(6) Different vantage points	B
(7) Different vantage points (continued)	C
(8) Roof bolts provide important cues	C
(9) Sand channels/clay veins	C
(10) Sand channels/clay veins (continued)	D
(11) Newly exposed face area	D
(12) Basic physics/rocks fall fast and hit hard	D

EXAMPLES

Two examples of the visuals and related instructor's discussion notes are excerpted below. Because the pictures are not shown in (3-D), details are less obvious than what appears in the module's slide reels. The first example (A2) is a highlighted scene; the second one (C21) is degraded.

Slide A2—Rock in the travelway.

As we enter the mine, we see 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?

Potential answers include:

- Loose rock on roadway indicates potential hazards.
- Rocks may have fallen from haulage 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.

Rocks in the roadway may result from pieces falling from the roof/rib or from a haulage truck; they may indicate that an area has been scaled or rescaled or 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 C 21—Sand channel running through rock.

Out by the bolted face that we just looked at, we see the reasoning behind the decision to bolt the face area (reference to previous slide—C20).

- Why are sand channels/clay veins signals of weakened strata?
- How would a sand channel or clay vein weaken rock strata?
- What hazards are associated with sand channels or clay veins?
- Why should scalers be extra cautious when removing loose rock in these areas?

Potential answers include:

- 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 when examining these areas is crucial.
- Scalers should pay particular attention to these areas and ensure that all loose rock is pulled down and/or secured by bolting.
- Large sand channels are extremely dangerous and should be called to the attention of management.

Sand channels and clay veins are a concern to limestone miners. They usually indicate that the potential for loose rock is high. The stability of the rock is compromised when these conditions are present. Sand or clay mixed within 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 coworkers and management any concerns so that the problem can be corrected and monitored.

AVAILABILITY

The module will be distributed through MSHA's National Mine Health and Safety Academy, Beckley, W.Va. It will be listed in the MSHA Catalog of Training Products for the Mining Industry. The catalog contains an order form for products listed. Catalogs are available by writing to the MSHA National Mine Health and Safety Academy, Attention: Office of Academy Services, P.O. Box 1166, Beckley, WV 25802-1166. Orders also may be called in (304) 256-3257 or faxed to (304) 256-3299. Costs are expected to be $1 for the Instructor's Guide and $1 for each 3-D slide reel. A class of 20 trainees, for example, would require 20 sets of reels ($80) plus one instructor's guide, for a total cost of $81. These, of course, are one-time expenses, as are the cost of viewers, since all materials in the module are reusable. ▲

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