01 Jan 2007

Identifying Trends in Underground Coal Mine Incidents Caused by Roof Falls

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Funding Source: UMR Opportunities for Undergraduate Research Experiences (OURE) Program

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Identifying Trends and Contributing Causes of Underground Coal Mine Fatal Roof Fall Incidents

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Abstract

Current technology and safety practices generally provide today's underground coal miner with a safe workplace in an unpredictable environment. However, incidents still occur and until the number of incidents resulting in injury or loss of life reaches zero, there will always be room for improving methods and technology used by the modern coal miner. This study analyzes underground coal mine incidents caused by roof falls. Information provided by the Mine Safety and Health Administration (MSHA) was analyzed for trends in factors that contribute to roof fall fatalities in underground coal mines. Identification of major contributing factors will allow for a focused approach to selecting new technology and practices as interventions to keep the underground coal mining workplace free of injury.

Introduction

The physical environment of an underground coal mine is constantly changing as development of the mine exposes workers to new areas of the coal seam that is being mined. Workers in this environment must always monitor their surroundings to detect potential hazards. Atmosphere control and ground control are conditions that are monitored most frequently and demand a systematic approach to deal with potential hazards. This research project focuses on the problem of roof control, one of three aspects of ground control which include, sloughing of the rib, heave in the floor, and material falling from the roof. The focus of this project has been narrowed to address the problem of roof falls because current practices do not eliminate injury and fatalities caused by roof falls. Measures that are already in place to prevent roof falls include regulations that require a written roof control plan, which specifies roof support systems that are required for varying degrees of instability in the roof. A fundamental application of risk analysis has been used in this project to categorize and identify what the main factors are that contribute to exposure of underground miners to roof falls. Research into this topic has produced three sub-topics within the entirety of the research conducted. The analysis of this information will hopefully provide a more focused approach for the development of new technology and practices that will help move the underground coal mining industry toward an injury-free workplace.

Sub-topic One *Fatal Incident Overview*

A brief initial search was conducted to determine the number of fatalities that were caused by roof falls in the underground coal mining industry as a whole. Data from 1995 to 2005 was collected from the Mine Safety and Health Administration (MSHA) and compiled in a spreadsheet. Figure 1 below illustrates the initial findings.

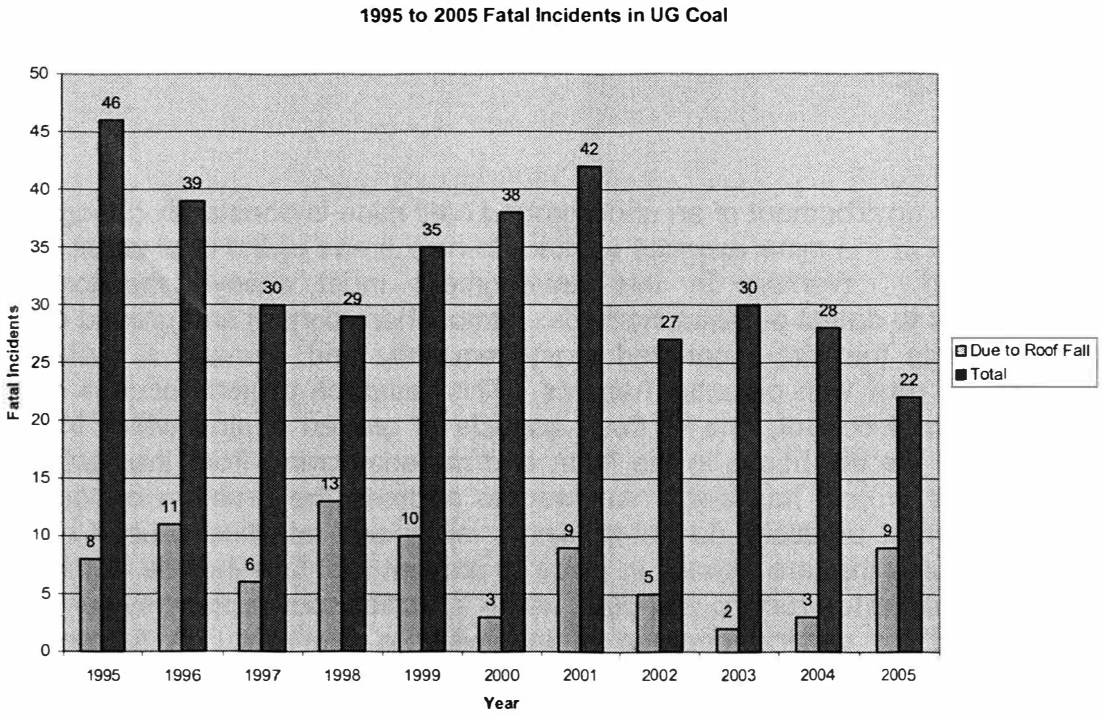

Figure 1 1995 to 2006 Fatal Incidents in UG Coal

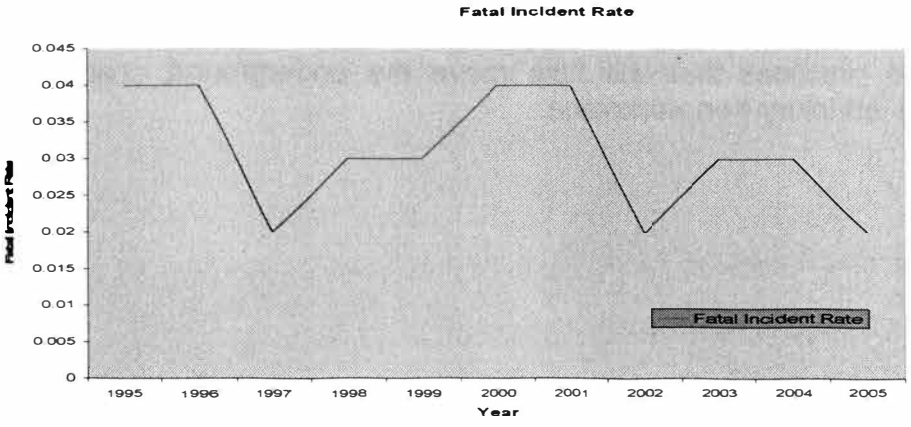

Figure 2 Fatal Incident Rate

Through the eleven years studied, roof falls continued to be a contributing cause of deaths in the underground coal industry. The lack of any rate of increase or decrease in the amount of deaths caused over this time period could be explained by variances in total man hours worked in the industry, or stagnation in the advancement in technology or industry practice. Examining the changes in the fatal incident rates (fig. 2) indicates that the variances in total man hours worked do not account for the changes in the number of deaths occurring each year. The initial study did not show a decreasing trend in fatalities, leading to the conclusion that the current state of the industry was not able to reduce the number of roof fall fatalities occurring. This prompted a more in-depth study of what may be causing roof fall fatalities in underground coal mines.

Sub-topic Two Fatal Incident Summary

The Mine Safety and Health Administration (MSHA) offers information on fatalities in two forms, short descriptions that are called fatalgrams and complete incident reports compiled by an MSHA inspection team. Fatalgrams of each incident were examined to first provide a general understanding of the incident. The incident reports were studied to provide information on the most prevalent factors that have contributed to fatalities caused by roof falls. The selected categories chosen for recording were mine size (number of workers), the number of violations associated with each incident, and a multitude of contributing conditions that are mentioned in the incident reports. The data was condensed into a two-part spreadsheet. Reading each incident report provided enough information to complete each category in the spreadsheet. An example analysis of an investigation report is included in attachment 1. The incident summary is included in attachment 2.

Mine Size Classification

The number of workers at each mine was recorded and divided into 5 classes based on how many employees worked at each site: very small (less than 20), small (between 21 and 50), medium (between 51 and 100), large (between 101 and 250), and very large (above 250). Recording this information allows any correlation between the size of mine and number of fatalities to be observed.

Number of Violations

The number of violations of Title 30 of the Code of Federal Regulations (CFR 30) was recorded with each incident. This information shows any potential correlation between the number of violations and each incident.

Contributing Factors

The most intensive part of analyzing each incident report was classifying and recording the different types of factors that contributed or caused the roof fall resulting in the fatality of the miner. The incident report contains different wording for contributing factors but ten factors have been established that are generally responsible for contributing to roof falls. The ten factors that contribute to roof falls are listed below (fig. 3).

A	**Equipment related**: The design or mode of operation of mining equipment compromised the safety of the worker in some way.
B	**Inadequate examination:** The pre-shift or other examination of the area disregarded or did not observe adverse conditions and no corrective action was taken as a result.
C	**Inadequate roof support:** The victim was located in an area where the roof support measures were not able to prevent a fall of roof. This includes "apparent compliance" cases. This occurs when the roof control plan is followed but further action should have been taken to support the roof.
D	**Inby roof supports:** This denotes situations where the victim was located past the protection of adequate roof supports at the time of the incident.
E	**Improper procedure:** This denotes situations where the approved roof control procedure was not followed. Insufficient roof supports, improper bolting order, improper placement of machinery, and any deviation from the approved roof control plan are categorized as "Improper procedure"
F	**No training:** The victim was not task trained for his/her particular duty.
G	**Retreat related:** The fall of roof occurred during retreat mining.
H	**Roofbolt failure:** The roof bolts were not able to function as designed for the conditions. Incompetent overlying strata, high stress areas, incorrect roof bolt placement, and weathering of roof bolts are common causes of roofbolt failure.
I	**Unsafe repair procedure:** The victim was making repairs to machinery or structure in a hazardous area.
J	**Geologic anomalies:** This denotes unanticipated situations where the rock strata above the work area was not stable enough to be held by the approved roof control plan. These conditions occur from hill seams, slickensided horsebacks, roof cutters, and other geological anomalies and are often not detected until after the incident.

Figure 3 Contributing Factors Table

Each incident report includes a reference to at least one of the above-mentioned contributing factors. Once the contributing factors were recorded, the totals of the contributing factors of all incidents were analyzed.

Sub-topic Three Roof Control Violations

Research from the incident summary project indicated that the majority of fatal incidents were accompanied by violations of CFR 30 Subpart C standards 75.200 – 75.223. Data was obtained from the MSHA data retrieval system on fourteen randomly selected mines that were studied in the incident summaries. The number of roof control-related violations was recorded for each month from January 2001 through December of 2003. The complete spreadsheet data is included in attachment 3. Three mines studied exhibited notable trends in the number of violations received each month. The Justice #1 mine and Upper Big Branch Mine (fig. 4 and 5) have sustained periods where at least one to two citations are issued each month. These trends in roof control violations could be due to poor management of the workforce, complacency of the workers, or a combination of both. The Camp Creek Mine (fig. 6) has a single month with a substantial number of violations followed by about two years of decreased violations. This trend could be caused by exceptionally unstable roof conditions followed by a change in roof control procedures. The possibilities for the causes of these unique trends cannot be pinpointed by this study. An individual analysis of each mine that contains more detailed information would be better suited to explain the trends found in these graphs.

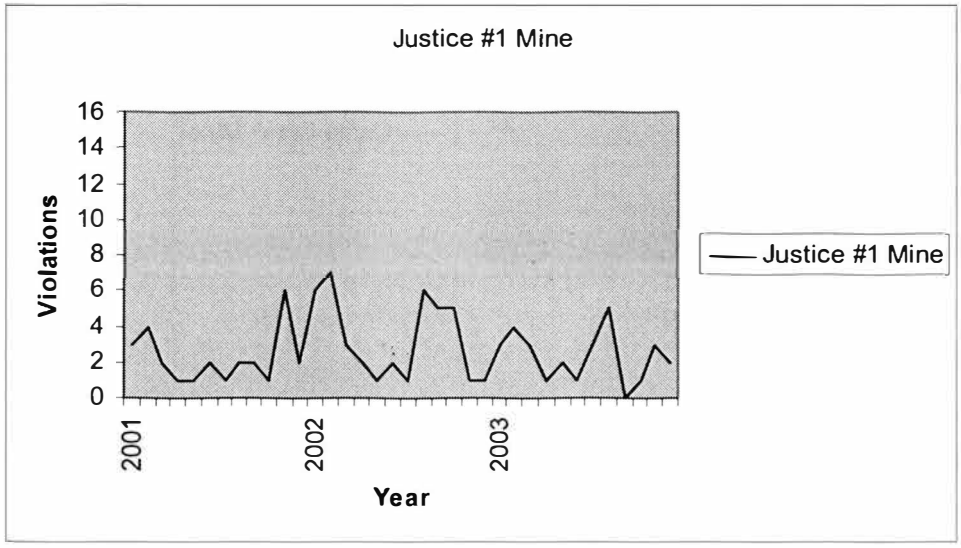

Figure 4 Number of Violations per Month at the Justice #1 Mine

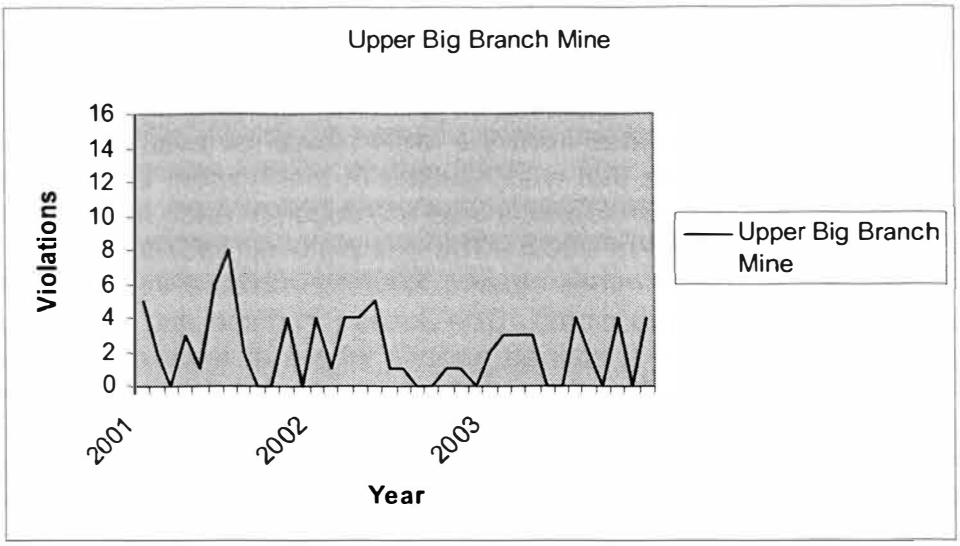

Figure 5 Number of Violations per Month at the Upper Big Branch Mine

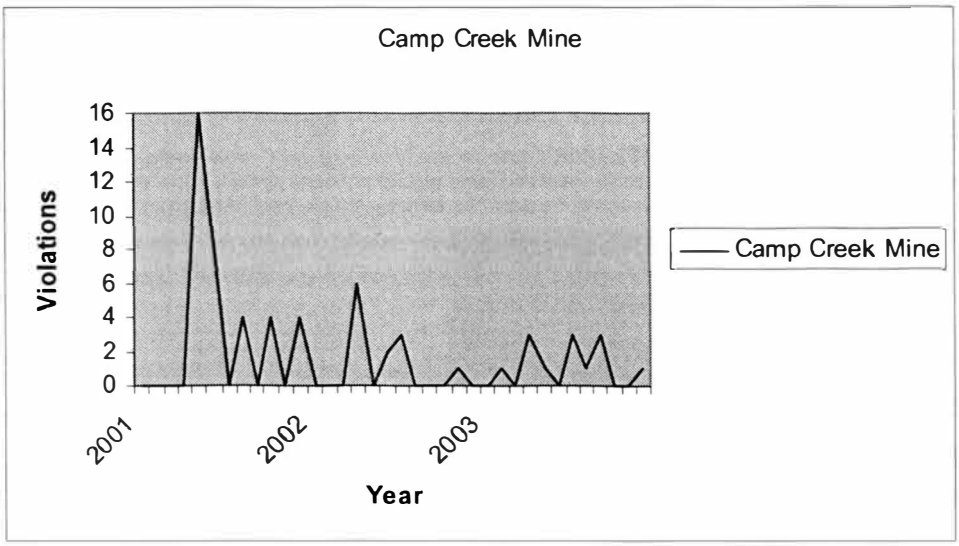

Figure 6 Number of Violations per Month at the Camp Creek Mine

Conclusions

Mine Size

A large percentage of the fatal incidents occurred in small mines (fig. 7). Since the number of accidents that result in a fatality is relatively small, the sample population for this analysis is also very small and may not provide a representative sample for studying the amount of accidents that occur in different sizes of mines. Thus this analysis does not readily provide any useful information on a correlation between the size of a mine and the amount

conditions or behaviors contributing to incidents. A more in-depth analysis would be required to examine these potential relationships.

Figure 7 Incidents Resulting in Fatality vs. Mine Size

Mine Size	Number of Employees	Incidents Resulting in Fatality	Percentage of Total Incidents
Very Small	0-20	11	15%
Small	21-50	28	38%
Medium	51-100	11	15%
Large	101-250	18	24%
Very Large	250+	6	8%

Contributing Factors

The results from the study of the most common contributing factors revealed that four contributing factors were common among most fatal incidents. A condensed table of results from the contributing-factor study is given below (fig 8).

Figure 8 Roof Fall Incidents Resulting in Fatality

Roof Fall Incidents Resulting in Fatality Cumulative Data 1995-2005											
	Incidents	Contributing Factors									
		A	B	C	D	E	F	G	H	I	J
Totals	77	6	8	39	27	27	6	20	2	2	45
Percentage	100%	8%	10%	51%	35%	35%	8%	26%	3%	3%	58%

Geologic anomalies were contributing factors for approximately 58% of all of the incidents studied. This result was expected as unstable roof is the ultimate cause of any roof fall. However, the anomalies in this category went undetected until the actual incident occurred. This can happen when a pre-shift examination of the work area does not reveal any unstable conditions or when the faults or bedding planes that caused weakness in the roof were not visible.

Inadequate roof support was a contributing factor to 51% of the incidents studied. This is often the result of the miner being located in an area where the roof support system is in place, but does not offer support needed to keep the roof

intact. Undetected geologic anomalies often create roof conditions that cannot be supported by conventional methods (such as roof bolts) that are specified in the roof control plan of the mine.

Workers that are located past the boundaries of controlled-roof areas were a contributing factor for 35% of all incidents studied. CFR 30 Subpart C standard 75.208 requires that a readily visible marking or physical barrier must be in place at the end of permanent roof support. However, of 77 incidents studied, 27 of these incidents occurred when the miner was beyond these warning devices.

Improper procedures were contributing factors for 35% of all incidents studied. CFR 30 Subpart C standard 75.220 requires that each underground coal mine must have a roof control plan that outlines procedures for installing roof control devices and methods for retreat mining. Even though roof control plans are in place, miners deviating from specified procedures account for a substantial portion of incidents resulting in fatalities.

Technology to support the roof of an underground mine is available and capable of providing varying degrees of support. Roof bolts, mobile roof supports, and arches are just a few of the support systems that are used, depending on the severity of conditions. Even with the available technology, unstable roof conditions are often not recognized and adequate roof support is often not implemented. Technology that readily detects potentially unstable roof conditions is needed to optimize the type of roof support used for each area of the mine.

Improper execution of roof control procedures and the location of the miner past permanent roof supports are factors that arise when complacency is present in the work place. Even though laws and regulations specify behaviors and measures that will keep the underground miner safe, these regulations are not always followed. Underground coal operations will only be able to avoid these situations if safety is practiced as a habit and included in the lifestyle of the miners, thereby creating a culture of prevention.

The results of this project indicate that the most common cause of unsafe conditions leading to roof fall fatalities may be linked to the inability of miners to evaluate the type of roof control to use with high accuracy. The second most common cause is the failure of underground coal mine operators to create a work place where safe practices are a regular habit.

Attachment 1: Sample Analysis

Contributing factors and other information that is included in the incident summary is highlighted. These were the main areas of focus when studying each of these reports.

UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
Coal Mine Safety and Health

Report of Investigation

Underground Coal Mine

Fatal Fall of Roof Accident

June 6, 2005

South Central Coal Company, Inc.
South Central Mine
Spiro, Le Flore County, Oklahoma
Mine ID No. 34-01787

Investigators

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Mining Engineer

Billy D. Owens
Supervisory Mining Engineer

Paul L. Tyrna
Mining Engineer/Geologist

David L. Weaver
Supervisory Training Specialist
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OVERVIEW

On Monday, June 6, 2005, Kenneth J. Orton, a 33-year old electrician, was fatally injured when he was struck by falling roof material that measured approximately 8 feet long, 4.5 feet wide, and 4 to 19 inches thick. Orton was in an area of unsupported roof, approximately 12 feet inby the last row of permanent roof support, when the accident occurred. Orton had 8 years and 45 weeks of mining experience.

The direct causes of the fatal accident were traveling in an area of unsupported roof and management's failure to ensure that the area was roof bolted prior to mining into the unsupported area. Contributing causes included failure to completely bolt the unsupported area (3-Right cut) on cycle, due to water accumulations in the face, and miscommunications regarding the presence of the unsupported roof where the accident occurred. Two possible contributing causes exist depending on Orton's route of travel into 3-Right cut. One was the extra roof warning device located approximately 20 feet outby the last row of roof supports, which potentially caused confusion and complacency as to the actual location of the end of roof supports. The second was the lack of a visible roof warning device when approaching on the ventilation curtain side of the place.

GENERAL INFORMATION

The South Central Mine is an underground coal mine operated by South Central Coal Company, Inc., and is located near Spiro, Le

Flore County, Oklahoma. The mine is accessed through drifts into the Hartshorne coal seam at the base of a shallow surface mine pit. The coal seam averages five feet thick and dips seven to eight degrees to the northwest. Overburden ranges from 50 feet near the portals to 750 feet at the deepest penetration of the mine. There are no known mines above, below, or adjacent to the mine.

At the time of the accident, the mine produced 530 tons of coal per day and employed 35 underground miners and 13 surface workers. The mine worked Monday through Friday, using two 10-hour production shifts and one maintenance shift per day.

Coal was extracted from the development sections by remote-controlled Joy 14 CM 15 continuous mining machines and was transported by Joy 10-SC shuttle cars. Roof supports were installed utilizing a Fletcher roof bolting machine.

The mine liberated 1,519,154 cubic feet of methane per 24-hour period and was ventilated by an exhausting Jeffrey axivane main mine fan, model 84-700, and an exhausting Spendrup axivane main mine fan, model 1050.

The principal officers for the mine were:

Bobby G. Meadows, Jr. ..... President
Timothy Ball ..... Vice President
Willard Deel ..... Section Foreman

Prior to the accident, the last regular safety and health inspection conducted by the Mine Safety and Health Administration (MSHA) was completed on February 11, 2005. The non-fatal days lost (NFDL) injury incidence rate for the South Central Mine for the previous quarter was 18.16 compared to the national NFDL rate of 5.17.

DESCRIPTION OF ACCIDENT

On Monday, June 6, 2005, the second shift miners entered the mine under the supervision of Willard Deel, Section Foreman, and arrived on the 1st South development section at 3:40 p.m. Normal mining activities commenced, following a typical cut sequence from the right (intake) side of the section to the left (return) side (refer to Appendix B).

While mining entry No. 3 (cut No. 4 on Appendix B), a geologic fault and drag fold were encountered that produced excessive amounts of water from the roof and floor. This water flowed outby and into the 3-Right working place, accumulating in the unbolted area mined during the previous cut (cut No. 3 on Appendix B). After mining was completed in entry No. 3, Jason Schafer, Right Side Roof Bolter Operator, and Troy Rowland, Left Side Roof Bolter Operator, entered the 3-Right working place and installed three rows of bolts. They did not bolt the remainder of the cut because water had accumulated near the face. This left an unsupported area approximately 16 feet long and 21 feet wide. Schafer and Rowland then proceeded to the working place in entry No. 3, where roof rock had fallen near the face. The fallen rock prevented the roof bolting machine drill heads from being extended near the face, so a portion of this cut was also left unsupported.

Schafer and Rowland then bolted the 2-Left working place (cut No. 5 on Appendix B) before moving the roof bolting machine to the 5-Right working place (cut No. 6 on Appendix B). While moving across the section, they spoke with Larry Carpenter, Continuous Mining Machine Operator, and told him that 3-Right cut (cut No. 3 on Appendix B) was not fully bolted. However, Carpenter had difficulty hearing over the equipment noise and perceived them to say that three rows of bolts were not installed in the face of entry No. 3 and that the cut in 3-Right was bolted. Schafer and Rowland then proceeded to 5-Right while Carpenter moved the continuous mining machine to the working place in entry No. 4 and started mining (cut No. 7 on Appendix B).

While entry No. 4 was mined, Kenneth J. Orton, Electrician/ victim, performed duties as helper on the continuous mining machine. When the working face of entry No. 4 cut into the unbolted area of the 3-Right cut, the shuttle car operators noticed water flowing from the face and asked Orton if they had mined into another area similar to the face of entry No. 3, where an abnormal amount of water was encountered.

Orton left the area, traveled outby around the pillar block and into 3-Right cut. At that time, approximately 11:05 p.m., Carpenter completed the left lift of cut No. 7. As Carpenter backed the continuous mining machine out of the cut, portions of the immediate roof fell and covered the inby 20 feet of the machine. The fall of immediate roof also extended into the unsupported area of the 3-Right cut, striking Orton. When the roof fell, Carpenter noticed a flash of light in the newly created intersection. Carpenter immediately stopped mining, traveled outby around the pillar block and into 3-Right cut where he found Orton under the fall of roof in the unsupported area (see sketch on page No. 1 for Orton's location at the time of the accident).

Orton was removed from under the fall and transported to the surface. He was treated by paramedics and taken by ambulance to the Sparks Regional Medical Center in Fort Smith, Arkansas, where he was pronounced dead.

INVESTIGATION OF THE ACCIDENT

Micheal Olsen, MSHA Supervisory Coal Mine Safety and Health Inspector at McAlester, Oklahoma, was notified of the accident by a telephone call from Bobby Meadows, Jr., President of the South Central Coal Company, at approximately 11:55 p.m., June 6, 2005. An order was issued pursuant to Section 103(k) of the Mine Act to ensure the safety of the miners until an investigation could be conducted.

MSHA's accident investigation team traveled to the mine, conducted an inspection of the accident site, interviewed employees, and reviewed employee and company records relevant to the accident. MSHA conducted the investigation with the assistance of mine management, mine employees, and the State of Oklahoma Department of Mines.

DISCUSSION

General Information:

The accident occurred on June 6, 2005, at 11:05 p.m. in the 1st South development section, in an unbolted area referred to as the 3-Right cut by mine officials. This area was also shown on the mine map as crosscut No. 4, between entry Nos. 3 and 4.

The 1st South section was being developed with five entries on 70-foot centers. The dip of the coal seam was 7 to 8 degrees to the northwest.

Geologic Conditions:

Although the coal seam was typically 60 inches thick, one to three feet of the immediate roof was usually mined with the coal resulting in a mined height ranging from 72 to 96 inches. However, in some parts of the 1st South section, the immediate roof was left in place and supported. The mined height in the accident area was 96 inches, indicating that part of the immediate roof had been mined with the coal. The immediate roof throughout the 1st South section was laminated shale and mudstone with slickensided ramp faults, bedding plane faults and drag folds (horsebacks).

Mining encountered a drag fold in the face of No. 3 entry that halted development and produced an abnormal amount of water. Some of the water from the face of entry No. 3 flowed into and accumulated in the idle, unbolted face in 3-Right cut. Attempts were made by Willard Deel, Section Foreman, to prevent the water from entering and accumulating in 3-Right cut, but were not successful.

The drag fold encountered in the entry No. 3 face extended into 3-Right cut (the accident site) and formed the left side of the fall cavity. The overburden in the fall area was between 280 and 300 feet.

Roof fall material covered the forward 20 feet of the continuous mining machine. The material consisted of various sized tabular slabs up to a maximum of 8 feet by 7 feet by 2 feet thick. The larger slabs exhibited highly polished upper surfaces that coincided with a nearly horizontal slickensided bedding plane fault that formed the upper boundary of the fall cavity. The rock that fell on Orton was approximately 8 feet long, 4.5 feet wide, and 4 to 19 inches thick. The victim was located approximately 5 feet from the right rib and 12 feet inby the last row of supports. Prior to the breakthrough, the unsupported area inby the last row of roof bolts in 3-Right cut was approximately 16 feet long and 21 feet wide. After the breakthrough and at the time of the accident, the unsupported area was approximately 26 feet 6 inches long and 20 to 21 feet wide.

Examinations:

The written "Preshift Mine Examiner's Report" for the preshift/onshift examination conducted on the 1st South section from 8:30 p.m. to 9:30 p.m. on June 6, 2005, indicates that entry No. 3 (cut No. 4) and 3-Right cut (cut No. 3 in crosscut No. 4) were "not bolted." The actual date, time, and initials found at 3-Right indicate that the exam was made at 8:36 p.m. by W.D. (Willard Deel). These were found on a roof bolt plate near the inby corner of the crosscut. This indicates Deel knew that 3-Right cut was unbolted at that time. Interviews with the roof bolters could not determine the times when bolting occurred in cut Nos. 3 and 4. In his interview, Deel stated that he did not know that 3-Right cut had been left partially unbolted. Deel did not return to re-examine the 3-Right cut prior to the breakthrough from entry No. 4 (cut No. 7). However, he was aware that water from entry No. 3 face was flowing into 3-Right cut and he unsuccessfully tried to correct this problem.

Date, time, and initials were also observed in entry No. 4 on a roof bolt plate on the next to last row of bolts. These were made at 8:38 p.m. by Willard Deel. This indicates that Deel examined entry No. 4 prior to cut No. 7 being made into 3-Right cut. Knowing the mining cycle, Deel would have been aware that cut No. 7 would breakthrough into 3-Right cut; however, he failed to return to 3-Right cut to ensure that it had been bolted. The certified foreman in charge of a working section is required to conduct an on-shift examination of the section at least once during each shift, or more often if necessary for safety.

Roof Control:

A Fletcher twin-boom roof bolting machine, model No. DDO-13, in conjunction with a T-bar type ATRS system rated at 36,000 pounds was used for installation of roof bolts for primary roof supports.

The roof was supported with 6-foot long, No. 5, resin grouted rebar roof bolts in conjunction with 6- by 16-inch roof bolt plates throughout the section. These roof supports were installed on a 4- by 4-foot pattern in accordance with the roof control plan approved April 1, 2005. Typically, the entries and crosscuts were mined at less than 20 feet wide.

Warning Devices for End of Roof Supports:

A reflective warning device was installed on the next to last row of roof bolts on the left side of the entry in the 3-Right accident area (see Appendix C for a picture of this warning device). At the time of the accident, a ventilation curtain was hung from the roof near the right rib in 3-Right, which provided blowing ventilation for the mining and roof bolting operations in the crosscut (see Sketch on Page 1 for the location of this curtain). Although the investigation could not determine Orton's route of travel, he may have walked between the curtain and the rib when he entered 3-Right. Thus, the curtain would have obstructed Orton's view of the reflective warning device located on the left side of the crosscut.

In 3-Right just outby the accident area, a second roof warning device was installed on the left side of the place, five rows outby the last row of permanent roof supports (see Sketch on Page 1 for location). This placed two roof warning devices in the same crosscut

with the second one approximately 16 feet outby the one on the next to last row of bolts (see Appendix D for a picture of these two devices). The 1st South section had four other roof warning devices hanging in areas that were not near the last row of permanent roof supports (see Appendix E for the location of devices on the section). These extra warning devices defeated the intent of the warning system, potentially caused confusion, and promoted complacency as to the proper location of the end of permanent roof supports.

Miscellaneous:

Orton performed his normal electrician duties during the shift, but was performing continuous mining machine helper duties just prior to the accident.

Orton was last seen by a shuttle car operator in entry No. 4 approximately two minutes prior to the accident.

Training and Experience:

Orton had a total of 8 years and 45 weeks of mining experience. He was a qualified electrician and had received annual refresher training in accordance with 30 CFR 48.28 on June 26, 2004. Orton had received task training for being an electrician, a general laborer, and for duties on the continuous mining machine, roof bolter, scoop, and shuttle cars.

ROOT CAUSE ANALYSIS

A root cause analysis was conducted. The following causal factors were identified that could have averted the accident entirely or mitigated the severity of the accident:

1. ***Causal Factor:*** Orton traveled inby permanent roof supports, which exposed him to an area of unsupported roof in 3-Right cut (located in crosscut No. 4, between entry Nos. 3 and 4) and to the fall of roof that caused the fatal accident. A number of potential factors may have contributed to Orton traveling beyond permanent supports, including:

a) The air current from the breakthrough was coursing through 3-Right cut, and would have placed Orton in the dust and water mist from the mining operation, which could have substantially reduced Orton's visibility and may have caused Orton not to see the reflective roof warning device.

b) Orton may not have been aware that the roof in 3-Right cut was unbolted, and he may have walked into the unsupported area unknowingly and without checking the roof as he entered. Orton was most likely looking at the floor and the accumulation of water on the floor because of discussions with the shuttle car operators.

c) Depending on Orton's route of travel into 3-Right, which could not be determined during the investigation, he may have walked between the ventilation curtain and the right rib. Thus, the curtain would have prevented Orton from seeing the reflective warning device that was hanging from the roof on the left side of the crosscut.

d) An extra roof warning device was located outby in 3-Right at the accident site, which, depending on Orton's route of travel, may have confused him as to the proper location of the end of permanent roof supports or caused complacency as to the use of these warning devices.

Corrective Action: The mine operator should develop procedures and means to ensure that persons do not work or travel beyond permanent roof supports. These should include removal of roof warning devices when places are completely bolted; installation of roof warning devices on both sides of the entry to ensure that one is readily visible from behind ventilation curtains; ensure that when breakthroughs are made that employees do not travel in the immediate area downwind from the breakthrough; and routinely observe work habits of miners to ensure that miners do not travel or work beyond the last row of permanent roof supports. Management should stress to all employees the critical importance of this safety standard.

2. ***Causal Factor:*** An area of roof approximately 16 feet long and 21 feet wide was left unsupported in the 3-Right cut. The working face of entry No. 4 (cut No. 7) mined into this unsupported area causing the fatal fall of roof to occur. The following potential factors may have contributed to the breakthrough into the unsupported area:

a) The roof bolter operators were unable to completely install all of the roof bolts in 3-Right cut due to an accumulation of water on the right (down-dip) side of the crosscut, which left the area of unsupported roof where the fatal accident occurred.

b) Prior to mining in entry No. 4 (cut No. 7), the continuous mining machine operator spoke with the roof bolter operators and understood them to say that the face of entry No. 3 (cut No. 4) was not completely roof bolted. Based on this discussion, the continuous mining machine operator thought that 3-Right cut (cut No. 3) was supported. The roof bolter operators thought they told the continuous mining machine operator that they had left 3 or 4 rows of roof bolts out of the face of 3-Right cut (cut No. 3), and that the face of No. 3 entry was not completely bolted. This miscommunication contributed to the breakthrough of entry No. 4 into the unsupported area of 3-Right cut.

c) The section foreman did not return to 3-Right cut prior to the breakthrough to determine that the cut had been supported as required.

Corrective Action: The mine operator should develop procedures and means to assure that a working face is not mined through into an unsupported area of active workings. These should include: requiring a visual examination to confirm that the area to be mined into is supported prior to breakthrough; training employees on the use of "repeat backs" during critical conversations such that the listener repeats back the information and it is confirmed by the speaker (training should include the theory behind effective communications

and the ways that using repeat backs can improve performance); and developing a system to address unusual conditions in unbolted places, so that unsupported areas can be roof bolted on cycle.

CONCLUSION

The direct causes of the fatal accident were traveling in an area of unsupported roof and management's failure to ensure that the area was roof bolted prior to mining into the unsupported area. Contributing causes included failure to completely bolt the unsupported area (3-Right cut) on cycle, due to water accumulations in the face, and miscommunications regarding the presence of the unsupported roof where the accident occurred. Two possible contributing causes exist depending on Orton's route of travel into 3-Right cut. One was the extra roof warning device located approximately 20 feet outby the last row of roof supports, which potentially caused confusion and complacency as to the actual location of the end of roof supports. The second was the lack of a visible roof warning device when approaching on the ventilation curtain side of the place.

ENFORCEMENT ACTIONS

Order No. 7623289 was issued to South Central Coal Company under the provisions of Section 103(k) of the Mine Act:

> The mine has experienced a fatal roof fall accident on the 1st South, MMU 002-0. This order is issued to assure the safety of any person in the coal mine until an examination or investigation is made to determine that underground working sections are safe. Only those persons selected from company officials, state officials, the miner's representative and other persons deemed by MSHA to have information relevant to the investigation may enter or remain in the affected area.

Citation No. 7636841 was issued to South Central Coal Company under the provision of Section 104(d)(1) of the Mine Act for a violation of 75.203(d).

> On June 6, 2005, at approximately 11:05 p.m., entry No. 4 working face was mined into the unsupported working place of 3-Right (crosscut No. 4 between entry Nos. 3 and 4, in MMU 002-0), on the 1st South working section. A fall of roof occurred in the unsupported working place of 3-Right, which struck and fatally injured an electrician who was in the unsupported area.

Citation No. 7636842 was issued to South Central Coal Company, under the provision of Section 104(a) of the Mine Act for a violation of 75.202(b).

> On June 6, 2005, at approximately 11:05 p.m., an electrician traveled approximately 12 feet inby unsupported roof in 3-Right (crosscut No. 4, between entry Nos. 3 and 4, in MMU 002-0), in the 1st South working section; and was struck and fatally injured by falling roof material that measured approximately 8 feet long, 4.5 feet wide, and 4 to 19 inches thick.

Citation No. 7636843 issued to South Central Coal Company under the provision of Section 104(a) of the Mine Act for a violation of 75.362.

> On June 6, 2005, at approximately 11:05 p.m., an electrician traveled approximately 12 feet inby unsupported roof in 3-Right (crosscut No. 4, between entry Nos. 3 and 4), in the 1st South working section; and was struck and fatally injured by falling roof material. The 3-Right cut area was examined by the section foreman at 8:36 p.m., prior to the accident, and the foreman recorded a hazardous condition that "3R" (cut No. 3 as shown on Appendix B in accident report) was "not bolted." Following this examination, the roof bolters entered cut No. 3 to bolt, but left the last 16 feet of the cut unbolted due to an accumulation of water at the face. The entry No. 4 working face was later mined into this unsupported area causing the fatal roof fall to occur. Due to the hazardous condition noted and the accumulation of water at the "3R" (cut No. 3, 3-Right) face, an additional examination for safety purposes should have been made to check for correction of the hazardous conditions prior to the breakthrough into the unsupported area. This additional examination was not made.

Citation No. 7636844 issued to South Central Coal Company under the provision of Section 104(a) of the Mine Act for a violation of 75.208.

> On June 6, 2005, at approximately 11:05 p.m., an electrician traveled approximately 12 feet inby unsupported roof in 3-Right (crosscut No. 4, between entry Nos. 3 and 4, in MMU 002-0), in the 1st South working section; and was struck and fatally injured by falling roof material. The end of permanent roof support in 3-Right was not posted with a warning device which was readily visible when approaching the end of support on the right side of the entry from behind the ventilation line curtain. A warning device was posted on the left side of the entry on the next to last row of roof bolts, but this device was not readily visible from behind the ventilation curtain. In addition, a second warning device was installed on the left side of the place, five rows outby the last row of permanent roof supports. Other areas on the 1st South section, as listed below, contained warning devices where the roof was permanently supported (roof bolted):
>
> a. Entry No. 1, between crosscut Nos. 2 and 3.
> b. Entry No. 2, between crosscut Nos. 2 and 3.
> c. The intersection of entry no. 2 and crosscut No. 3.
> d. Crosscut No. 3, between entry Nos. 3 and 4.
>
> These devices were not removed after the places were permanently supported with roof bolts. Failure to remove these devices defeats the intent of the regulation, promotes complacency, and provides a false impression as to where the end of permanent roof support is located; thereby not accurately warning miners where unsupported roof exists.

Attachment 2: Incident Summary

The incident summary is the excel table that was used to compile data from 1995-2005 incident reports. The contributing factor table of definitions is listed in the body of the report (fig. 3)

The table is currently available in electronic form as Attachment 2_incident summary.xls

Attachment 3: Roof Control Related Violations

Roof control related violations have been recorded for the specified mines on a month to month basis. The tables for each mine and the violation data is available as 75.200 violations.doc

Nomenclature

Back – The roof of an underground mine opening

Fatalgram – A short summary of a fatal incident occurring in a mining operation; prepared by MSHA

Inby – Facing the direction of the working face.

Rib – The wall of an underground mine opening

Acknowledgements

I would like to acknowledge Dr. Larry Grayson for the support and insight provided during my work on this project. He is passionate about many things but safety in the mining workplace is his first and foremost concern. His previous papers on coal mine safety provided a general direction for work on this topic.

References

The Mine Safety and Health Administration website

http://www.msha.gov

**The reference list is not complete. More details of MSHA website information will be included.*