

**UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
Metal and Nonmetal Mine Safety and Health**

REPORT OF INVESTIGATION

**Surface Nonmetal Mine
Crushed and Broken Limestone**

**Fatal Fall of Highwall Accident
July 25, 2016**

**Vulcan Construction Materials, LLC
Savannah Quarry
Savannah, Hardin County, Tennessee
Mine I.D. No. 40-00108**

Accident Investigators

**Rory Smith
Supervisory Mine Safety and Health Inspector**

**David Allen
Mine Safety and Health Specialist**

**Dai Choi
Civil Engineer – MSHA Technical Support**

**Terry Lingenfelter
Mine Safety and Health Specialist**

**Ryan O'Boyle
Supervisory Mine Safety and Health Inspector**

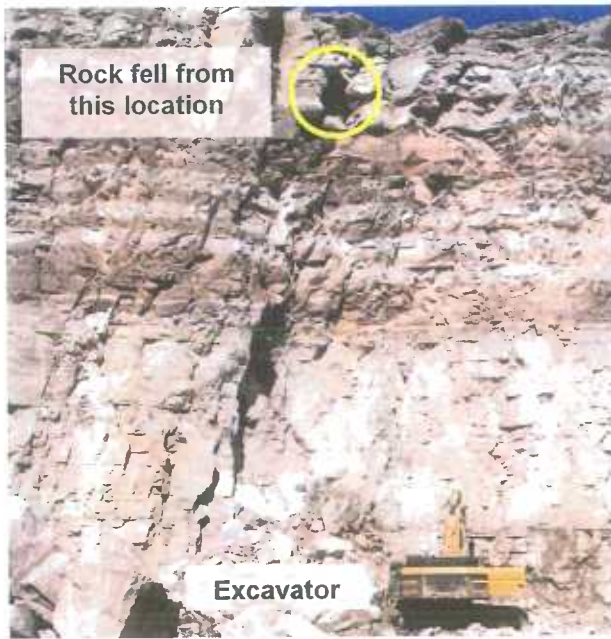
**Ed Jewell
Mine Safety and Health Inspector**

Originating Office

**Mine Safety and Health Administration
Southeast District
1030 London Drive, Suite 400
Birmingham, AL 35211
Samuel K. Pierce, District Manager**

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OVERVIEW

On July 25, 2016, James T. Lynn (age 59) was killed when rock from a highwall, approximately 80 feet above, fell on the operator's cab of the hydraulic excavator that he was operating.

The accident occurred because the operator's mining methods did not maintain wall stability where the victim was working. The operator failed to take down or support hazardous ground conditions before work commenced in the area and failed to identify hazardous ground conditions during examinations in the work area prior to work commencing.

GENERAL INFORMATION

The Vulcan Construction Materials, LLC (Vulcan) Savannah Quarry is a surface limestone mining operation located in Savannah, Hardin County, Tennessee. The Plant Manager is Doug Britt and the Safety and Health Manager is Mike Junkerman. The mine operates five days per week with one shift per day. Shifts range from 10 to 14 hours in length. The mine employs 13 people.

There is one active pit at the mine. Vulcan drills and blasts (shoots) the limestone. Excavators and front-end loaders load the resulting material into haul trucks for delivery to on-site processing facilities. The mine produces aggregates, primarily for road construction, and agricultural lime.

The Mine Safety and Health Administration (MSHA) completed the last regular inspection at this operation on May 5, 2016.

DESCRIPTION OF THE ACCIDENT

On July 25, 2016, the operator held a 30-minute safety meeting with the miners beginning around 6:00 a.m. Miners traveled to their respective work sites after the meeting. James T. Lynn (victim), a 59-year old miner with over 17 years of experience, traveled to the active working pit area at the north end of the west highwall to operate a track-mounted, Caterpillar 345B excavator to segregate and load rock previously shot from the highwall. At 7:00 a.m., he began loading rock into a Caterpillar 775D, haul truck operated by David Brown.

The victim was operating the excavator on an elevated pad, or perch, constructed of older shot material near the highwall. During the loading process and while waiting on the haul truck to return, the victim used the excavator to move large rocks out of the way so that smaller rock material could be loaded into the truck to haul to the rip-rap plant. The rip-rap plant was located approximately 400 yards away from where the victim was working.

At approximately 8:45 a.m., Brown heard a loud noise as he was hauling a load to the rip-rap plant. He initially thought it was coming from loading rip-rap at the plant but did not see anyone in that direction. Brown was concerned something had happened and tried to contact Lynn via CB radio. Receiving no response, Brown traveled back to the excavator and saw large rocks on top of it and could not see the operator's cab. The excavator was still running and hydraulic fluid was pouring out. The cab side of the excavator was closest to the highwall with the rear of the excavator facing away from the highwall.

Ronnie Cagle, Heavy Equipment Operator, was using a front-end loader to load the hopper at the rip-rap plant and overheard Brown trying to contact the victim on the radio. Brown thought the rock could be moved off the excavator with the front-end

loader and asked Cagle to come quickly with it. Cagle drove the front-end loader to the accident site and saw the rock on the excavator cab. He realized there was no way to get to the victim and that the potential for additional rock movement presented a danger.

Doug Britt was at the mine and overheard Brown calling to the victim over the radio. Brown asked Britt to call 911. Britt contacted emergency services at 8:48 a.m. and traveled to the accident site. Emergency services started arriving at 9:00 a.m. including Hardin County EMS, Hardin County Fire and Rescue, and the Hardin County Sheriff's Office. An emergency response helicopter was also dispatched to the mine.

Due to the condition of the cab and the location of the excavator in relation to the highwall, the mine operator used a Caterpillar D8 bulldozer to pull the excavator to a safe location to extricate the victim. The operator used vise grips to clamp the fuel line to stop fuel flow and turn off the machine. An EMT with Hardin County EMS could not feel a pulse and did not receive a response when asking the victim to respond. The EMT report indicates that the victim "expired on the impact of the boulders landing on the cab."

INVESTIGATION OF THE ACCIDENT

Mike Junkerman notified MSHA of the accident at 9:03 a.m. CDST on July 25, 2016, by a telephone call to the Department of Labor's National Contact Center (DOLNCC). The DOLNCC contacted David Allen, Safety Specialist, Southeast District. Junkerman was not at the mine when the accident occurred and reported to the DOLNCC that an excavator operator was trapped when rocks fell on top of the excavator. MSHA initially considered this a rescue and recovery operation and verbally issued an order pursuant to Section 103(j) of the Federal Mine Safety & Health Act of 1977, as amended, by phone, prior to the arrival of an inspector. Ed Jewell, Mine Safety and Health Inspector, arrived at the mine and reduced the Section 103(j) order to writing. When he learned it was no longer a rescue and recovery operation, the inspector modified to a Section 103(k) order to ensure the safety of miners until an investigation could be conducted.

MSHA's accident investigation team conducted a physical inspection of the accident scene, interviewed employees, reviewed training documentation, and examined work procedures relevant to the accident. MSHA Technical Support participated in the investigation to help determine causal factors contributing to the accident and to make measurements using a calibrated, Laser Technology Impulse 200 range finder. The investigation was conducted with the assistance of mine management. There were no eye witnesses to the accident.

DISCUSSION

Weather

The most recent measurable rainfall prior to the accident was 0.04-inch on July 16, 2016. July 25, 2016 was hot and dry with a high temperature of 100° F. Adverse weather did not play a part in the accident.

Training and Experience

The victim had over 17 years of mining experience, 8 of which were at this mine. A representative of MSHA's Educational Field and Small Mine Services staff conducted an in-depth review of the victim's training records. MSHA determined that there were no contributory training deficiencies.

Geology

The mine produces aggregates from the Dixon, Lego, and Laurel limestone formations of the Wayne group in descending order. The Dixon formation is alternating layers of brown and green calcareous mudstone interbedded with limestone. The Lego formation is composed of green and reddish brown limestone. The Laurel formation is similar to the Lego formation. There is one-foot thick Waldon shale between the Lego and Laurel formations.

The formations in the quarry are highly jointed. This creates a rugged highwall face, as shown in APPENDIX B, Photos 1, 2, and 3, and increases the likelihood of rockfalls. The portion of the west wall at the accident site is nearly vertical with strike in the north to south direction. The primary joint set in the accident area runs in the direction of N26°E. Measurements indicate that the dip of the joint set was 88.6°, or nearly vertical. One of the joint sets was traced to 48 feet on the top of the highwall and was visible in the north highwall 252 feet away as shown in APPENDIX B, Photo 4. In addition, there were at least four additional joints parallel to the primary joint in an area 24 feet from the highwall face. The spacing between the joints was as close as 13 feet. The joints were visible and appeared tight well behind the highwall face, but were open as the joints got closer to the face. A close-up view of a primary joint set near the highwall face is shown in APPENDIX B, Photo 5.

Perch

The interviews revealed that the victim sometimes constructed a perch from the top of which he would load and separate materials. The victim was operating the excavator on a perch that was approximately 7 feet high, 27 feet wide and 25 feet long. The accident investigation team estimates that the top of the excavator cab was 19 feet above the pit floor. The excavator was positioned on top of material left from a shot made on June 23, 2016. The victim was loading and separating material shot on July 21, 2016.

Highwall and Rockfall

The accident investigation team measured the highwall to be approximately 111 feet high from the pit floor to the top of the wall at the accident site. The rockfall appears to

have initiated at a height between 96 and 102 feet above the pit floor, approximately 80 feet above the excavator cab, and left a V shape cavity in wall. The excavator was located near the highwall with the rear of the excavator facing away from the wall. This placed the operator's cab directly adjacent to the highwall.

One piece of rock remaining on top of the excavator was examined. This particular rock measured 3 feet high, 4 feet long, and 20 inches thick, and was calculated to weigh approximately 3,300 pounds. The strata in this rock matched the strata at the V-shaped cavity in the highwall.

As shown in Appendix B, Photo 1, an area adjacent to the excavator's location previously failed at some undetermined time. Highwall material slid from a height of approximately 57 feet above the pit floor. Such failures should be cause for further investigation as they are often indicative of instability.

Mining Methods

The operator uses drilling and blasting to remove material from the highwall. The standard shot-pattern is 19 feet by 21 feet with 6.5-inch holes. Holes are drilled to a depth of 123 feet. The mine does not use pre-splitting blasting methods. Pre-splitting helps control back-break and maintain wall stability by controlling fragmentation.

The direction of mining, in relation to the jointing, contributed to highwall instability due to the multiple planes of weakness present in the highwall strata at an acute angle to the face. Blasting practices, in conjunction with the direction of mining relative to the joints, created a broken and blocky highwall susceptible to failures and rockfalls from a near-vertical face.

The operator did not have equipment with sufficient reach and capability to scale the highwall at the mine. Vulcan used an excavator to scale from the top of the highwall, but it only had the capability of scaling approximately 27 feet from the top, leaving a sizable portion of the highwall face that could not be scaled due to its height.

Where loose highwall material could not be scaled, the common practice at the mine was to construct barricades using previously shot material to prevent persons from entering the hazardous area. In such cases, active mining would move to another location until the highwall could be shot again at some time in the future to remove the hazardous conditions. At the time of the accident, nearly the entire interior perimeter of the pit was barricaded to prevent exposure to hazardous highwall conditions. The only location where a barricade was not present was at the active working location. At the time of the accident, the excavator was positioned on a perch constructed of material from a previous shot, which would typically be material used to construct a barrier to prevent entry into a hazardous area.

Ground Conditions

Accident investigators observed broken, loose, and hanging rock and multiple joints on the highwall. They also observed loose material “dribble” off the highwall in areas near the accident site on at least two occasions while investigators were present. These conditions were present throughout the pit. The operator had not taken down or supported the loose ground before work commenced in the area. The active working area was not posted with a warning against entry and there was no barrier to impede entry to the area.

Examinations

Under Vulcan policy, each miner was designated to conduct examinations of their respective work areas. This included examinations of ground conditions where work was to be performed prior to work commencing. Miners made records of their examinations daily. There were no records indicating hazardous highwall conditions prior to the accident. The examination of ground conditions at the accident site area for July 25, 2016, either had not been recorded or could not be located following the accident.

The broken, loose, and hanging rock and multiple joints were obvious from the pit floor. The extent of these conditions was even more obvious when viewed from the top of the highwall. The joints were clearly visible and displayed signs of separation as they neared the edge of the highwall. Due to curvature in the highwall, the broken, loose, and hanging rock materials were clearly visible when viewing the active highwall area from the side as shown in Appendix B, Photo 3. Examinations from the top of the highwall (as shown in Appendix B, Photo 4 & 5) were not a routine part of the miners’ examinations of ground conditions before work commenced below. Prudent examinations of highwall ground conditions include observations from multiple vantage points to ensure hazardous conditions are identified and corrected before miners are exposed to them.

ROOT CAUSE ANALYSIS

A root cause analysis was conducted and the following root causes were identified:

- Root Cause: The operator’s mining methods did not maintain wall stability in places where persons work or travel.

Corrective Action: The operator has revised their mining methods to alter the mining direction with respect to jointing and has revised the shot pattern to reduce back-break.

- Root Cause: The operator failed to take down or support hazardous ground conditions before work commenced in the area.

Corrective Action: The operator has instituted and trained all employees in a plan for taking down hazardous ground conditions with equipment that can reach all areas of the highwall face.

- Root Cause: The operator failed to conduct an adequate workplace examination. The operator failed to identify hazardous ground conditions in the work area prior to work commencing.

Corrective Action: The mine has instituted written highwall inspection procedures which include conducting examinations from the top of the highwall before work commences. All miners have been trained in these inspection procedures.

CONCLUSION

The accident occurred because Vulcan's mining methods did not maintain wall stability where the victim was working. The operator failed to take down or support hazardous ground conditions before work commenced in the area, and failed to identify hazardous ground conditions during workplace examinations prior to work commencing.

ENFORCEMENT ACTIONS

Order No. 8818895 – issued July 25, 2016, pursuant to Section 103(j) of the Federal Mine Safety & Health Act of 1977 (originally issued verbally and reduced to writing upon arrival of an inspector and subsequently modified to an order pursuant to Section 103(k)):

An accident occurred at this operation on 07/25/2016 at approximately 0845. As rescue and recovery work is necessary, this order is being issued under Section 103(j) of the Federal Mine Safety and Health Act of 1977 to assure the safety of all persons at the operation. This order is also being issued to prevent the destruction of any evidence which would assist in investigating the cause or causes of the accident. It prohibits all activity at the mine's pit area until MSHA has determined that it is safe to resume normal mining operations in this area. This order applies to all persons engaged in the rescue and recovery operation and any other persons on-site. This order was initially issued orally to the mine operator at 0940 and has now been reduced to writing.

Subsequent Action No. 8818895-01 – issued July 25, 2016, to modify the original 103(j) order to an order pursuant to Section 103(k) of the Federal Mine Safety & Health Act of 1977

Citation No. 8904016 – issued August 11, 2016, pursuant to Section 104(d)(1) of the Federal Mine Safety & Health Act of 1977 for a violation of 30 CFR § 56.3130:

Failure to maintain wall stability contributed to a fatal accident that occurred at this mine on 25 July, 2016, when the cab of a track-mounted excavator was crushed by a fall of material from the quarry highwall. The excavator was being used to sort and selectively load blasted rock into a haul truck, and was working from an elevated position constructed from the remnants of a previous shot adjacent to the quarry wall. The quarry face intersects strong Geologic jointing at an acute angle. The jointing is pervasive vertically and extensive laterally. This condition contributes to a highly-fractured quarry wall by creating multiple planes of weakness in the rock strata. This resulted in obvious and extensive broken, loose and hanging rock on the wall. The operator did not employ benching, nor did the operator provide any equipment on-site with sufficient reach and capability to scale the quarry wall (the highwall is 111ft high, excavator has 40ft max horizontal, 27ft vertical downward, and 35ft vertical upward reaches). There were no signs or barricades in place to prevent the excavator from entering an area where hazardous conditions existed.

Management engaged in aggravated conduct constituting more than ordinary negligence by failing to use mining methods that maintain wall stability. This violation is an unwarrantable failure to comply with a mandatory health and safety standard.

Order No. 8904017 – issued August 11, 2016, pursuant to Section 104(d)(1) of the Federal Mine Safety & Health Act of 1977 for a violation of 30 CFR § 56.3200:

Failure to correct loose ground conditions on the quarry wall contributed to a fatal accident that occurred at this mine on 25 July, 2016, when the cab of a track-mounted excavator was crushed by several large boulders. One of the boulders measured in excess of 3000lbs, and fell from approximately 80ft above the excavator cab. The excavator was being used to sort and selectively load blasted rock into a haul truck, and was working from an elevated position constructed from remnants of a previous shot adjacent to the quarry wall. When the excavator was repositioned along the quarry wall in the course of the operator's tasks, it was struck by material falling from the highly-fractured quarry face.

Management engaged in aggravated conduct constituting more than ordinary negligence by failing to take down or support loose ground and post warnings or

barricade the area against entry. This violation is an unwarrantable failure to comply with a mandatory health and safety standard.

Order No. 8904018 – issued August 11, 2016, pursuant to Section 104(d)(1) of the Federal Mine Safety & Health Act of 1977 for a violation of 30 CFR § 56.3401:

Failure to conduct an adequate examination utilizing multiple vantage points of the quarry wall contributed to a fatal accident that occurred at this mine on 25 July, 2016. The cab of a track-mounted excavator was crushed by a fall of material from the quarry highwall. The excavator was being used to sort and selectively load blasted rock into a haul truck, and was working from an elevated position constructed from the remnants of a previous shot adjacent to the quarry wall. An examination of the quarry wall was not adequately conducted to identify hazardous ground conditions prior to the excavator being placed near the highly-fractured quarry wall where broken, loose and hanging rock was obvious and extensive.

Management engaged in aggravated conduct constituting more than ordinary negligence by failing to ensure exams are adequately conducted to identify hazardous loose ground conditions. This violation is an unwarrantable failure to comply with a mandatory health and safety standard.

Approved:  Date: 1/5/17
Samuel K. Pierce
Southeast District Manager

APPENDIX A – Persons Participating in the Investigation

Vulcan Construction Materials, LLC

Doug Britt	Plant Manager
Bill Huffman	Central Division Safety and Health Manager
Mike Junkerman	Safety and Health Manager
Kevin Connors	Area Production Manager

Mine Safety and Health Administration

Rory Smith	Supervisory Mine Safety and Health Inspector
David Allen	Mine Safety and Health Specialist
Dai Choi	Civil Engineer, Technical Support
Terry Lingenfelter	Mine Safety and Health Specialist
Ryan O'Boyle	Supervisory Mine Safety and Health Inspector
Ed Jewell	Mine Safety and Health Inspector

APPENDIX B – Photos

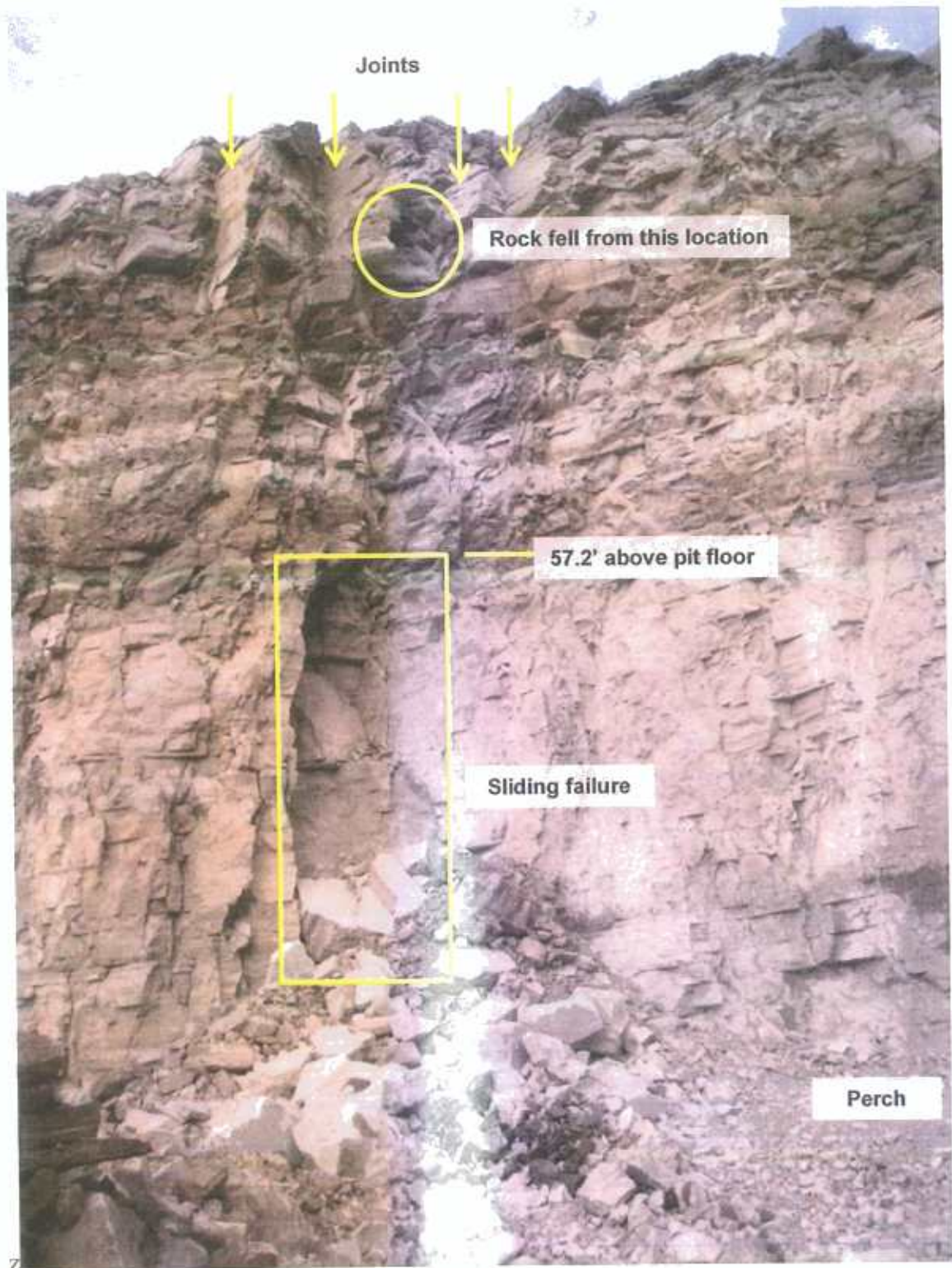


Photo 1
Overview of Rockfall Area



Photo 2
Close-up View of Rockfall Origination and Highwall Face