UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
DISTRICT C

FINAL REPORT OF MINE-EXPLOSION SHAFT SINKING OPERATIONS ZENI-McKINNEY-WILLIAMS CORPORATION GRUNDY, BUCHANAN COUNTY, VIRGINIA

January 24, 1967

by

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Technical Assistant

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INTRODUCTION

This report is based on an investigation made in accordance with the provisions of the Federal Coal Mine Safety Act (66 Stat. 692; 30 U.S.C. Secs. 451-483) as amended.

An explosion occurred about 3:10 p.m., Tuesday, January 24, 1967, in the connecting entry between the supply and air shafts of the Virginia Pocahontas Mine No. 1. All work in the shafts and underground was being done by the Zeni-McKinney-Williams Corporation, a subsidiary of the Dravo Corporation. The operation is owned by the Island Creek Coal Company, but the coal company had not assumed control at the time of the explosion. Two men were killed instantly; one died 14 days later; and four other men underground were hospitalized due to burns and/or injuries; four other employees in the coal entries and five in the skip shaft sump were uninjured. A surface employee working at the supply shaft on the surface received minor injuries and was hospitalized. Officials and employees of the contractor with assistance from representatives of Island Creek Coal Company removed the dead and injured to the surface. The names of the victims, their ages, occupations, number of dependents and experience are listed in Appendix A of this report.

Bureau of Mines investigators believe that the explosion originated in the connecting entry between the supply and air shafts where an explosive mixture of methane gas was ignited by an electrical arc or spark when a spring controlled open-type switch in the d.c. circuit was being opened. Forces of the explosion extended to the surface via the three shafts, the greatest force from the air shaft.

GENERAL INFORMATION

The sinking of the shafts and driving the connecting entries for the Virginia Pocahontas Mine No. 1 was performed by the contractor, Zeni-McKinney-Williams Corporation. The mine is located on Dismal Creek in Buchanan County, Virginia, about six miles southeast of Grundy. The names and addresses of the operating officials of the Dravo Corporation are:

Robert Dickey	President	Pittsburgh, Pennsylvania
C. Russel Mattson	Manager, Accident Prevention Hazard Control Department	Pittsburgh, Pennsylvania

Officials of the Zeni-McKinney-Williams Corporation are as follows:

K. C. Cox	Vice President and General Manager	Pittsburgh, Pennsylvania
W. H. Robertson	Superintendent	Vansant, Virginia
Charles D. Dobson	Chief Engineer	Pittsburgh, Pennsylvania
Frank Wood	Job Engineer	Grundy, Virginia

Coal was not being mined on the day of the accident nor had coal been produced for several days previously. All coal mined, 8,000 to 9,000 tons, had been stockpiled, awaiting completion of the preparation plant. A total of 75 men was employed, 45 underground and 30 on the surface; this number included certified mine officials who supervised the work in the coalbed and adjacent strata.

The mine is opened by three circular, reinforced concrete lined shafts; namely, skip, supply, and air shafts. Hereinafter they will be referred to as A, B, and C shafts, respectively. The inside diameter, depth, and top elevations of the shafts are as follows:

Name	Inside Diameter	Depth (Bottom of Coalbed)	Elevation (Top of Shaft)
Skip Shaft - A	20'	1,167'	1,207'
Supply Shaft - B	22'	1,157'	1,204'
Air Shaft - C	20'	1,159'	1,198'

The shafts are connected by a single entry driven in the Pocahontas No. 3 coalbed, which averages 50 inches in thickness. Openings were driven in the coalbed around the bottoms of the B and C shafts (see Appendix B).

The roof was brushed in portions of the openings around or near the three shaft bottoms. The connecting entry and openings were driven 18 to 21 feet wide. The immediate roof was dark gray or sandy shale up to six feet thick. The main roof was massive sandstone. The bottom was of firm fire clay.

The analysis of a coal sample of the Pocahontas No. 3 coalbed taken from the nearby Beatrice Mine, Beatrice Pocahontas Company, is as follows:

	Percent
Moisture.....	2.2
Volatile Matter.....	17.3
Fixed Carbon.....	76.8
Ash.....	3.7
	100.0

Numerous tests by the Bureau of Mines have shown that coal dust having a volatile ratio of 0.12 is explosive and that the explosibility increases with an increase in the volatile ratio. The volatile ratio of the coal in this mine as determined from the aforementioned analysis is 0.18, indicating that the dust from this coal is explosive.

A Federal inspection of the shaft sinking operations had not been made.

MINING METHODS, CONDITIONS, AND EQUIPMENT

Mining Methods

The only development of the mine had been the driving of the connecting entries between the three shafts. Some entries had also been driven around C and B shafts to facilitate the movement of equipment and supplies. Work was also in progress to sink the A shaft below the coalbed for coal handling purposes. The approaches to the various shafts were concrete lined. A continuous miner was used to drive the entries between and around the shafts. Coal was loaded into shuttle cars and hoisted in buckets to the surface. Rock was loaded with loading machines into shuttle cars and the rock was also hoisted by buckets to the surface.

The suspension method of roof support was used with 5/8" high strength steel bolts 48" in length. The bolts were installed on 4' centers both crosswise and lengthwise. In some areas, posts on 4' centers had been installed on the side opposite the power wires. These posts were used principally to carry the brattice line during the development work.

Percussion drills supplied with air piped from compressors on the surface were used for drilling underground. A 3-inch diameter steel air line had been installed on the mine floor beneath the power wires in the entry between C and B shafts.

Explosives

Permissible explosives, Hercogel A in $1\frac{1}{4}$" x 8" cartridges, were used for brushing and blasting rock in the mine. Instantaneous and short period delay detonators were used. Explosives in their original containers were transported underground in the muck bucket and stored principally in the first entry to the left from the C shaft opening. The explosives were then either carried or transported in the shuttle cars to the work areas. Detonators were transported and stored in a similar manner. Detonators and explosives were not transported together.

Normally, six 10-foot shot holes were charged with 6 to 8 cartridges of explosives. Clay dummies were used for stemming. After charging the shots had been completed, the detonator leg wires were wired in series and connected to a 2-conductor blasting cable. Thereafter, the shots were fired from the mine power circuit. From available information, gas tests were made before and after blasting. At the time of the explosion, no blasting was being done but large quantities of loose explosives were found at various locations underground.

During the investigation, a supply of explosives, estimated at 100 pounds, was in the first entry to the left from the C shaft opening. These explosives and some detonators were scattered about in the entry. At the No. 3 shuttle car, 106 cartridges of explosives were found scattered along the left coal rib. At the left junction to B shaft entry 12 cartridges of explosives were found scattered along the entry. Six and one-half cartridges were found in the southeast approach to the B shaft. Twenty-three cartridges and five boxes of detonators with five unshunted detonators were found in the southwest approach to B shaft (see Appendix B).

Two 50-pound cases of Hercules Powder Company's explosives used at the operation were tested at the Bureau of Mines Bruceton plant and found to meet the minimum requirements of the Bureau of Mines Schedule 1-f as set up for permissible explosives.

Ventilation and Gases

The mine was ventilated by means of three fans and natural drafts.

A 36-inch diameter axial flow fan on the surface at C shaft exhausted about 35,000 CFM through 36-inch steel tubing. The tubing intake was behind the southeast plywood stopping at the bottom of the shaft. A 48-inch Aerodyne fan was installed underground in the northeast approach to B shaft and was blowing toward B shaft. The fan was encased in a plywood stopping provided with airlock doors. The quantity of air moved by this fan, operated at 1,760 RPM in No. 4 blade position, is not known. A centrifugal blower on the surface at A shaft was operated blowing through an 18-inch diameter steel tubing which extended into the pit at the bottom of A shaft. This fan produced about 7,000 CFM and it was used to ventilate the pit below the coalbed.

Plywood stoppings were across the northwest, southwest, and southeast openings around C shaft. A regulator was reported to have been across the entry north of B shaft, and pieces of this regulator were observed after the explosion. It was ascertained that stoppings had been in place in the northwest, southwest, and southeast approaches to B shaft, but apparently at some undetermined time before the day of the explosion, they had been removed or blown down during blasting and not replaced. A witness underground in the area around B shaft during the explosion, stated that the stoppings were not in place on the day of the explosion, and the only stopping remains noted by the investigators during the investigation were part of the fan enclosure.

Since the portals of the A, B, and C shafts were at virtually the same elevations, natural drafts could not be expected to cause air movements through the mine. The fan at shaft C, assisted by high-density air during cold weather, would cause air flow down shaft C and possibly toward shafts A and B. As the surface temperature increased, the flow through shaft C should decrease since the fan would no longer be assisted by high-density air and could be resisted by the warm low-density air entering the shaft. With the stoppings in the northwest, southwest, and southeast approaches to the underground fan at B shaft removed, air recirculation could, conceivably, approach the capacity of the fan at B shaft, especially when the surface temperature equalled or exceeded the underground temperature because the flow through C shaft would be retarded by the same surface temperature increase.

Such ventilation changes occurred on the day of the explosion as surface temperatures ranged from 38° to 65°.

The mine had been classed gassy by the State. Preshift and on-shift examinations for gas and other hazards were made and recorded by certified officials. Survivors stated that shortly before the explosion, a test for methane had been made with a permissible flame safety lamp near the continuous miner by Paul Herndon, mine foreman, and Clifford Barnett, first shift foreman; Barnett advised that methane was not detected. This coalbed is known to be extremely gassy and to emit methane freely. The fireboss' record book for the second shift of January 23, 1967, showed that methane was detected, but the location where the gas was found was not indicated. Air samples collected during this investigation contained methane of various percentages, and an air sample collected at the top of A shaft on January 25, 1967, showed 0.86 percent of methane and a liberation of 619,000 cubic feet of methane from the mine in 24 hours.

Dust

Generally, the mine surfaces were dry; however, the entries around C shaft and the approach to A shaft were wet. Loose coal and coal dust were observed during this investigation along the entry between C and B shafts. Rock dust had been applied to the mine surfaces. Eleven spot-location mine dust samples were collected in the explosion area on January 25, 1967, and analyzed for incombustible content and coke (see Table 2). The incombustible content of the 11 samples collected ranged from 31.0 to 69.8 percent; but only two samples contained more than 65 percent incombustible material. Water was used to allay dust during the mining operations. During the underground investigation, it was evident that coal dust had entered into and helped propagate the explosion. Evidence of violent pressure and/or forces was found in the immediate ignition area, and evidence of burning coal dust, such as coke deposits, was found in the same area.

Transportation

At the time of the occurrence, all mined materials, supplies and men were hoisted in a 2-cubic yard muck bucket at the C shaft; a 1-cubic yard bucket was also available. Both buckets were provided with self-locking handles. The hoist was equipped with safety devices, and a signaling device and telephone were provided at the top and bottom of the shaft. A top man and a bottom man were on duty at all times while men were working underground. Coal and rock were transported underground in shuttle cars.

Electricity

Electric power at 110, 220, 440 and 2,300 volts alternating current was used on the surface; and 440 volts alternating current and 275 volts direct current were used underground. The direct current power was transmitted underground from a rectifier installed on the surface, equipped with overload and short-circuit protection. The two single insulated 795,000 circular mil cables were anchored adequately and suspended in the C shaft. In the connecting entry between C and B shafts they were supported on porcelain insulators and on insulated J hooks attached to timbers. Two sectionalized cutout switches were used underground--one at the bottom of C shaft and the other about 300 feet inby. Some bare places were found in the power cables where they had been used as nipping stations. The alternating current power was transmitted underground by 3 single insulated conductors installed in the B shaft to furnish power to operate the fan at the bottom of B shaft and the portable sump pump in the A shaft. The cables and equipment were provided with overload and short-circuit protection. The direct current powered face equipment of the permissible type consisted of three shuttle cars, two loading machines and one continuous miner. The trailing cables on this equipment were flame resistant 2-conductor cables, each provided with short-circuit protection. Temporary splices in the trailing cables were made with splice rings and were well insulated. The portable equipment was not frame-grounded. Following the explosion, it was found that the feeder cables had been dislodged from their supports and were on the mine floor from the cutout switch between C and B shafts to the inby end of the cables, a distance of 600 feet. The dislodged cables were in contact with each other and the metal compressed air line at several places; holes were burned through the pipe line at four contact locations. The alternating current power lines to the fan and pump remained intact. The permissible electrical equipment was examined by a State and a Federal coal mine electrical inspector and an electrical man representing the company. The following defects were found:

Joy 32E Standard Drive Shuttle Car (No. 1)

One seal on the controller compartment cover was broken; one seal missing from one of the covers on the pump motor; the cable-reel collector ring compartment cover had an opening in excess of .004 inch; the connection box at the cable reel had one lock washer missing; the cable connection box at the right traction motor had an opening in excess of .008 inch and the conduit clamps were missing; the conduit clamps at the entrance of the cable connection box to the pump motor were missing; and the locking bolt and seal were missing from the deck end headlight. This shuttle car was not being operated on January 24, 1967, because of a broken axle.

Joy 32E Standard Drive Shuttle Car (No. 2)

The seal on the deck end headlight and the seals on the controller case covers were missing; headlight resistor covers had openings in excess of .004 inch; locking bolt and seal were missing from one of the headlights; one bolt was missing from the cable-reel collector ring compartment cover; and the trailing cable was not clamped to the cable-reel drum.

Joy 32E Opposite Standard Drive Shuttle Car (No. 3)

Locking bolt and seal were missing and the lens was cracked on the deck end headlight; locking bolt and seal were missing from the foot control switch cover; seals on the controller compartment covers were broken; cable connection box at the left traction motor had an opening in excess of .008 inch and the conduit clamps were missing; a seal was broken on one of the covers on the left traction motor; locking bolt and seal were missing from the front headlight; and cable connection box at the right traction motor had an opening in excess of .008 inch.

Lee Norse Miner

A seal was broken on one of the covers on the right cutting motor, and a seal was broken on one of the covers on the pump motor; power cables were exposed where they entered the junction box under the boom; and the conduit clamps were missing.

14 BU Joy Loader (No. 1)

The master switchbox cover had an opening in excess of .004 inch and four of the cover bolts were missing; the cable connection box for the right tramming motor had an opening in excess of .008 inch; three of the cover lock bolts were missing from the right head motor; lock bolt and seal were missing from one of the covers on the left head motor; a bolt was missing from the conduit clamp on the left head motor; and the conduit was not clamped on the packing gland on the pump motor. This loading machine was taken out of service and removed from the mine after the explosion.

14 BU Joy Loader (No. 2)

The trailing cable was not secured with a strain clamp at the bell mouth entrance, and packing gland locking screws were missing from the connection boxes to the right and left head motors.

The continuous miner and the three shuttle cars were in the connecting entry between C and B shafts. The two loading machines were in the entries near B shaft. Reportedly, the continuous miner and the No. 2 shuttle car were the only face equipment energized at the time of the explosion.

Reportedly, tests for methane were made with a permissible flame safety lamp by certified officials before electric face equipment was operated and frequently while such equipment was being operated.

Illumination and Smoking

Permissible electric cap lamps were used for portable illumination underground. Fixed lighting at the bottoms of C and A shafts was by means of enclosed lights activated by air-operated generators. Evidence of smoking was not observed underground.

Mine Rescue

A mine rescue team was not maintained at the operation. Necessary rescue equipment and some trained personnel were maintained at the Beatrice Mine about nine miles distant. The Island Creek Coal Company maintains mine rescue teams and equipment at their West Virginia mines. Trained personnel and equipment are available at five mines within 50 miles of the operation. Self-rescuers were carried by the underground employees, and some of the self-rescuers were used following the explosion and during recovery operations. Three 20-pound fire extinguishers, suitable for B and C type fires, were placed at strategic locations underground. Air-operated pumps, with connecting pipeline, were located and used at sumps and other water gathering locations underground.

STORY OF EXPLOSION AND RECOVERY OPERATIONS

Participating Organizations

Officials and employees of Zeni-McKinney-Williams Corporation, officials of Dravo Corporation, Island Creek Coal Company, Virginia Division of Mines and Quarries and United States Bureau of Mines participated in the investigation. Removal of the injured men and victims to the surface was done by officials and employees of the local contractor and Island Creek Coal Company.

Activities of Bureau of Mines Personnel

About 4:30 p.m., Tuesday, January 24, 1967, J. S. Malesky, District Manager, was notified by a telephone call from W. F. Mullins, Chief Mine Inspector, Virginia Division of Mines and Quarries, that an explosion had occurred at the shaft sinking operation of the Virginia Pocahontas Mine No. 1 and that some men were known to be killed. About 5:40 p.m., C. E. Linkous, Director of Safety and Industrial Relations, called and advised Mr. Malesky that an explosion had occurred; two men were dead; five men were injured; and four were uninjured. All men and the victims had been removed from the mine and the survivors were sent to hospitals by 5:00 p.m. on the day of the occurrence. Immediately after learning of the occurrence, Mr. Malesky instructed Harold H. Wiley, John J. Pendergast, Jr., and Frank P. Stefkovich, Federal Coal Mine Inspectors located at Richlands, Virginia, to proceed to the mine where they arrived about 6:30 p.m. Additional Bureau personnel, George L. Mears, William R. Stewart, and Ray G. Ross, arrived at the mine about 8:00 p.m. Arrangements were made to start the investigation of the occurrence at 9:00 a.m. the following day.

On the evening of January 24, 1967, a withdrawal Order was issued under Section 203 (a) of the Federal Coal Mine Safety Act debarring all personnel from going underground, except those needed for exploratory and investigative work. Before the Order was issued, all men, except those mentioned above, had been kept from entering the mine.

W. R. Park, District Manager, District B, and Carl E. Stinnette, Federal Coal Mine Electrical Inspector, arrived at the mine January 26 and participated in the investigation. Bureau personnel remained at the operation until the contractor completed his underground construction work on February 10, 1967.

Mine Conditions Immediately Prior to Explosion

The mine operated normally from 8:00 a.m. to 3:00 p.m., January 24, 1967. The surface temperature, recorded in one of the record books at the mine for January 24, 1967, stated: Clear and sunny; 8:00 a.m., 38° with 65° high; the high reading was at approximately 3:00 p.m. The barometric pressures and temperature readings of January 24, 1967, recorded at the Bluefield, West Virginia Airport, approximately 45 air miles away, were as follows:

Time	Barometer	Temperature
8:00 a.m.	30.31	33°
12:00 Noon	30.33	60°
3:00 p.m.	30.26	62°

The following barometer readings were recorded at the Beatrice Mine, about 9 miles away, for the period January 23-27, 1967:

Date	Barometer
1/23/67	30.13
1/24/67	30.03
1/25/67	30.00
1/26/67	30.00
1/27/67	29.94

It is the opinion of the Bureau investigators that the slight variation in atmospheric pressure had no bearing on the explosion. Inasmuch as positive ventilation in the underground areas was not provided and mine ventilation was affected materially by surface temperature changes, the gradual rising of the surface temperature on the day of the explosion had a direct bearing on the decrease of air flow in the mine entries on the day of the occurrence. All fans were operating; but, as stated previously, the fan located on the surface at C shaft ventilated the openings around the bottom of C shaft; the fan at the bottom of B shaft was installed in such a manner as to allow recirculation of air in this general area; and the fan located on the surface at A shaft ventilated the pit below the coalbed at A shaft.

Evidence of Activities and Story of Explosion

The day shift crew entered the mine at 8:00 a.m. and proceeded to their respective working areas. The work of loading top rock, which had been blasted on the previous shift in the parallel entry west of B shaft, and the cleaning up of loose material in the adjoining entries around B shaft continued without incident until about 2:00 p.m. At this time, Herndon gave instructions to start the projected entry north off the connecting entry between C shaft and B shaft (see Appendix B). This entry was to be driven 100 feet and then turned 45° northeast to intersect the southwest approach to B shaft. The southwest approach was to be graded to make a sump and the driving of this additional entry would facilitate loading the bottom rock.

John Honaker, electrician, trammed the Lee Norse continuous miner from the southwest approach of B shaft to the intersection of the west parallel entry and the connecting entry from C to B shaft. Zayne Childress, continuous miner operator, then trammed the miner toward C shaft to where the new entry was to be started. While the miner was being trammed in the entry, fire erupted from an insulation break in the miner trailing cable. The nip was removed and rubber tape and friction tape were used

to repair the cable, then the nip was replaced on the power wire. Paul Herndon, mine foreman, was supervising the work in the area. Immediately prior to the explosion, Honaker was preparing to cut the energized feeder cable so that the nipping station could be moved outby the location where the new entry was to be driven. Honaker asked Kirby Ward, shuttle car operator, to pull the power switch in the d.c. circuit, which was located 280 feet outby the miner. Ward proceeded on his shuttle car (No. 2) to the power switch and was in the act of pulling the switch when the explosion occurred. Two of the seven men working in the connecting entry between B shaft and C shaft were killed instantly, and the remaining five men suffered burns and/or other injuries. One of the injured men died February 7, 1967. The other four men in the mine were working in the vicinity of B shaft and were uninjured.

Clifford Barnett and G. T. Harris III, inside foremen; Daniel Johnson, shuttle car operator; and Kenneth Anders, inside laborer, were near B shaft when the explosion occurred. They heard what they described as a blast but saw no flame. They proceeded immediately to the explosion area and became aware that something unusual had occurred and that the men in the area had been injured. Barnett told the three men with him to take care of the injured men and he would check the area toward C shaft. Visibility was limited due to smoke and dust but Barnett had no trouble breathing. Two small cable fires were extinguished as Barnett traveled to C shaft. Upon arriving at C shaft, Barnett found James Scott, bottom man, and Kirby Ward, shuttle car operator (No. 2). Ward said he had crawled from his shuttle car to the shaft. The smoke and dust were very dense in this area at that time. The hoist signal line and telephone had been destroyed. Barnett told the men he would go to the surface by way of A shaft to obtain assistance and started toward A shaft. On the way he met Harris and told him again to stay with Childress and Honaker, both injured. Upon arriving at A shaft, Barnett met Bob Asbury and Perry Yost who had just entered the mine. They proceeded to B shaft to help with the injured men while Barnett went on to the surface to get additional help.

After Barnett left for the surface, Daniel Johnson traveled to C shaft to see if he could get out that opening. Finding no means to signal the surface, Johnson decided to return to B shaft. About this time, Kenneth Anders arrived at the C shaft bottom. Johnson left Anders with the two injured men (Ward and Scott) and went back to B shaft where he met Bob Asbury. The two men took Zayne Childress to the surface via A shaft. Honaker had already been taken to the surface by Perry Yost and an unidentified man who had entered the mine via A shaft.

When Barnett arrived on the surface, he was instructed to work with James Hunter, superintendent of the Beatrice Mine, in the recovery work. Hunter, Barnett, and three additional men proceeded to C shaft to enter the mine. The empty muck bucket was lowered to make certain the shaft was clear. When the bucket reached the bottom, the men on the bottom got into it and signaled by hammering on the bucket. These signals were heard on the surface and Anders, Scott, and Ward were hoisted thereto.

The party of Hunter, Barnett, and three other men then entered the mine. Some smoke and dust were present around the shaft bottom but some air was moving toward B shaft and no difficulty was encountered in traveling the entry toward B shaft. The body of Paul Herndon was found about 600 feet inby C shaft bottom. Arnold Rowe, shuttle car operator, seriously injured, was found along the left rib about 15 feet inby Herndon. The body of Paul White, laborer, was found at the intersection of the connecting entry and the west parallel entry of B shaft. The injured men and the bodies of the victims were removed from the mine by 5:00 p.m.

Kirby Ward, operator of the No. 2 shuttle car, stated that when Honaker asked him to pull the power switch, he proceeded on the shuttle car to the switch. Sitting in the deck of the shuttle car, he grasped the switch handle and was in the act of pulling the handle when fire came out and hit him in the face. His hair was on fire and he put the fire out with his hands and then crawled along the right rib of the entry to C shaft. Ward said that he could not be certain as to whether he did or did not get the power disconnected. According to Ward, he did not hear a blast.

Interviews with the survivors indicated that for some time prior to the explosion, the employees and officials were aware that air movement underground was sluggish and limited as compared with air movement on previous days. Honaker, electrician, stated that shortly before the explosion the mine foreman (Herndon) picked up a handful of dust from the floor and dropped it to check the air movement, but that the dust fell directly to the mine floor. Herndon then remarked that something was wrong with the air and he had better check it. Herndon thereafter instructed Barnett to take his men and construct a regulator near A shaft. Barnett and others had just passed B shaft when the explosion occurred. Reportedly, Herndon and Barnett made a test for methane alongside the miner shortly before the explosion and methane was not detected. The flame safety lamp used in making the gas test belonged to Herndon, but it was being carried and used by Barnett as his (Barnett's) flame safety lamp was not in proper working order and was left on the surface.

The general area where the explosion originated was immediately apparent to the investigative group, but the type and cause of the occurrence were more difficult to determine. The investigators found in their initial examination of the immediate explosion area three pieces of permissible face electric equipment (a miner and two shuttle cars) in nonpermissible condition, large amounts of permissible explosives loose and scattered on the mine floor, the d.c. feeder lines dislodged from insulators and in contact with each other and the metal pipe line, holes burned into the pipe line, and evidence that coal dust had entered into the explosion. During the initial examination, large quantities of air were moving from C shaft through the explosion area toward B shaft although the underground fan at B shaft was inoperative.

During this initial examination, the investigators found numerous cartridges of explosives scattered on the mine floor at five different locations. More than 100 cartridges of explosives were scattered on the mine floor close to the north left rib of the entry at the No. 3 shuttle car. Because these explosives were in the underground area showing the greatest evidences of force and because of a small shattered hole in the floor material immediately outby the shuttle car, the investigators strongly suspected that the explosion had been initiated by the accidental detonation of explosives. However, the absence of material blown upon the roof as would be expected from an unconfined blast of explosives and the absence of discoloration on the floor, as is usually present following a blast of explosives, indicated that further investigation was necessary. Additional investigation of the underground areas and statements from the survivors who were in the mine when the explosion occurred showed that the explosion had not been initiated by the premature or accidental detonation of explosives. Statements of the survivors were that none had smelled or observed explosive fumes at anytime after the blast occurred, and nothing was found by the investigators that would indicate sufficient shock or heat to cause the premature detonation of explosives.

As mentioned previously, the metal 3-inch air line contained four holes and any one might have released sufficient air under pressure to place or force a cloud of coal dust into suspension of sufficient density that it might have been ignited. However, careful examination of the openings into the air line showed conclusively that the openings had been made by electric burning and that such burning in all likelihood occurred after the explosion. Statements of the survivors again indicated that prior to the explosion they had not observed dust in suspension, that they had not heard or observed air escaping under pressure, and that the feeder lines were intact in their insulators prior to the explosion. Because

of the foregoing facts and statements of the survivors, the investigators discounted the likelihood that the explosion had been initiated when an electric arc or spark ignited a cloud of dust that had been thrown into suspension by air escaping from the air line.

Another possible source of the explosion that was considered carefully was that a piece of the electrical equipment being moved might have contacted and damaged the feeder cables or the air line and ignited dust at such a location because of such dust being thrown into the air by a break in the air line. Evidence could not be found that such a contact had been made with the feeder line, the air line, the cutout switch, or the enclosure to the cutout switch.

As mentioned previously, survivors of the explosion stated that air movement along the entry between C and B shafts was sluggish and almost nonexistent shortly before the occurrence. Examinations for gas in the open entries and along the ribs by the investigators revealed that as much as 2% methane was present occasionally in the moving air current, that gas was emitting freely from the exposed ribs, that gas feeders along ribs that had been exposed for some time were emitting audible quantities of gas, that an air sample collected against the north left rib about 600 feet inby C shaft contained 15.7 percent methane and that over 600,000 cubic feet of methane was being released from the mine in a 24-hour period.

Because of the foregoing facts concerning gas liberation and mine ventilation, the investigators believe that gas accumulated in the explosive range at and near the cutout switch located 300 feet inby C shaft. It is further believed that the accumulated methane was ignited by an electric arc when Ward (shuttle car operator) opened the cutout switch. Because of the construction of the cutout switch, it must be assumed that the cutout switch was opened at least momentarily to break the circuit and create an arc. Thereafter, upon being struck in the face with fire, Ward instinctively reclosed the switch to eliminate the fire. Such action by Ward would have caused an arc to ignite methane and thereafter reenergize the d.c. circuit inby the switch so as to result in short circuits and electric burning at the short circuits.

Recovery Operations

Immediately after the explosion, the four uninjured underground employees accounted for the dead and injured. Surface officials deenergized the underground direct current power system; notified officials of the Beatrice Mine, Beatrice Pocahontas Company, Virginia State Police, hospitals and doctors at Grundy and Richlands, Virginia. Representatives from

each arrived within the hour. James Hunter, Superintendent of the Beatrice Mine, assisted officials of the contractor with the recovery operations. Some of the men assisting with recovery operations used self-rescuers. The dead and injured were recovered and brought to the surface by 5:00 p.m. As the injured persons were brought to the surface, they were examined and treated by doctors and then taken to hospitals at Grundy or Richlands, Virginia. Auty Branham and Joe Davis, District State Mine Inspectors, arrived at the mine about 4:00 p.m. Guards were posted at each opening to prevent unauthorized entrance. The investigation was scheduled to start the following morning.

Rehabilitation of the mine began on January 26, 1967. Positive ventilation was provided, the connecting entry between C and B shafts was cleaned of coal dust and rerock-dusted, suitable explosives storage and handling facilities were provided, a permissible shot-firing unit was procured, and the electric face equipment was restored to permissible condition. The withdrawal Order of January 24, 1967, was annulled by the Federal Coal Mine Safety Board of Review on February 1, 1967.

INVESTIGATION OF CAUSE OF EXPLOSION

Investigation Committee

The underground investigation into the cause of the explosion was begun January 25, 1967, and continued for several days thereafter. Members of the investigating committee were:

Dravo Corporation

C. Russel Mattson	Manager, Accident Prevention Hazard Control Department

Zeni-McKinney-Williams Corporation

W. H. Robertson	Superintendent
Charles D. Dobson	Chief Engineer
Frank Wood	Job Engineer

Island Creek Coal Company

William Bellano	President
Stonie Barker, Jr.	President, Island Creek Division
C. E. Linkous	Director of Safety and Industrial Relations

Virginia Division of Mines and Quarries

W. Foster Mullins	Chief Mine Inspector
Jack J. Gembach, Jr.	Assistant Chief
Elmer A. Thomas	Electrical Inspector
Auty Branham	District Mine Inspector
Louis E. Henegar	Roof-Control Inspector
Joe C. Davis	District Mine Inspector

United States Bureau of Mines

W. R. Park	District Manager, District B
G. L. Mears	Technical Assistant
H. H. Wiley	Coal Mine Inspection Supervisor
W. R. Stewart	Coal Mine Inspection Supervisor
R. G. Ross	Technical Assistant

An examination of the areas affected by the explosion was made by members of the investigating committee. The electrical equipment underground was examined by electrical inspectors and other interested persons; their findings are recorded elsewhere in this report. Following the underground investigation of January 25, 1967, two of the men that survived and were underground at the time of the occurrence were interrogated by the Virginia Division of Mines and Quarries at the coal company office near the shafts. The interrogation was headed by W. F. Mullins, Chief Mine Inspector, and by other State personnel. Representatives of the contractor, coal company, and Bureau of Mines participated in the interrogation. The purpose was to talk to people who had knowledge of events prior to the occurrence or practices leading thereto.

Other survivors were interrogated on January 27 and 28, 1967, and later dates by representatives of the contractor, the coal company, the State, and Bureau of Mines. The intention was to record all testimony relative to the practices in the mine prior to and on January 24. An effort was made to determine therefrom, if at all possible, the cause of the explosion. Salient parts of the information obtained during various interrogations are included in the report.

Methane and/or Dust As a Factor in the Explosion

The mine is classed gassy by the Virginia Division of Mines and Quarries. The Pocahontas No. 3 coalbed is known to be extremely gassy and to give off methane readily. Methane had been detected when the shafts intersected the coalbed and gas had been detected on many occasions while the entries were being developed. Records of gas detected in the mine are

shown in the mine record books. Following the explosion, air samples were collected during the investigation and various amounts of methane were detected. An air sample collected at the top of A shaft in a return of 50,000 cubic feet of air a minute showed a methane liberation of 619,000 cubic feet in 24 hours. On January 30, 1967, between the hours of 2:00 p.m. and 3:00 p.m., methane in the amounts of 1.54 and 2 per centum was detected in the ventilating current with a permissible flame safety lamp and a Riken methane indicator in the connecting entry between A and B shafts. Outside temperatures at this time were about the same as on the afternoon of January 24, 1967. During the construction work following the explosion, methane was detected with a Riken methane indicator and the percentages varied with the amount of air flow between the various shafts. Methane, in excess of 15 per centum, was indicated in an air sample collected against the north coal rib in the connecting entry between C and B shafts after positive ventilation was provided. Such areas had been found previously in the mine and are called gas feeders but are locally known as "hot spots". It is believed that the explosion resulted from an ignition of a quantity of methane that was being liberated from the ribs while the air current was stagnant or when there was practically no air movement between C and B shafts. With methane being liberated freely, an accumulation of methane is likely possible in a very short time following a cessation of air movement.

Flame

Flame, of short duration, extended west to the bottom of C shaft and north to about midway between B and A shafts. Soot streamers were not observed. Pieces of plastic brattice cloth and pieces of plastic material in which explosives are shipped were found curled as a result of heat. The exposed portions of the bodies of the three deceased men and three of the four injured men suffered burns of various degrees. Flame extended from near the continuous miner to the C shaft bottom, a distance of 500 feet where the cager received second and third degree burns. Ten of the eleven dust samples, collected in the explosion area contained coke particles. The presence of coke in the mine dust samples is one of the criteria by which the extent of flame was fixed, although there is a possibility that some of the coke farthest from the origin of the blast might have been blown there. Plastered coal and coke were found on posts near the continuous miner.

Forces

Evidence in the mine indicated that forces of the explosion originated near the cutout switch 300 feet inby C shaft and traveled in both directions therefrom. The forces traversed the entry to C shaft, out

C shaft, and were dissipated on the surface. Forces also traveled to B and A shafts, out the shafts, and were dissipated on the surface. The greatest violence was evident in the vicinity of the continuous miner as indicated by blown-out and splintered timbers and splattered material on the timbers that were left intact. Much explosives were strewn about in this area. The plywood encasing the fan at the bottom of B shaft was blown down. The most severe burns and injuries were received by the men who were in the vicinity of the continuous miner.

Probable Point of Origin

Bureau of Mines investigators believe that the explosion originated about 300 feet inby C shaft opening at the cutout switch in the d.c. feeder line.

Factors Preventing Spread of Explosion

All evidence indicated that the explosion was comparatively weak underground and that high pressures and/or excessive speeds that might have developed during the explosion propagation were dissipated through the shaft openings.

Summary of Evidence

Conditions observed in the mine during the investigation following the explosion, together with information obtained from company officials, workmen, and mine records, provided evidence as to the cause and the origin of the explosion. The evidence from which the conclusions of the Federal investigators are drawn is summarized as follows:

1. Records of the preshift or foreman's examinations of the mine indicated no unusual conditions on the day of the occurrence.

2. The Pocahontas No. 3 coalbed in the area is extremely gassy and during mining operations considerable methane is liberated. Methane liberation from the coal ribs is substantial and "hot spots" were found along the ribs. On January 30, 1967, between the hours of 2:00 p.m. and 3:00 p.m., methane in the amounts of 1.54 to 2 per centum was detected with a permissible flame safety lamp and a Riken methane indicator in the air current in the connecting entry between A and B shafts.

3. An air sample collected against the north rib of the entry about 600 feet inby C shaft on February 6, 1967, contained 15.7 percent methane.

4. The only flame safety lamp in the mine at the time of the explosion was in the possession of foreman Barnett who was near the B shaft bottom.

5. A test for gas made with a flame safety lamp near the continuous miner shortly before the explosion did not indicate the presence of methane in the atmosphere.

6. Evidence indicated that the most force was in the vicinity of the continuous miner on the entry between B and C shafts and the forces traveled from this location to all shafts.

7. The underground fan at B shaft was installed blowing toward B shaft. Airlock doors in the passageway by the fan were left open, and the absence of stoppings in three of the four connecting openings around B shaft made recirculation of the air possible.

8. The fans, with metal tubing, located on the surface at A and C shafts had very little effect on the ventilation of the underground workings inby the shaft bottoms.

9. Outside temperatures had a marked effect on the direction and velocity of the air movements and the air movement from C shaft to B shaft at the time of the explosion was sluggish.

10. Explosives and detonators were found loose and scattered at five locations underground.

11. Blasting was not being done at the time of the explosion nor were explosives or detonators being transported.

12. Loose coal and coal dust were present along the connecting entry from C to B shaft.

13. Rock dust had been applied along the entry between B and C shafts.

14. Six of the seven persons in the connecting entry between C and B shafts received burns of varying degrees.

15. Ten of the eleven dust samples collected contained coke particles.

16. All of the electric face equipment was in nonpermissible condition at the time of the explosion.

17. Power wires were down and burned into at three locations along the entry from C to B shafts.

18. The power wires were grounded against the 3-inch compressed air line and holes were burned in the line at four locations from 300 feet to 700 feet inby C shaft.

19. The continuous miner and the No. 2 shuttle car were the only equipment energized at the time of the explosion. The controls of the miner were in the "Off" position and the shuttle car was reported to be stationary at the time of the explosion.

20. The knife blade cutout switch, 300 feet inby C shaft, was being opened at the time of the explosion.

Cause of Explosion

The Federal investigators are of the opinion that this explosion was caused by the ignition of a body of methane by an electric arc or spark. The methane was liberated from the exposed coal ribs and accumulated because of insufficient ventilation.

Recommendations

The following recommendations are made to prevent similar occurrences:

1. When the ventilation in a gassy mine is disrupted or is materially reduced, the power shall be disconnected at the main power switch on the surface immediately and the men promptly removed from the mine.

2. After shafts intersect the coalbed, positive ventilation shall be maintained in coal excavations made to connect the shafts or development for any other reason.

3. The practice of connecting shafts with a single entry should be discontinued. Such connections shall be made with entries driven in sets of at least two with suitable crosscuts.

4. Main and auxiliary fans used for ventilating shafts and/or underground workings shall be suitably installed on the surface.

5. The volume and velocity of the air current in all open places shall be sufficient to dilute so as to render harmless, and to carry away flammable or harmful gases.

6. Each official in gassy mines whose regular duties require him to inspect working places for dangers should be required to have in his possession at all times while underground a permissible flame safety lamp and such official shall make necessary gas tests.

7. Examinations for methane shall be made frequently to assure that methane does not accumulate in dangerous quantities in underground areas. Such examinations shall include tests near the ribs.

8. Each shot firer and each operator of electric face equipment should be trained in the use of and provided with a permissible flame safety lamp. Rules governing the frequency of such testing shall be established and made known to all concerned.

9. Electric face equipment should be provided with methane monitors and consideration should be given to installing such monitors in all split and main returns.

10. Coal dust and loose coal shall not be permitted to accumulate in dangerous quantities in active underground workings.

11. Rock dust shall be distributed uniformly on the roof, ribs, and floor and maintained in such quantity that the incombustible content of the combined rock dust, coal dust, and other dust will not be less than 65 percent, plus 1 percent for each 0.1 percent of methane in the ventilating current.

12. Permissible equipment shall be maintained in permissible condition. A suitable maintenance program that will keep permissible equipment in permissible condition shall be developed, adopted, and followed. The equipment should be frame-grounded or equivalent protection provided.

13. Explosives and detonators should be transported in special closed containers designed especially for that purpose.

14. Supplies of explosives and detonators for use underground should be kept in section boxes of substantial construction and located at least 25 feet from roadways or power wires.

15. Not more than a 48-hour supply of explosives or detonators should be stored underground.

16. Explosives and detonators carried anywhere underground should be in containers constructed substantially of nonconductive material.

17. Permissible explosives should be fired only with the use of a permissible shot-firing unit.

18. Metal air and water lines should be installed on the side of the entry opposite the power wires.

ACKNOWLEDGMENT

The writers gratefully acknowledge the courtesies, cooperation, and assistance extended by officials and workmen of the Zeni-McKinney-Williams Corporation, Dravo Corporation, Island Creek Coal Company, and representatives of the Virginia Division of Mines and Quarries during this investigation.

Respectfully submitted,

George L. Mears

George L. Mears

W. R. Stewart

W. R. Stewart

Ray G. Ross

Ray G. Ross

Approved by:

J. S. Malesky

District Manager
Health and Safety
District C

ANALYSES OF AIR SAMPLES

TABLE 1

John Pendergast, Jr.
R. G. Ross
J. E. Tisdale
W. R. Stewart

MINE Operations Shaft Sinking COMPANY Zeni - McKinney - Williams Corporation COLLECTED BY

DATE	BOTTLE NO.	LOCATION IN MINE	PERCENT IN VOLUME					CUBIC FEET AIR PER MINUTE	CUBIC FEET METHANE IN 24 HOURS
			CARBON DIOXIDE	OXYGEN	METHANE	CARBON MONOXIDE	NITROGEN		
1/25/67	G9213	between C and B shafts 261 feet inby C shaft bottom	0.05	20.77	0.34	none	78.84	26,880	132,000
1/25/67	G9214	intake south cross entry surrounding B shaft	0.08	20.67	0.62	none	78.63	7,350	66,000
1/25/67	G9181	return between B shaft and A shaft 150 feet inby A shaft	0.05	20.56	0.89	none	78.50	40,660	521,000
1/25/67	G9209	return top B shaft	0.05	20.88	0.00	none	79.07		
1/25/67	G7814	return top C shaft	0.05	20.88	0.00	none	79.07	18,000	
1/25/67	G9210	return top A shaft	0.05	20.24	0.86	none	78.85	50,000	619,000
1/31/67	D5625	return first curve inby A shaft	0.10	19.62	1.07	none	79.21	7,200	111,000
1/31/67	D5626	return coal level at A shaft	0.10	20.64	1.35	none	77.91	7,200	140,000
2/4/67	G9382	return auxiliary fan at C shaft	0.05	20.79	0.14		79.02	35,000	71,000
2/4/67	G2488	return at B shaft near fan	0.05	20.69	0.34		78.92	109,800	538,000
2/6/67	G9381	entry between shafts C and B against north coal rib 6 feet outby projected entry	0.0	17.5	15.7	0.0	66.8		

ANALYSES OF DUST SAMPLES

TABLE 2

DATE COLLECTED January 25, 1967

MINE Operations Shaft Sinking COMPANY Zeni - McKinney - Williams Corporation COLLECTED BY John Pendergast, Jr. and F. P. Stefkovich

SAMPLE NO.	SAMPLE OF DUST FROM	LOCATION IN MINE	ALCOHOL COKE TEST	AS-RECEIVED PERCENT INCOMBUSTIBLE
		EXPLOSION SAMPLES		
1	band	connecting entry between C and B shafts 170 feet inby C shaft bottom	small	50.2
2	"	connecting entry between C and B shafts 261 feet inby C shaft bottom	small	49.4
3	"	connecting entry between C and B shafts 360 feet inby C shaft bottom	small	44.7
4	"	connecting entry between C and B shafts 460 feet inby C shaft bottom	small	35.5
5	roof and ribs	connecting entry between C and B shafts 560 feet inby C shaft bottom	small	41.1
6	same	connecting entry between C and B shafts 660 feet inby C shaft bottom	small	31.0
7	band	connecting entry between C and B shafts 760 feet inby C shaft bottom	trace	41.0
8	"	left entry surrounding B shaft 50 feet inby southwest approach	none	66.5
9	"	entry north of B shaft 50 feet outby the connecting entry to A shaft	trace	69.8
10	"	connecting entry between B and A shafts 200 feet inby northeast approach to B shaft	small	58.7
11	"	right entry surrounding B shaft 50 feet inby southeast approach of B shaft	small	37.9

APPENDIX A

VICTIMS OF EXPLOSION
SHAFT SINKING OPERATIONS
ZENI-McKINNEY-WILLIAMS CORPORATION
GRUNDY, BUCHANAN COUNTY, VIRGINIA

January 24, 1967

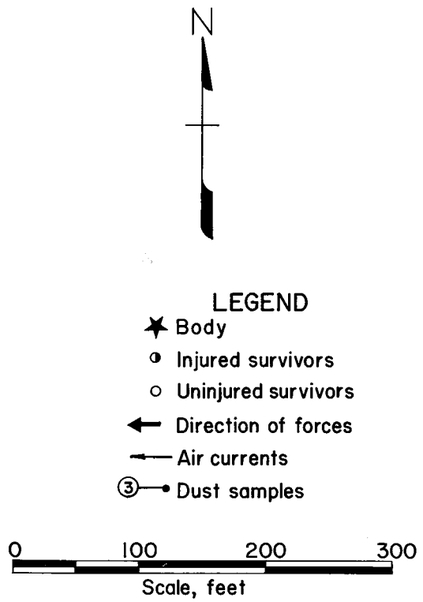
Name	Age	Dependents	Occupation When Injured	Experience in Mines
Paul Herndon	45	2	Mine Foreman	28 Yrs.
Paul White	39	3	General Laborer	11 Yrs.
Arnold Rowe	43	2	Shuttle Car Operator	Not known

PERSONS BURNED AND/OR INJURED BY EXPLOSION

Name	Age	Occupation
Zayne Childress	33	Continuous Miner Operator
John Honaker	42	Electrician
James Scott	49	Bottom Man
Kirby Ward	43	Shuttle Car Operator
Robert Walker	49	Surface Employee

APPENDIX B
MAP OF SHAFT CONNECTIONS SHOWING
PERTINENT DATA FOLLOWING
MINE EXPLOSION

SHAFT SINKING OPERATIONS
ZENI–McKINNEY–WILLIAMS CORPORATION
GRUNDY, BUCHANAN COUNTY, VIRGINIA
JANUARY 24, 1967



POCOHONTAS
No. 3 COALBED
50" THICK

S-1076