APPENDIX

REPORT of INVESTIGATION

into the

MINE EXPLOSION at the

UPPER BIG BRANCH MINE

APRIL 5, 2010

BOONE / RALEIGH CO., WEST VIRGINIA

WEST VIRGINIA OFFICE of MINERS' HEALTH, SAFETY & TRAINING

FEBRUARY 23, 2012

C.A. PHILLIPS, DIRECTOR

LIST of APPENDICES

APPENDIX 1

Definitions

Errata

APPENDIX 2

Geology and Mining Conditions

- **2.2-1** Geology
- **2.2-2** Petrographic and X-ray diffraction analysis of sandstone roof from the Longwall

Communication and Tracking System

- **2.5-1** The Approved Communication and Tracking Plan
- **2.5-2** Violation and extensions
- **2.5-3** Time drift correction: Pyott-Boone PC clock
- **2.5-4** Calculations for 108 second delay: Pyott-Boone

APPENDIX 3

Incidents of Prior Gas Inundations

- **3.2-1** Report of a Methane Ignition at UBB, January 4, 1997

APPENDIX 4

Origin and Path of the Explosion

- **4.1-1** Longwall production reports
- **4.3-1** Effectiveness of a water barrier in stopping the explosion in the inby reaches of #21 Headgate

APPENDIX 5

Chronology of Events

- **5.1-1** List of Victims

APPENDIX 6

Regulatory Compliance

- **6.2-1** Belt Books

APPENDIX 7

Structure of the Joint Investigation

- **7.2-1** Individuals who exercised 5th Amendment Rights

Flames and Forces Mapping

- **7.9-1** Sampling and Analyzing of Mine Dusts
    - **Exhibit 1-** WVOMHS&T impacted dust samples: Summary of test results
- **7.9-2** Using Roof Pans as Indicators of Wind Pressure and Heat
    - **Exhibit 1-** Format for describing condition of roof pans

APPENDIX 8

Mine Gases

Coal Dust

APPENDIX 9

West Virginia Flames and Forces Maps

Definitions

B-Lock: A metal component that helps keep the pin of the ranging arm of the longwall shearer in place.

Belt Conveyor: A looped belt on which coal can be carried and is generally constructed of a reinforced rubber or rubber-like substance.

Cenospheres: (Meaning "Empty spheres") Round, hollow ash-rich particles of microscopic size that are indicative of high temperature coal combustion.

CFM: Cubic feet per minute

Coke: Residual constituents of coal after high heat has vaporized some or all of the volatile matter.

Crosscut: Mine passageway that connects entries

Entry (Entries): Mine passageways in the direction of mining advance, used for haulage and ventilation.

First Mining: The initial development of a section. Mining in an area where the mine has not been developed (a.k.a. "advance mining".)

Gob: That part of the mine from which the coal has been removed and the area is caved (area behind the longwall shields). Also, loose waste in a mine.

Headgate: The beginning of the longwall face.

Inby: Direction or location from your present location and progressing in an inward direction of the mine (looking/ moving from the outside - in).

Intake Air: The fresh air current which is drawn or forced into a mine or section of a mine.

Interburden: Rock layer(s) between two coal seams.

Jarrells Branch/Jarrels Branch J/Jarrells' Branch: Each spelling used throughout the report.

Leeward: The side of a structure opposite of the wind direction (opposite the windward side).

Longwall: Method of mining using a shearer or steel plow which progresses across a face of coal that is usually several hundred feet long.

Mains: Major travelway of a mine. Starting at the portal and usually continuing to the farthest extent of the mine.

Mouth: Beginning of a section. Area where the section branches from the mains.

Neutral Air: Normally an air current that ventilates areas of the mine where entries may be common, however, the neutral air current is separated from the intake and return by permanent ventilation controls.

NIOSH: National Institute of Occupational Safety and Health

Outby: Direction or location from your present location and progressing in an outward direction of the mine (looking/moving from the inside - out).

Overcast: A structure in an intersection of mine passageways that allows one air current to pass over (under) another without interruption or mixing.

psia: Pounds per square inch, atmospheric

psig: Pounds per square inch, gauge

Portal: Mine entrance (a.k.a. "drift" or "drift mouth"). A horizontal or approximately horizontal opening through the strata or in a coal seam.

Pyrolize: Thermochemical decomposition of organic particles at high temperatures.

Return Air: A volume of air that has passed through and ventilated all the working places in a mine section.

Rock Dust: The general name for inert dust used in rendering coal dust inert.

Seal: A barrier or wall constructed across all the entries of an abandoned area. This barrier or wall isolates the abandoned portion of the mine from the active portion of the mine.

Second Mining: Additional mining of support pillars as the sections withdraw outby (a.k.a. "longwall mining" or "retreat mining").

Shaft: A vertical opening through the strata that is or may be used for the purpose of ventilation, drainage, and the hoisting and transportation of individuals and material, in connection with mining of coal.

Shields: Large hydraulic jacks with heavy steel canopies used to support the roof during longwall mining.

Stopping: A wall constructed in the crosscuts between adjacent entries in series to channel fresh air to working areas (intake air) and channel contaminated air away from the working area (return air).

Tailgate: The end of the longwall face.

T - Split: Intersection where the longwall face intersects the tail gate entry ventilating current. The air at this point has the potential to split both inby and outby the longwall face. (The T-split is a critical location where the longwall ventilation can become restricted).

TIC: Total incombustible content.

Working Face: Any place in a coal mine in which work of extracting coal from its natural deposit in the earth is performed during the mining cycle.

Working Section: All areas of the coal mine from the loading point of the section to and including the working faces.

West Virginia Office of Miners' Health, Safety and Training: Various abbreviations used in this report include, WVOMHST, WVOMHS&T, WVMHS&T and OMHS&T.

Windward: The side of a structure facing the wind direction.

Errata

APPENDIX 2.2-1

GEOLOGY

The Upper Big Branch Mine is in the Eagle seam of coal, which is a “mid-vol” metallurgical coal of the Kanawha Formation, and belongs to Pottsville Group of the Middle Pennsylvanian Period (Upper Carboniferous Period), (see **Figure 1**).

At least eight (8) other seams over the Eagle have been mined to various extents. These include the Powellton[1], Peerless[2], Lower Cedar Grove[3], Hernshaw, Winifrede, Coalburg[4], Clarion, and Upper 5-Block seams (see **Figure 2**). All except the Clarion Seam are members of the Kanawha Formation. The Clarion and Upper 5-Block seams are part of the Allegheny Formation.

Stratigraphy

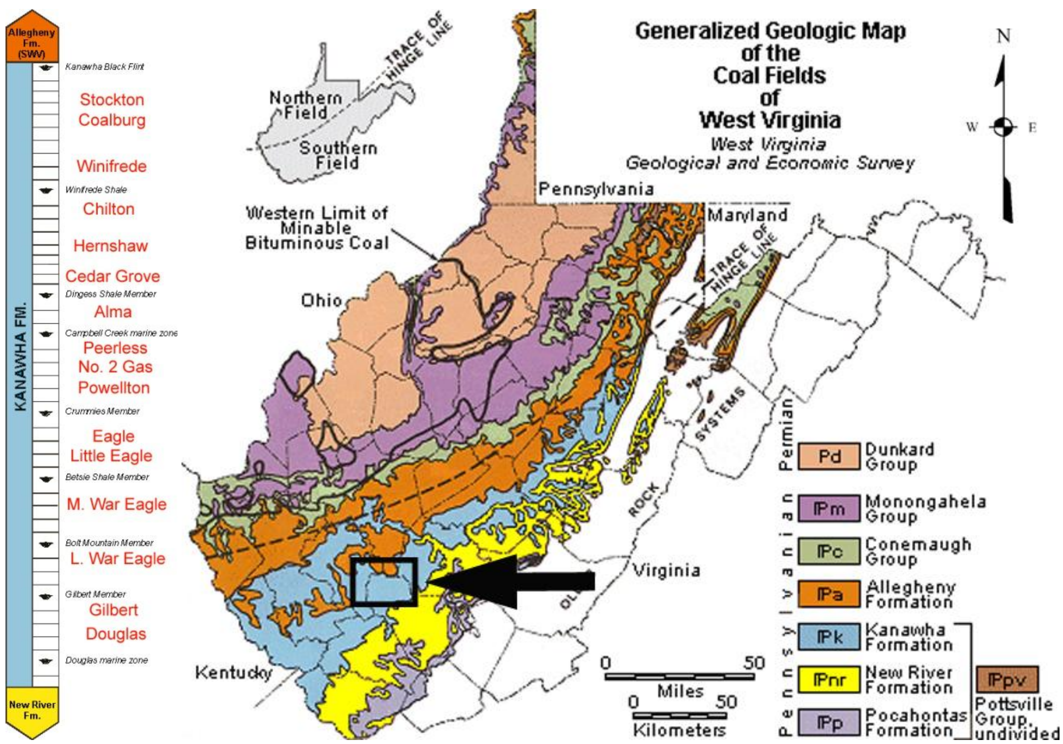

Figure 1. Mining at the UBB Mine is in the Eagle seam of coal, part of the Kanawha Formation, of the Middle Pennsylvanian Period. The surface geology across West Virginia decreases in age in a north-westerly direction. Adapted from the *West Virginia Geologic and Economic Survey*.

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1 The Castle Mine is in the Powellton Seam and is active

2 The Castle Mine connects by a slope to the overlying Peerless Seam (active)

3 The Black King Mine is in the Lower Cedar Grove Seam and is active.

4 The Black Knight II Mine is in the Coalburg Seam and is active

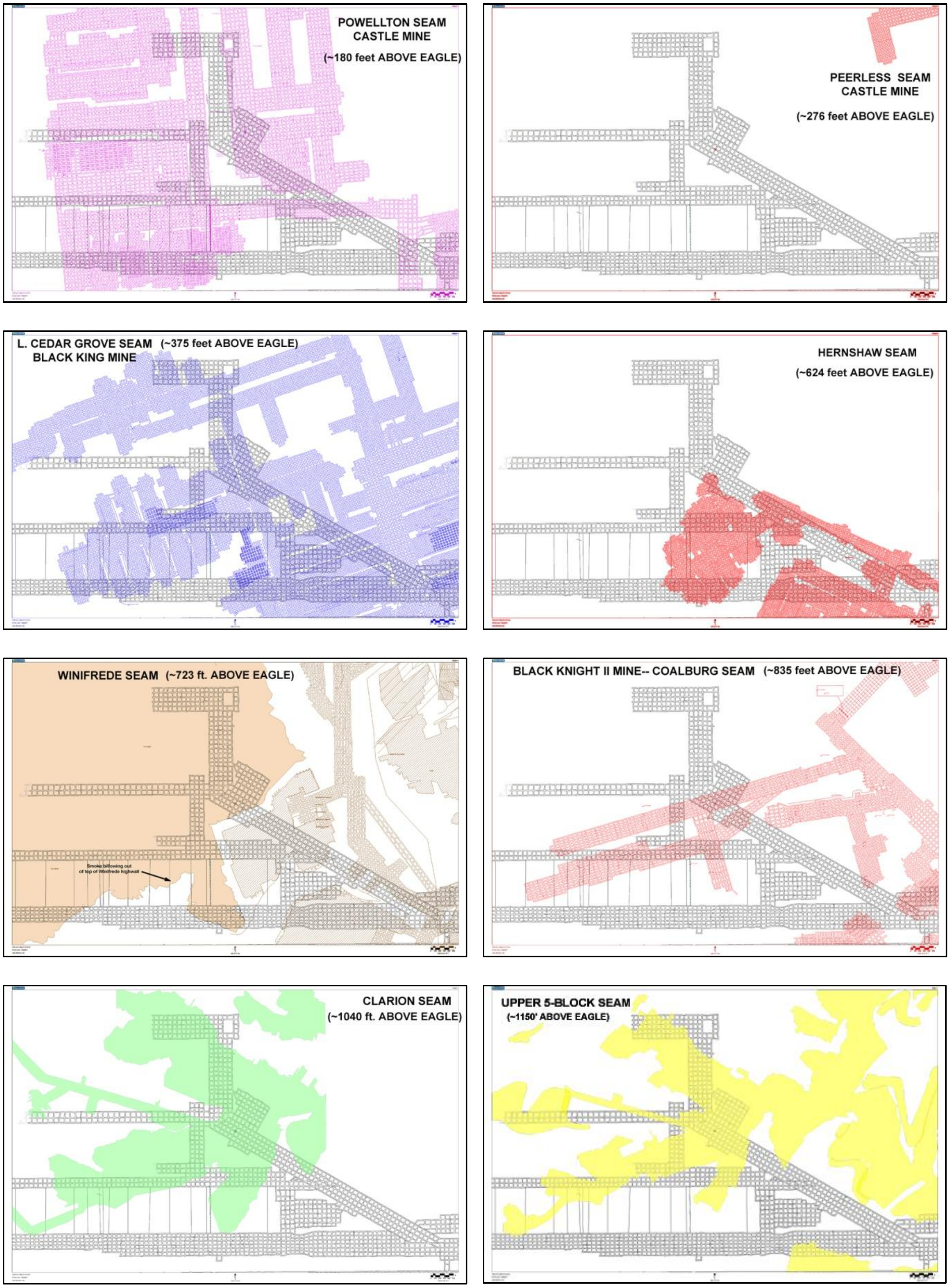

Figure 2. The approximate extent of mining in various coal seams overlying the Eagle Seam, as of April, 2010. No mining below the Eagle seam is known to have occurred.

The origin of coal in southern West Virginia involved accumulation of peat deposits in a delta environment that existed at or near sea level. As accumulating sediments buried them to considerable depths they were transformed into bituminous coal,[5] then subsequently uplifted to their present elevations, which for the Eagle seam at UBB is approximately 800 to1,000 feet above sea level. In the process, water and gas were liberated, first by diagenesis, as the seams consolidated, and then later by fracturing[6] along bed-normal[7] joint surfaces, in response to compressional tectonic forces and tensional unloading during relaxation and stress release.

The depositional environment where Appalachian coal formed was a coastal swamp associated with meandering river deltas carrying volumes of sediments from ancestral highlands which existed to the south and east. Coal deposition and preservation was controlled by rates of sediment consolidation, subsidence, and sea level changes. Infrequent transgressions of marine units onto this swamp platform deposited marine sediments like the Betsie Shale. The Betsie Shale lies directly beneath the Little Eagle seam which underlies the Eagle seam (see **Figure 3A** and **Figure 3B**).

Over time the heat and pressure from accumulating sediments turned layers of sand and mud sediments into sandstone and shale rock. In the process, hydrocarbon gases such as methane were released, which migrated upward through fracture networks and permeable rock layers.

Gas from coal is derived almost entirely from plant remains, resulting in light hydrocarbon gases of almost pure methane, or *coalbed gas*, and containing trace amounts of the higher hydrocarbons such as ethane. The heavier gases are derived in greater amounts, along with methane, from source rocks rich in organics from microscopic animal remains, such as are contained in marine sediments. This gas, still predominately methane, may be referred to as *natural gas*. The gas that investigators noted coming from the mine floor contained more heavy hydrocarbons than would be expected from coalbed gas, although it is still common for this gas when it enters the coal mine to be referred to as methane.

Upward-migrating gases can accumulate in fractures such as joints and cleats, and also in porous reservoir rocks, like sandstone if there is an impermeable cap rock preventing upward escape. At the UBB Mine small gas pockets have been encountered during mining, and usually originate beneath the mine floor. These gas pockets blow-out within hours or days, but sometimes exhibit high pressure, on occasion being compared to the sound of a jet engine.[8] There is no direct evidence that UBB encountered a pressurized gas pocket on April 5, 2010, but in view of the prior history it is possible. Regardless, the main source of gas in the UBB gob is believed to have come from beneath the floor.

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5 The heat and pressure necessary for this transformation requires a burial depth of 10,000 to 20,000 feet.
6 Such fractures in rock are called "joints" and in coal are called "cleats".
7 Perpendicular to the bedding plane
8 Interview testimony, Fred Wills, MSHA Field Supervisor, June 8, 2010, pp.19-21,34; re July 4, 2003 event.

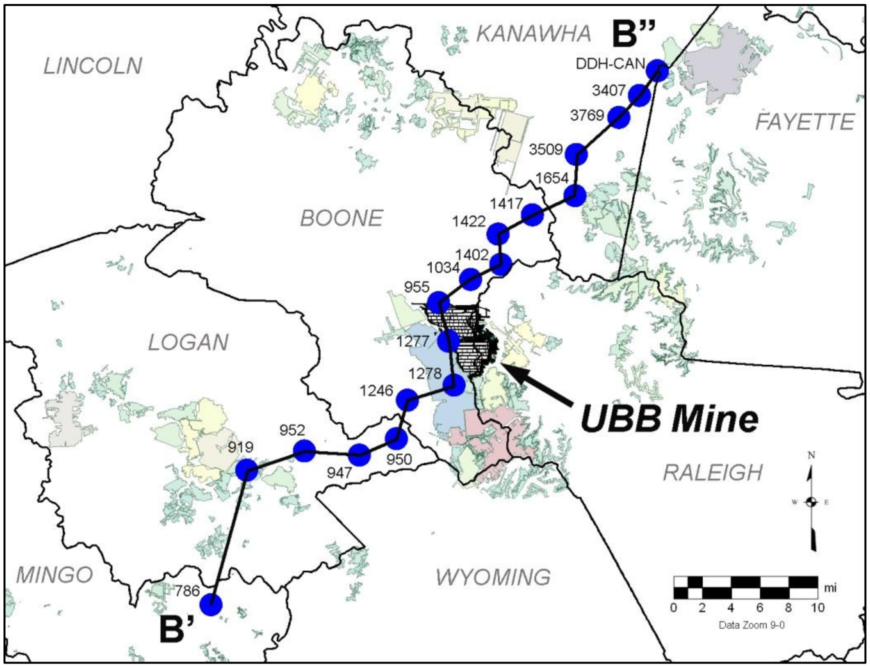


Figure 3A. Profile B' – B'' shows the location of gas well logs used in a USGS report of the Betsie Shale, a marine zone just beneath the Eagle Seam (see **Figure 3B**). Note UBB mine location.

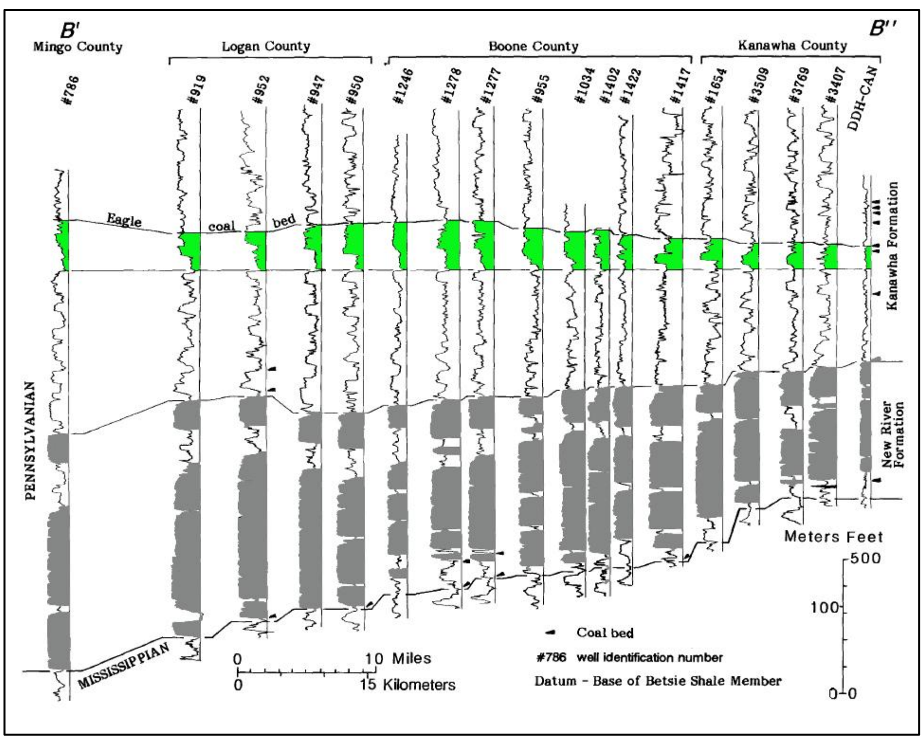


Figure 3B. Gamma-ray logs from existing gas wells along ***Profile B' – B''*** show the position and thickness of the Betsie Shale Member (green) of the Kanawha Formation. The "gray shade" represents massive sandstones of the New River Formation.

The Betsie Shale marine unit

Marine shale rock formations are source beds for oil and gas. The Betsie Shale[9] is a layer of marine rocks a few feet below the Eagle seam and has an apparent thickness of 100 to 250 feet. In a SW-NE profile of eighteen (18) geophysical logs[10] from gas wells between Mingo County and Kanawha County (see **Figure 3A**), the Betsie Shale is depicted (shaded light green, **Figure 3B**).

A separate SE-NW profile (**Figure 4A**) constructed by investigators from coreholes requested from and supplied by Performance Coal Co. appears in **Figure 4B.** Trending through the locations of the three (3) documented gas events (1997 to 2004) and the 2010 explosion, the data show that the top of the Betsie Shale is mostly sandstone (**Figure 4B)**. Sandstones can make good reservoirs for hydrocarbons if they are porous and permeable and if they have an impermeable cap. Sandstone with sufficient porosity can collect hydrocarbons from neighboring shales. Any marine shale below the sandstone, including the Betsie Shale itself or the deeper Devonian shales, could be a source for gas. Deep shales such as the Marcellus are rich in natural gas but are unable to release it freely because the shales lack permeability. Creating fracture conduits by *hydrofracking* provides permeability in tight shales by interconnecting their existing pores and fractures.

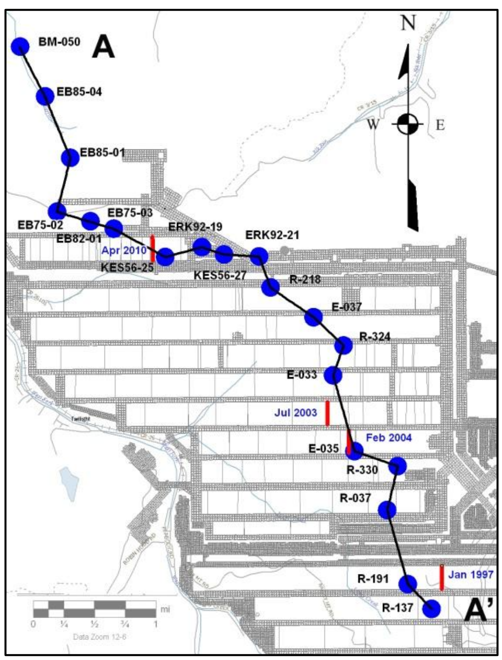


Figure 4A. Index map of profile line A- A' (see **Figure 4B**).

9 Marine origin for the Betsie Shale is indicated by Mitch Blake, WVGES, personal communication.
10 USGS Bull. 1834; The Betsie Shale Member A Datum for Exploration and Stratigraphic Analysis of the Lower Part of the Pennsylvanian in the Central Appalachian Basin; Charles L. Rice, et.al. 1987.

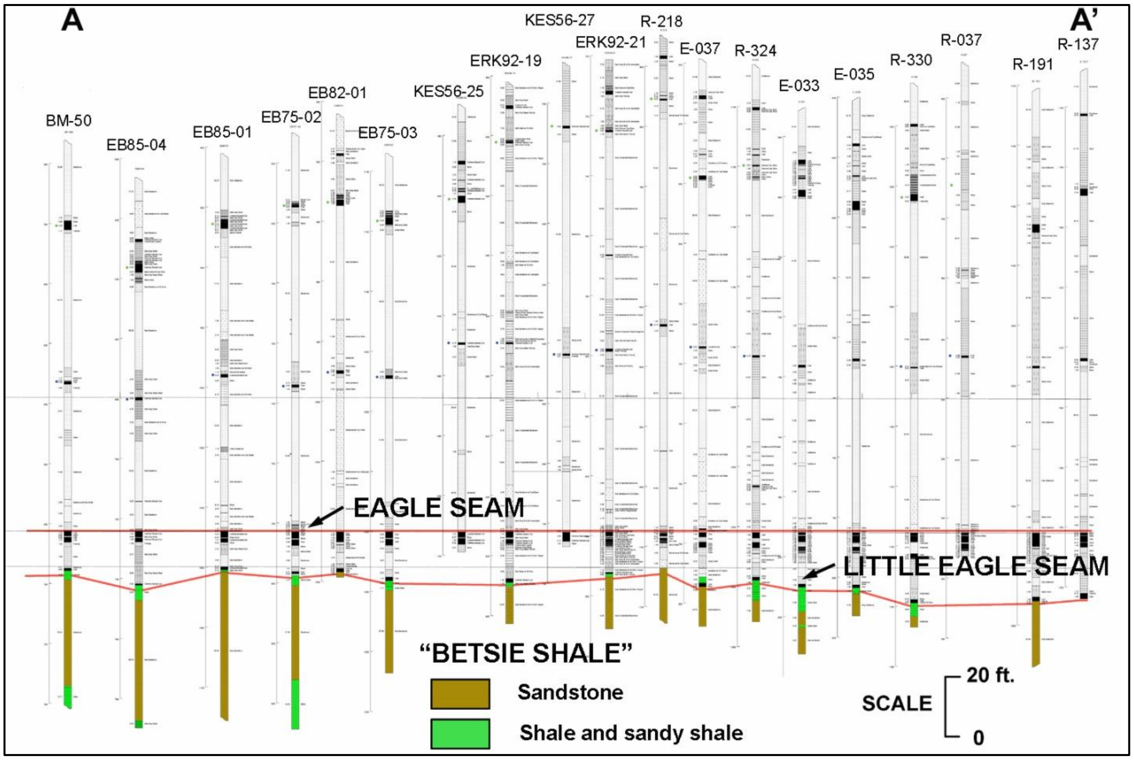


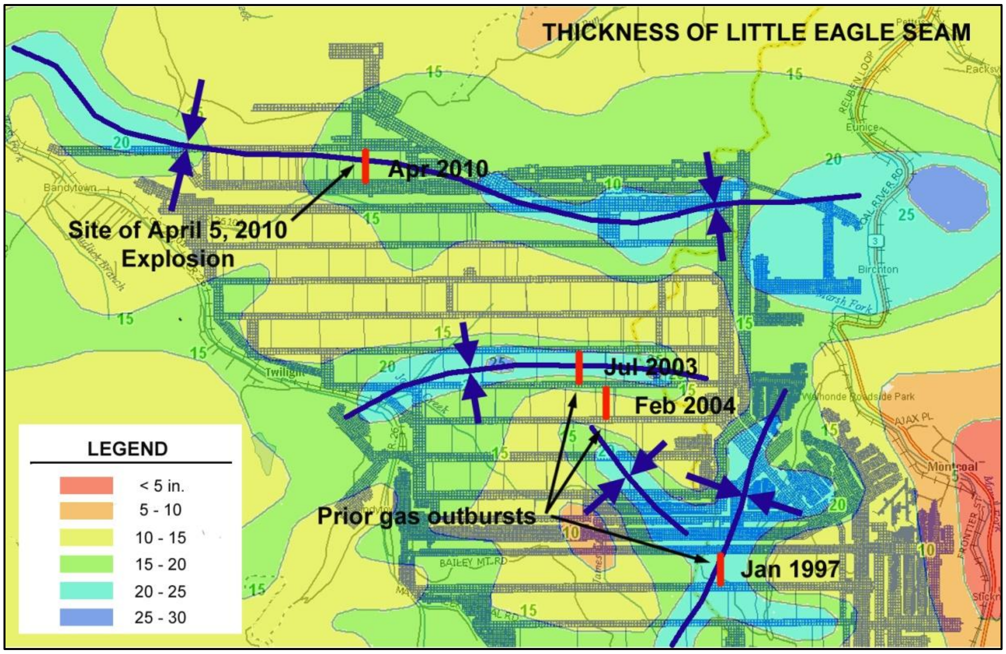
Figure 4B. ***Profile line A-A'*** across Upper Big Branch Mine, showing the Betsie Shale below the Eagle seam from available core hole logs. The top of this marine unit is sandstone.

There is not enough known about the Betsie Shale to draw firm conclusions. However, it is possible that it is both source rock and reservoir for accumulated small pockets of gas, which are inadvertently tapped during longwall mining.

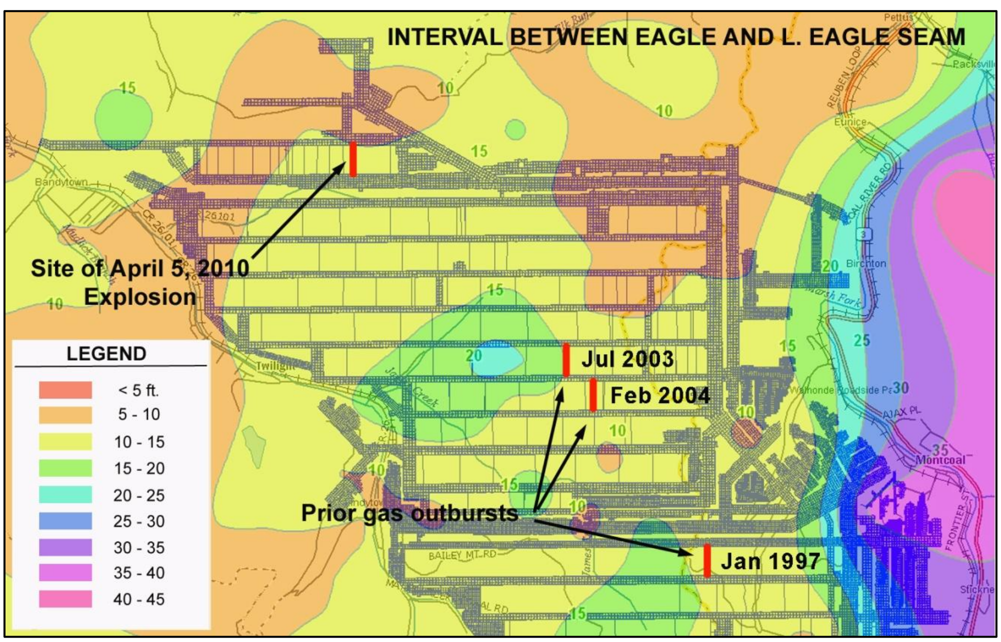
The Little Eagle Seam

The "Little Eagle" seam was evaluated using core logs and isopach maps requested from and provided by Performance Coal Co. The core logs were converted into graphic form and arranged into a stratigraphic profile through the area of interest and used to illustrate the rock strata below the Eagle seam (see **Figures 4A** and **4B**). The interburden thickness between the Eagle and Little Eagle seams along this profile ranges from 10 to 20 feet. Below the Little Eagle is the sandstone top of the Betsie Shale.

A *Thickness Isopach Map* (**Map 1**) suggests an association between local depositional troughs (where the Little Eagle seam is comparatively thick), and the occurrence of known UBB gas events. The margins of such local subsidence troughs are frequently associated with slips and fractures, along which relatively weak and porous zones can occur, which facilitates local gas accumulations. Weak floor would be more sensitive to abutment stresses under cover depths exceeding 800 feet.



Map 1. *Thickness Isopach Map* of the Little Eagle seam (inches). Known past gas events appear to be associated with local depositional troughs of comparatively thick Little Eagle.

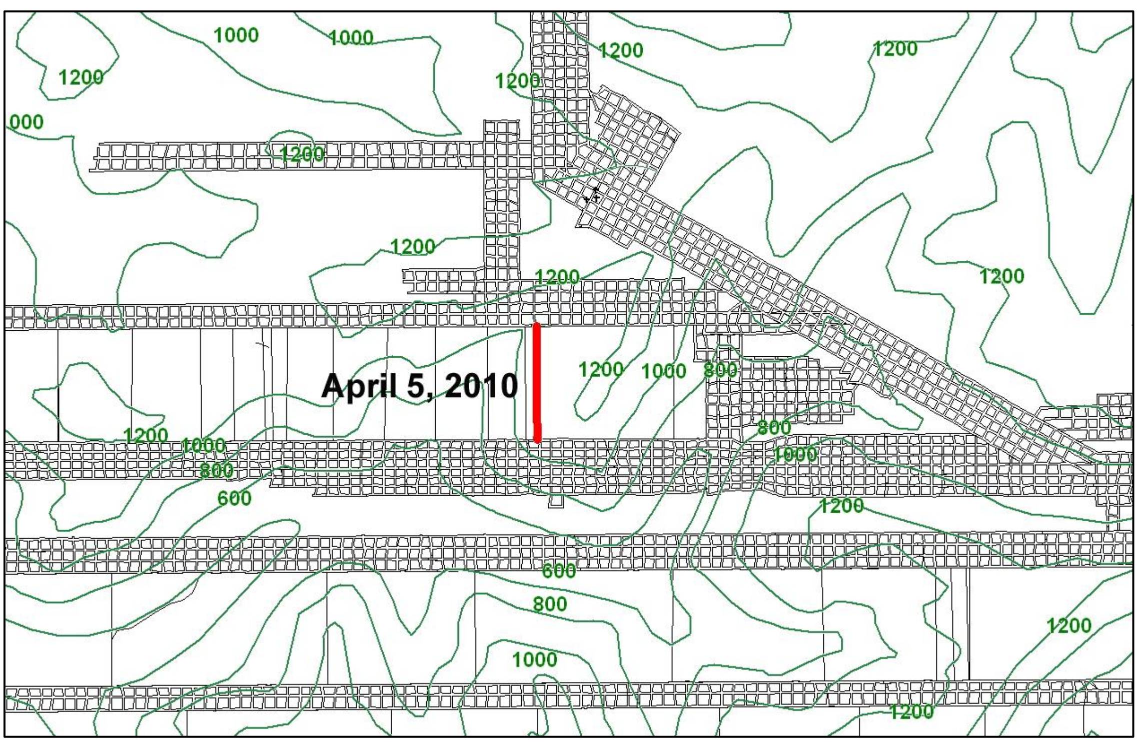


Map 2. *Interburden Isopach Map* showing the thickness (feet) of rock between the Little Eagle seam and overlying Eagle seam. Approximately 10 to15 feet of interburden separates the Eagle and Little Eagle seams where gas events have occurred.

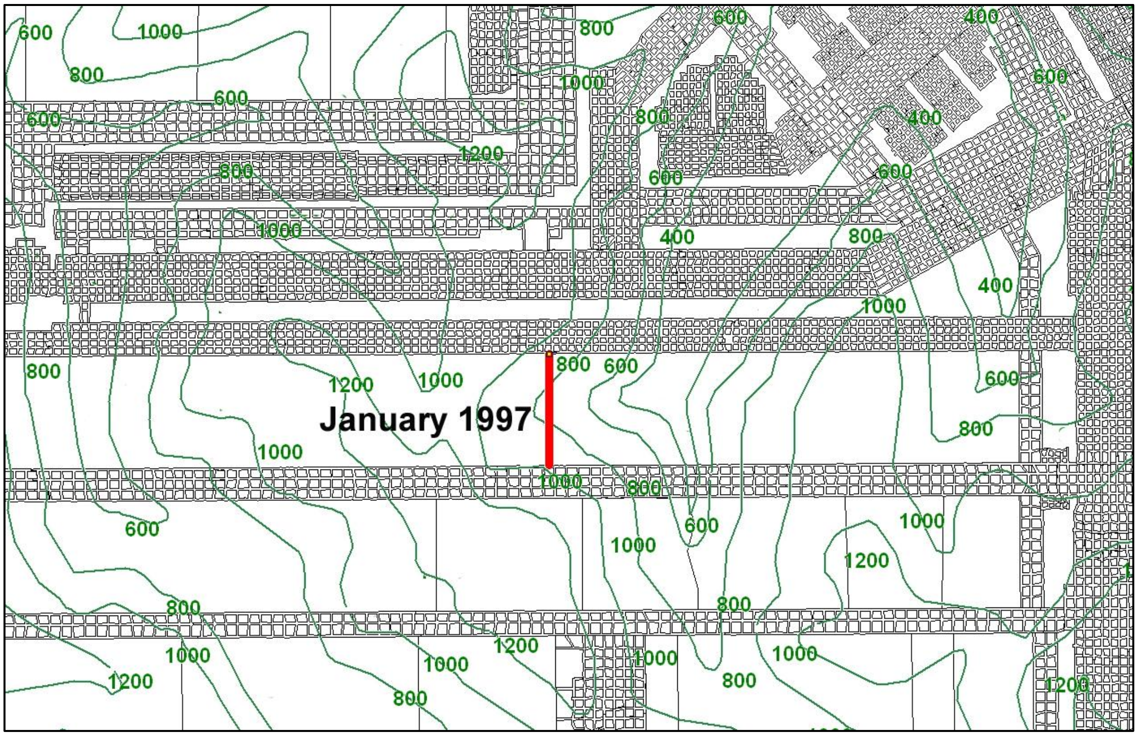
The thickness in the rock interburden between the Eagle seam and the Little Eagle seam is shown in **Map 2**. The location of the active longwall on April 5, 2010 and during the three prior gas events were where intervals between the Eagle seam and the underlying Little Eagle seam were approximately 10 to15 feet. This is in the mid-range of interburden thickness, with the low range being 5 to10 feet and the high range being 15 to 25 feet. All things being equal it would be logical for the thinner interburdens to be more easily ruptured by abutment stresses, allowing gas from below to enter the mine. However, there was little longwall mining where the interburden is less than 10 feet thick. Also, the spacing of core holes may exceed the frequency of variations in the interburden thickness, and predicting such small changes may not be of practical benefit.

Cover Depth

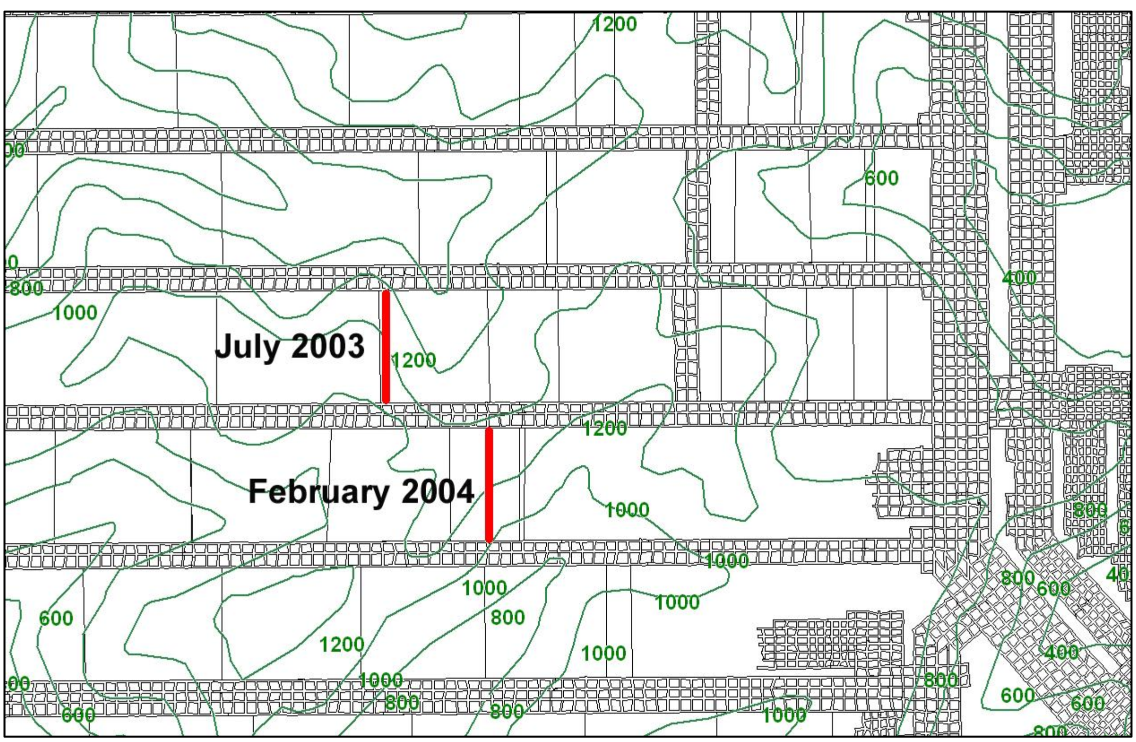
The depth of cover on April 5, 2010 was approximately 1,000 to1,050 feet. The three (3) documented gas events at UBB, (1997, 2003, and 2004) were associated with longwall mining where the depth of cover exceeded 800 feet. The gas excursion that occurred in 2004 occurred at a cover depth 1,000 to1,250 feet, and this is the same range that existed at the time of the event in 2003. The shallowest cover appears to be during the 1997 event, where cover depths were approximately 800 to 900 feet. These trends are further illustrated in **Maps 3A, 3B** and **3C**.



Map 3A. The depth of cover over the Longwall on April 5, 2010 was 1,000 to1,050 feet.



MAP 3B. The depth of cover over the Longwall on January 4, 1997 was 800 to 900 feet.



MAP 3C. The depth of cover over the Longwall on July 4, 2003 was 1,000 to1,250 feet. The depth of cover over the Longwall on February18, 2004 was also 1,000 to1,250 feet.

Fracture System

Fracture trends in the roof, floor, and coal seam were observed by investigators and their orientations recorded. These are natural fractures in the coal and in the rock that existed before the explosion. In some cases the prominence of fractures is enhanced by displacements, for example breakage in the mine floor due to bottom heave. The 2-D expressions of the fractures are summarized in "rose diagrams," below.

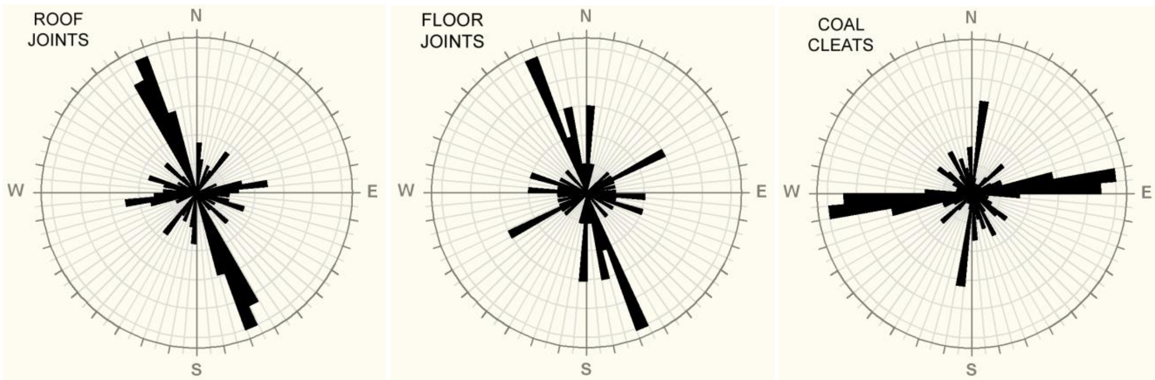


Figure 6. (LEFT) MINE ROOF extension joints trend approximately N25°W. (MIDDLE) MINE FLOOR extension joints trend approximately N20°W. (RIGHT) The COAL face cleat is oriented approximately N80°E.

Fractures which are oriented normal to the rock bedding plane and without shear movement along their surfaces are called Mode I opening fractures or *joints*. Extension joints are formed by disrupting the hydrologic equilibrium of rock by geologic processes, such as through tectonic earth forces, thereby causing an overpressure condition that mobilizes fluids and gases which then search for a way out. If there is not an existing pathway to relieve fluid pressures a form of natural hydraulic fracturing can occur, whereby a rupture or fracture is created in the direction of the maximum principle compressive stress. This type of joint is an extension joint, and can be positively identified if plumose fracture patterns are present on the joint surface.

A subsequent release joint typically forms perpendicular to the extension joint, either immediately or eons later, as a stress readjustment. Release joints terminate against the extension fracture and do not exhibit plumose structures. They are also typically more irregular and less planar. Together, the extension fracture and its orthogonal release fracture comprise a "fracture set."

Coal cleats are formed early in the tectonic cycle, parallel to the maximum in-situ stress that existed then. Roof and floor rocks that contain extension fractures oriented differently from the coal face cleat are indicative that they were formed during a later tectonic event.

Structurally, the dominant extension fracture in the UBB mine roof is approximately N25°W. This is similar to the mine floor, which is more difficult to ascertain, but appears to be approximately N20°W. The dominant face cleat directions are approximately N80°E.

Because the dominant fractures in the sandstone roof above the Eagle seam are of similar orientation to the sandstone of the mine floor (the Eagle/Little Eagle interburden) the possibility exists that pre-existing conduits for gas migration might exist which are inadvertently intercepted during mining. These conduits might be pre-established pathways for upward-migrating of gas that ceased when gas pressures and resisting stresses of confinement reached equilibrium. The Eagle/Little Eagle interburden may act as a cap or seal for this confinement, and when ruptured by abutment stresses under areas of deep cover can release pockets of residual gas where the floor is locally weakened and/or fractured.

While it is probably not possible to eliminate floor gas seepage and outbursts from occurring, understanding the factors which may lead to their occurrence, and mitigating the potential for dust explosions through adequate ventilation and rock-dusting, are two logical and prudent responses. The combined effects of thick overburden, proximity to depositional troughs associated with thick Little Eagle coal, and piping through local joint systems in roof and floor cracks may together enhance liberation of Eagle seam floor gas. These interactions are not well-understood but deserve additional study.

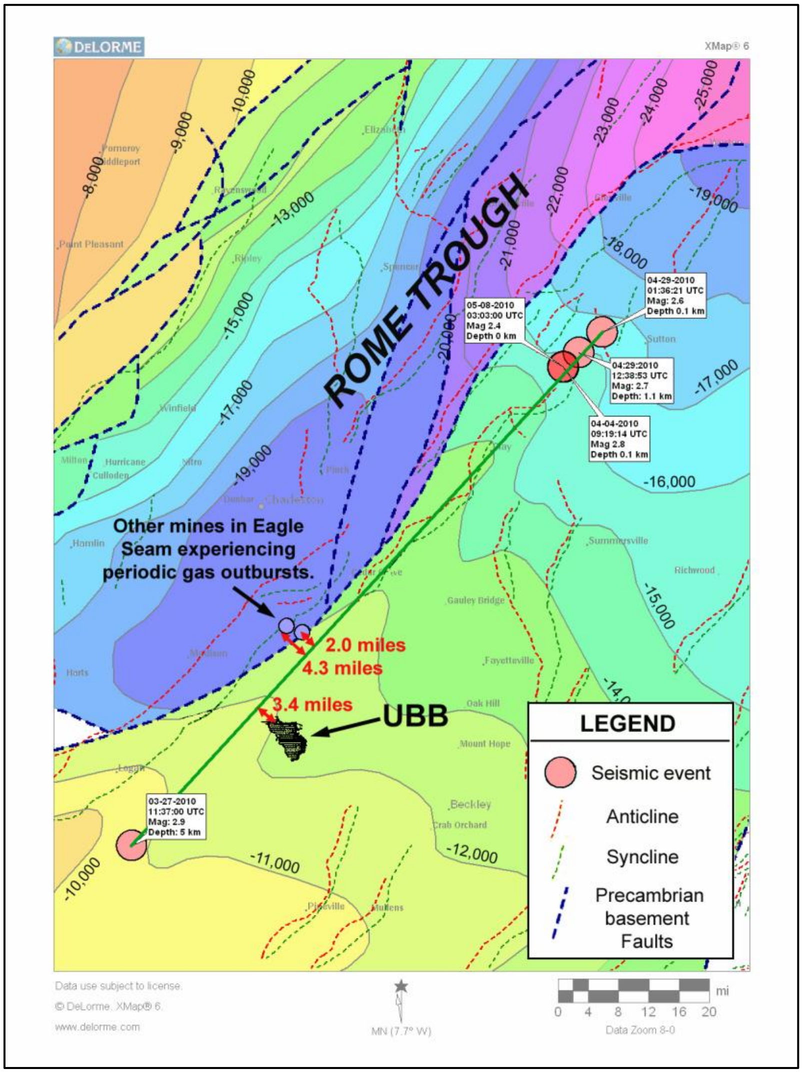
Seismic Events

West Virginia is seismically quiet and not prone to earthquakes, so a cluster of seismic events within a short time period gets attention. In a 90-day period including April 5, 2010 there were five small seismic events reported.

The first event occurred approximately 25 miles SW of UBB, in Logan County, on March 27, 2010, reportedly registering 2.9 and at a depth of approximately 5 km. This was followed by a cluster of seismic events reported in Braxton County. On April 4, 2010 (the day before the explosion), a seismic event was reported 60 miles NW of UBB, near Sutton, WV. At the same relative location seismic events were subsequently also reported on April 28, 2010 and May 8, 2010.

The reported locations of these events appear along a relatively straight line. The April 5, 2010 explosion at UBB is 3.4 miles south of this line. Two other longwall mines in the Eagle seam which periodically experience gas incursions are situated 2 miles and 4.3 miles, respectively, from this same line.

However, upon closer inspection of the seismic reports it appears that natural crustal disturbances may not have been involved. The March 27, 2010 event was apparently not detected by local seismographs. The other four events may be related to industrial activities, and not natural events. Despite their proximity to the edge of the Rome Trough (an ancient major fault system in the Precambrian basement), and their impressive alignment, it appears the correlations are circumstantial, and are probably not related to events causing a gas release or other condition that contributed to the explosion in the UBB mine on April 5, 2010.



Map 4. Location of seismic events reported within 45 days before or after April 5, 2010. The nearby *Rome Trough* is an ancient Cambrian rift system of faults deep in the Precambrian basement rocks, and along such faults subsequent tectonic adjustments (earthquakes) might occur. The structure contour intervals shown are in feet, relative to sea level, and are adapted from information obtained from the West Virginia Geological and Economic Survey. Despite the apparent linear alignment of the seismic events, however, it is not believed that the seismic events reported during the time period were related to events causing a gas release or other condition that contributed to the explosion in the UBB mine on April 5. 2010.

Petrographic and x-ray diffraction analysis of sandstone roof from the longwall

Petrographic Summary Report on Referred Samples

Samples provided by Mr. Monte Hieb

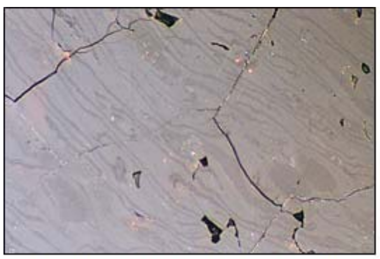
Date: 10/10/2011

Analyst: Cortland Eble, Kentucky Geological Survey (eble@uky.edu)

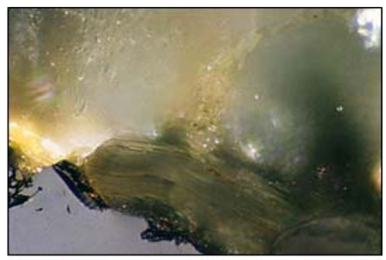
Summary

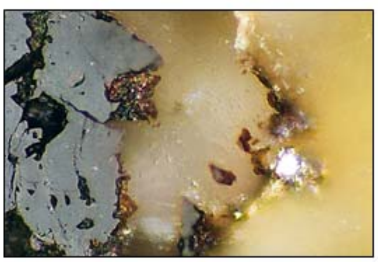
Both of the submitted samples are dominated by quartz, with fairly common organic detritus appearing principally as vitrinite (coal maceral). Small grains of pyrite are also common in both samples, but are volumetrically minor. What is believed to be albite is present, though in minor amounts. XRD confirms the presence of albite. Pictures of the observed minerals and macerals are included. All photographs were taken from polished petrographic pellets with reflected light. Magnification = 1280X.

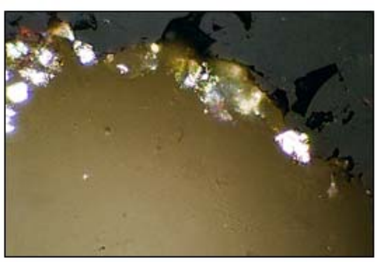
Please contact me if you have questions regarding any of the identifications.

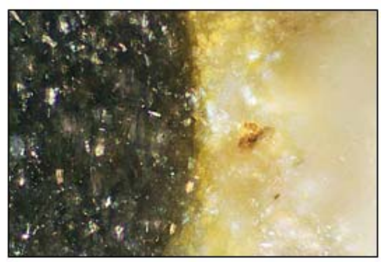

Telinite (coal maceral)

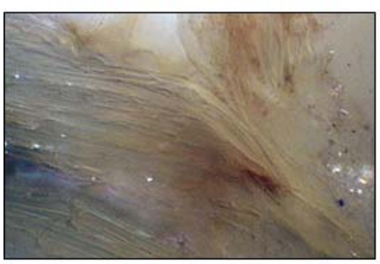

Quartz grains

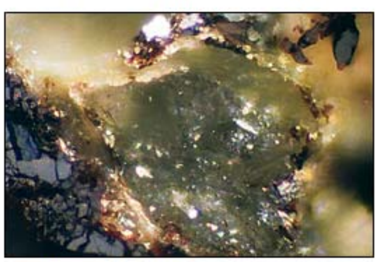

Collotelinite + quartz

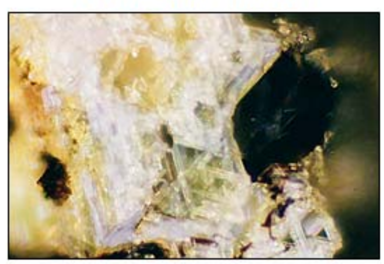

Collotelinite + quartz


Collotelinite, quartz + pyrite


Albite (?)+ Quartz


Quartz


Vitrodetrinite + quartz


Unknown mineral

sample analysis update

Francis, Henry [francis@email.uky.edu]

Sent: Tuesday, October 04, 2011 8:44 AM

To: Hieb, Monte R

Attachments: Report 0811.xlsx (9 KB)

Monte,

The attached data file is an update to include the Mossbauer analysis for your samples:

The WA-1 sample had a major ferric or pyrite absorption, but the derived parameters did not fit either very well. I suspect it represents a mixture of pyrite, FeOOH, and Fe^{3+}/clay. A small amount of siderite is also exhibited in this sample.

The WA-2 sample fit very nicely to Fe^{2+}/clay, jarosite, and pyrite/marcasite,

Jarosite, a likely oxidation product of pyrite weathering, was only present in the WA-2 sample.

Both samples contained a minor amount (<5% of the total iron) of a magnetic phase, tentatively identified as magnetite

The % Fe from the Mossbauer results represents the total Fe in the sample, not the % iron phase indicated in the table.

If you have questions, please call

henry

Sample	Si (%)	Al (%)	Fe (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Ti (%)	S (%)	C (%)	Quartz (%)	Albite (%)	Illite (%)	Muscovite (%)	Kaolinite (%)	Chlorite (%)
WA-1	40.74	5.64	2.08	0.19	0.37	0.83	1.74	0.25	0.11	8.38	67.2	12.7	3.9	7.6	4.7	4.0
WA-2	41.13	4.92	2.40	0.18	0.29	0.76	1.55	0.24	0.98	8.50	29.4	28.2	9.7	19.2	13.6	

WA-1 7" above SS/coal contact
WA-2 Immediate 2" of sandstone roof

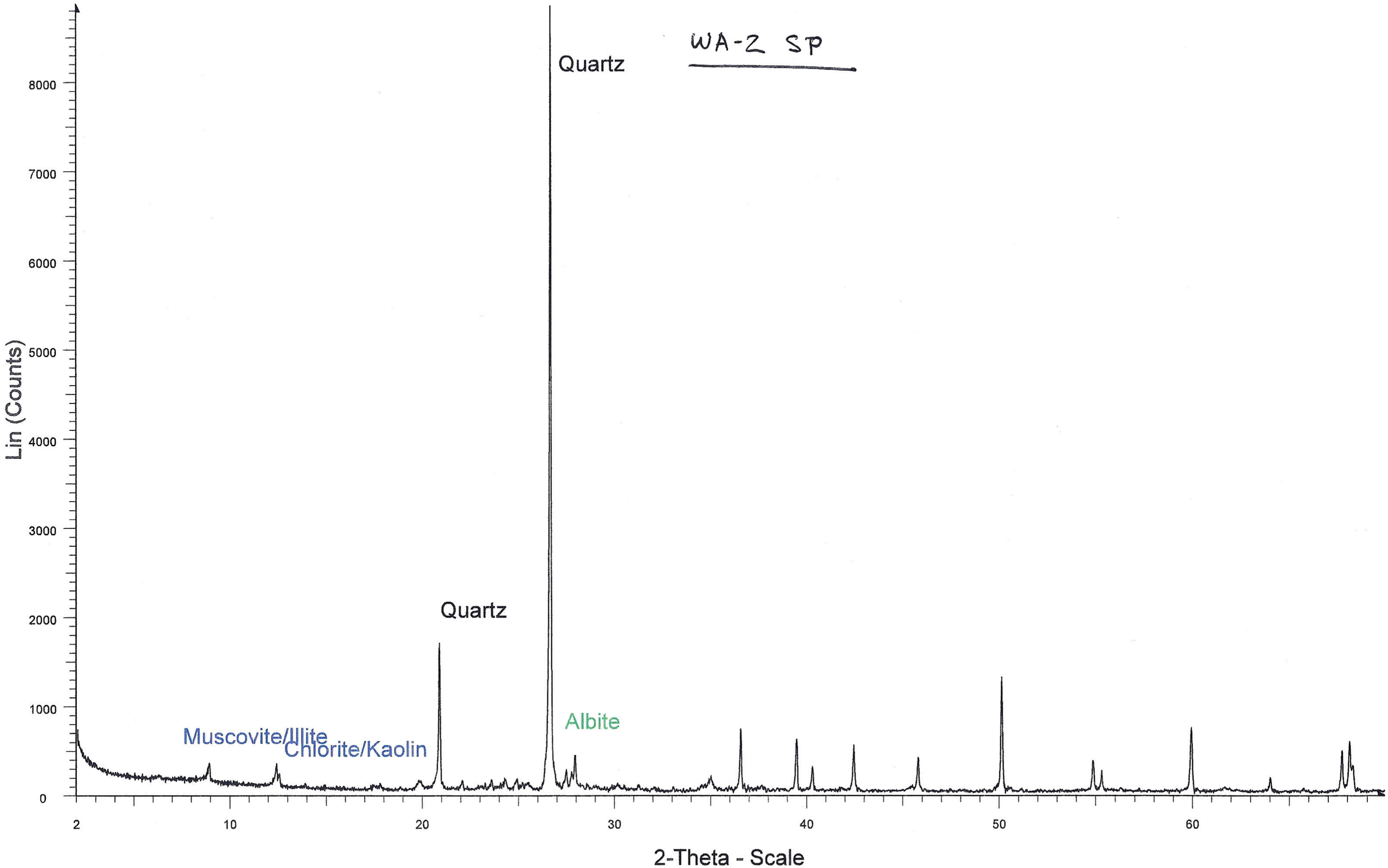
WA-1

%Fe	ID
24	Fe^{3+}/clay ± Pyrite ± FeOOH
55	Fe^{2+}/clay (illite)
21	Siderite, $FeCO_3$
Trace	Magnetite?

WA-2

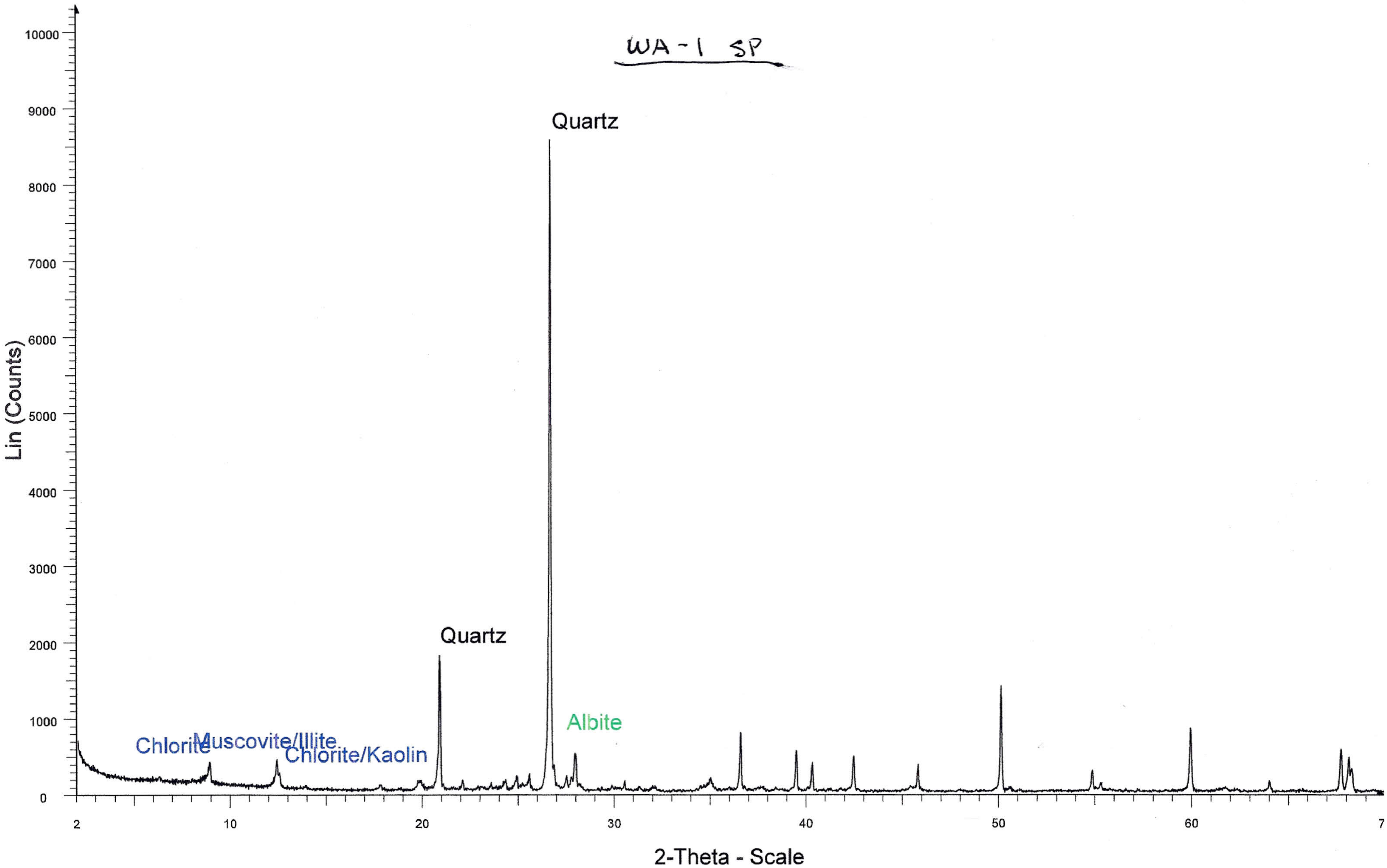
%Fe	ID
39	Pyrite, Marcasite (approx. 3:2)
29	Fe^{2+}/clay (illite)
32	Jarosite
Trace	Magnetite?

WA2 SP



WA2 SP - File: WA-2 SP.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 70.000 ° - Step: 0.020 ° - Step time: 2. s - Temp.: 25 °C - Time Started: 13 s - 2-Theta: 2.000 ° - Theta: 1.000 ° - Chi: 0.00 ° - Phi: 0.00 ° - X: 0
Operations: X Offset -0.020 | Strip kAlpha2 0.500 | Import

WA 1 SP



WA-1 SP - File: WA-1 SP.raw - Type: 2Th/Th locked - Start: 2.000 ° - End: 70.000 ° - Step: 0.020 ° - Step time: 2. s - Temp.: 25 °C - Time Started: 13 s - 2-Theta: 2.000 ° - Theta: 1.000 ° - Chi: 0.00 ° - Phi: 0.00 ° - X:
Operations: Strip kAlpha2 0.500 | Import

State of West Virginia
Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
Ronald L. Wooten, Director
1615 Washington Street East ▪ Charleston, West Virginia ▪ 25311-2126
Telephone 304-558-1425 ▪ Fax 304-558-1282
www.wvminesafety.org

January 22, 2008

Mike Vaught
Performance Coal Company
Upper Big Branch Mine
P. O. Box 69
Naoma, WV 25140

Subject: Review of revised emergency communications and tracking/locating plan submitted under WV Legislative Rule Title 56, Series 4 Legislative Rules Governing Protective Clothing and Equipment

Sir:

After the evaluation of the documentation submitted and your staff's discussions with our staff, your plan is determined to meet the requirements of §56-4-9 for emergency communication and tracking/locating systems.

Currently utilized communication systems and manual tracking/locating procedures shall be maintained until the operational date and shall remain the backup procedures for no more than a reasonable time in the event of any failure that result in loss of communication or tracking/locating while the system is being restored to an operational state. Such periods shall not exceed the time as is required to promptly examine the communications and or tracking/locating system and if the cause of the failure is determined during this examination, to immediately correct the same from spare equipment maintained at the mine where possible.

The mine's phone system shall be installed to each WV approved emergency shelter deployed per WV §56-4. The phones shall be supplemented by the wireless communication and tracking/locating systems, when operational, such that one or more communication option remains functional to the maximum duration for which the shelter is rated.

▪ **Region One** ▪ 205 Marion Square - Fairmont West Virginia 26554-2800 ▪ Telephone 304-367-2706 ▪ Fax 304-367-2707
▪ **Region Two** ▪ 891 Stewart Street - Welch, West Virginia 24801-2311 ▪ Telephone 304-436-8421 ▪ Fax 304-436-2100
▪ **Region Three** ▪ 137 Peach Court - Suite 2, Danville, West Virginia 25053 ▪ Telephone 304-369-7823 ▪Fax 304-369-7826
▪ **Region Four** ▪ 142 Industrial Drive- Oak Hill, West Virginia 25901-9714 ▪ Telephone 304-469-8100 ▪ Fax 304-469-4059

The documentation of training on emergency communications and tracking/locating systems required under WV §56-4 shall be maintained for inspection on the permitted property.

No later than February 12, 2008 you shall submit as an addendum to your plan, a copy of any contract, or purchase order, or other proof of purchase of WV approved equipment required to complete the emergency communication and tracking/locating system and for installation and ongoing maintenance. The purchase orders shall contain the delivery dates and operational date of the system as approved in this plan.

Fifteen days prior to the operational date an updated emergency communication and tracking/locating plan shall be submitted that indicates the as-built details of all elements. Thereafter the placement and status of the elements shall be included with required progress maps.

Any changes to the purchase documentation or changes in mining plans that result in significant changes in the operation of the emergency communication and tracking/locating system require the submittal to this office of a request for modification.

Under §56-4-9 the Director may require modifications to emergency communication and tracking/locating plans at any time following the investigation of a fatal accident or serious injury, if such modifications are warranted. If such a situation arrives you will be notified with requirements and the period for compliance.

Additionally the following stipulations apply to this approval:

1) No provision of this plan modifies the requirements of §56-4-9,
2) No duties assigned the miner monitoring the communication and tracking/locating systems shall interfere with those required under §56-4-9.13,
3) A copy of the approved plan shall be kept at the mine site,
4) A copy of the approved plan shall be provided to the mine rescue teams designated to provide coverage at this mine, and that
5) This plan is void upon the District Inspector's recommendation.

Sincerely,

Philip Adams

Safety Instructor
Office of Miners' Health, Safety and Training

Note: Attached are the rule sections relevant to this approval. A current copy of all W. Va. mine safety rules can be obtained through your regional office or downloaded from http://www.wvminesafety.org/PDFs/LawRev2007.pdf

West Virginia Office of Miners' Health, Safety and Training

Communication & Tracking Plan
Performance Coal Company
Upper Big Branch Mine

WV ID U-3042-92
MSHA ID 4608436

Table of Contents

Tab 1

Emergency Contact Information

1. Mine Name:
   Upper Big Branch Mine

2. Mine Address:
   Performance Coal Company
   P.O. Box 69
   Naoma, WV 25140

3. Mine ID #:
   WV ID U-3042-92
   MSHA ID 46-08436

4. Location:
   1 mile off of Rt. 3 in Montcoal, Raleigh County WV

5. Emergency Contacts:

   Mine Superintendent:

   Rick Hodge
   Home Phone:

   General Manager:

   Jason Whitehead
   Home Phone:

Safety Director:
Mike Vaught

6. Communication System Manufacturer: Tunnel Radio, Varis Smart Com, MineCom.

   Phone # Hughes Supply Company- 304/252-1918, Wholesale Mine Supply 724/515-4993, Pyott Boone- 276/988-5505,

   E-Mail Address: info@hughessupplycompany.com; BillHensler@WholesaleMineSupply.com; pboone@pyotteboone.com

7. Communication System Vender: Hughes Supply Company, Delta Electric, and Pyott Boone

   Phone # Hughes Supply Company- 304/252-1918, Delta Electric- 304/752-4625; Pyott Boone- 276/988-5505,

   E-Mail Address: info@hughessupplycompany.com; pboone@pyotteboone.com

8. Tracking System Manufacturer: Matrix, Pyott Boone, Tunnel Radio

   Phone # Matrix- 859/967-1710, Pyotte Boone- 276/988-5505, Hughes Supply Company 304/252-1918

   E-Mail Address: pboone@pyotteboone.com; info@hughessupplycompany.com

9. Tracking System Vender: Matrix, Pyott Boone, Tunnel Radio

   Phone # Matrix- 859/967-1710, Pyotte Boone- 276/988-5505, Hughes Supply Company 304/252-1918

   E-Mail Address: pboone@pyotteboone.com; info@hughessupplycompany.com

West Virginia Office of Miners' Health Safety & Training

1615 Washington Street, East
Charleston, WV 25311-2126
(304) 558-1425 Fax (304) 558-1282 website: www.wvminesafety.org

GENERAL INFORMATION FORM

Region IV   Circle Type of Operation (select only one)   Please complete both sides

UNDERGROUND COAL MINE   SURFACE COAL MINE   COAL HANDLING FACILITY   QUARRY

All Applicants must complete the following section

WV Permit No.: U-3042-92   **MSHA ID No:** 46-08436
Company Name: Performance Coal Co., Inc. **Mine/Facility Name:** Upper Big Branch Mine
Mailing Address: P.O. Box 69
City: Naoma   **State:** WV   **Zip:** 25140
County(s): Raleigh   **Location:** Approx. 1.5 miles off Rt. 3 at Montcoal).
Latitude: 37°55'03"   **Longitude:** 81°33'05"   **Quadrangle:** Whitesville
No. of Shifts: 2 producing, 1 maintenance   **Working Status:** Active
Company Phone: (304) 854-1852   **Mine/Facility Phone:** 304-854-1761
Name of Company Contact: Mike Vaught   **Title:** Safety Director
Superintendent: Rick Hodge   **Foreman:** Bill Harless
Certified Person Responsible for Training: Mike Vaught
Miners' Representative (if applicable): N/A

Assessment Contact Officer and Assessment Mailing Address: (assessments will be mailed to this address unless otherwise notified)
Name: Mike Vaught   **Title:** Safety Director   **Phone:** 304-854-1761
Address: P.O. Box 69   **City:** Naoma   **St:** WV   **Zip:** 25140
Email Address: **WV Workers Compensation #**

Underground and Surface Coal Mine Applicants must complete the following section
Name of Reclamation Permit Holder: Performance Coal Company, Inc.
Name of Production Contractor (DMM60) Company and Permit Number:
Responsible for Reporting Tonnage: Performance Coal Company, Inc.
Seam(s) Being Mined: Eagle   **Thickness:** 30 – 60 Inches

Underground Coal Mine Applicants must complete the following section (circle mine type)

Mine Type: Shaft   Slope   Drift **X** or   Combination   **No. of Sections:** 1
Mining Direction (advance or retreat) Both   **Roof Bolt - Type and Size:** Torques/tension-72"
Inside Haulage Type: Belt
Mine Rescue Services provided by (required by 22-1A-33): Performance Coal Company – Southern WV Mine Rescue

Surface Coal Mine Applicants must complete the following section (circle operation type)
Operation Type: Contour   Open Pit   Mt.TopRemoval   Auger   Highwall   Other
No. of Acres: **Does this Operation Use High Voltage Electrical Equipment** Y/N

Coal Handling Facility Applicants must complete the following section (circle facility type)
Facility Type: Loadout   Tipple   Prep Plant   Cleaning Plant   River Dock   Other
Type of Haulage into facility: **Type of Haulage out of Facility:**
No. of Employees: **Operating Days:**   **Empl. Hrs. Worked Per Month:**

Quarry Applicants must complete the following section
Mineral(s) Produced: **Geological Formation:**
No. of Sections:

Email Address Information: (Use additional sheet if necessary to include all emails for person you want listed)
Email Address of Company Representative: chris.blanchard@masseyenergyco.com
Email Address of Safety Department Contact: mike.vaught@masseyenergyco.com
We are asking for this information so that we can send electronic mailings, safety notices, regulations, etc.

Applicant Signature (owner or officer) [signature]

Title President   Date 11-15-07   GI Form - Rev:2006

PERMIT APPLICATION
OWNERS - OFFICERS

In accordance with the Federal Privacy Act, 5 USC 552a, and 1974 addendum Public Law 93-579 7(b), please provide the names, titles and social security numbers of every officer, partner, resident agent, director, or person performing a function similar to a director, together with the names and titles of any person owning of record ten percent (10%) or more of any class of voting stock of the applicant: (use attachments as necessary). **PLEASE NOTE: WE NOW ASK FOR THE LAST FOUR (4) DIGITS OF SOCIAL SECURITY NUMBERS. THIS INFORMATION IS REQUIRED FOR IDENTIFICATION PURPOSES FOR PERMIT ISSUANCE SYSTEM. THIS INFORMATION IS REQUIRED.**

AGENT:

Name **PLEASE SEE ATTACHED** Last four digits of SSN: xxx-xx-_____

Address _____ Address City State ZIP

Telephone No. _____ E-mail Address: _____

OWNERS / OFFICERS

First Name	MI	Last Name	Last four digits of SSN	Title
1.			xxx-xx-	
2. **PLEASE SEE ATTACHED**			xxx-xx-	
3.			xxx-xx-	
4.			xxx-xx-	
5.			xxx-xx-	
6.			xxx-xx-	
7.			xxx-xx-	
			xxx-xx-	
9.			xxx-xx-	
10.			xxx-xx-	

(If additional owners/officers are to be listed, use additional sheet(s)).

Do Not Write Below This Line

Miners' Health, Safety and Training use only:

Company ID _____ File Update _____ Incomplete _____

REGIONAL OFFICE ADDRESSES

REGION I
WV MHS & T
205 MARION SQ.
FAIRMONT, WV 26554-2800
(304) 367-2706

REGION II
WV MHS & T
891 STEWART STREET
WELCH, WV 24801
(304) 436-8421

REGION III
WV MHS & T
137 PEACH CT. SUITE 2.
DANVILLE, WV 25053
(304) 369-7823

REGION IV
WV MHS & T
142 INDUSTRIAL PARK DR
OAK HILL, WV 25901
(304) 469-8100

REVISED 12-2004

Performance Coal Company
P. O. Box 69
Naoma WV 25140-0000

NAME: _Blanchard, Christopher L._
MAILING ADDRESS: _P. O. Box 69_
Naoma, WV 25140
TELEPHONE NO.: _(304) 854-1761_
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: _Director_
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: _Director_
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: _3/1/2007_
ENDING DATE OF AFFILIATION:

NAME: _Blanchard, Christopher L._
MAILING ADDRESS: _P. O. Box 69_
Naoma, WV 25140
TELEPHONE NO.: _(304) 854-1761_
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: _President_
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: _President_
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: _3/1/2007_
ENDING DATE OF AFFILIATION:

NAME: _Brewster, Lex Alan_
MAILING ADDRESS: _P. O. Box 69_
Naoma, WV 25140
TELEPHONE NO.: _(304) 854-1761_
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: _Chief Accounting Officer_
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: _Chief Accounting Officer_
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: _9/20/2002_
ENDING DATE OF AFFILIATION:

Performance Coal Company
P. O. Box 69
Naoma WV 25140-0000
55-0736927

NAME: *Clemens, Mark A.*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Director*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Director*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *7/12/2007*
ENDING DATE OF AFFILIATION:

NAME: *Grinnan, Richard R.*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Secretary*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Secretary*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *5/31/2005*
ENDING DATE OF AFFILIATION:

NAME: *Harvey, M. Shane*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Assistant Secretary*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Assistant Secretary*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *5/30/2007*
ENDING DATE OF AFFILIATION:

Performance Coal Company
P. O. Box 69
Naoma WV 25140-0000
55-0736927

NAME: *Monroe, Phillip C.*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Assistant Secretary*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Assistant Secretary*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *5/30/2007*
ENDING DATE OF AFFILIATION:

NAME: *Nichols, Philip W.*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Treasurer*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Treasurer*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *5/31/2005*
ENDING DATE OF AFFILIATION:

NAME: *Palmer, Larry Eugene*
MAILING ADDRESS:

TELEPHONE NO.:
EMPLOYER ID NO.:
OWNERSHIP/CONTROL RELATIONSHIP TO APPLICANT: *Assistant Secretary*
LOCATION IN ORGANIZATIONAL STRUCTURE:
OFFICIAL TITLE WITHIN ORGANIZATION: *Assistant Secretary*
PERCENT OF OWNERSHIP:
BEGINNING DATE OF OWNERSHIP:
BEGINNING DATE OF AFFILIATION: *8/1/1997*
ENDING DATE OF AFFILIATION:

Tab 2

Communication & Tracking System Description

General System Roles & Descriptions

The mine communication and tracking system will be composed of an underground radio network, communication & tracking devices and a surface control center where all tracking, communication, and coordinating functions are performed.

A West Virginia Office of Miners Health, Safety and Training approved leaky feeder type radio system will be installed to provide two-way communications in two separate air courses, one of which will be an intake. This system will utilize hand held multi channel capable radios. The system will also use a series of signal amplifiers, power supplies, and all other necessary cabling and connectors to form a communication network.

Along with communications, tracking will be provided at specified locations. These locations will be determined during mine planning and development to assure coverage at major intersections, section sub-mains, at the mouth of all working sections, SCSR storage caches, and emergency shelters. Miners will be tracked through RFID technology. Tracking data will be collected via a software application. Data will be stored and displayed for the designated communication personnel.

In the event of a power failure, the communication and tracking system will remain active for a minimum period. Alternate or backup power sources will be connected to the system to maintain operability.

Communication and tracking will be extended to each shelter location. Hardware will be installed so as to provide tracking and communication with miners who enter the shelter. The wireless system will provide primary communication and tracking data. As a second line of defense, a mine page phone system will be extended into the shelter for communication.

The communication and tracking system will be installed in such a manner as to provide the most survivability in the event of an emergency or accident. Devices will be housed in durable cases to provide mine duty protection. In areas where potential fire hazards, and mobile equipment could cause damage to the components of the communication and tracking system, these components will be installed in such a manner as to provide multiple pathways, armored or suitably located to help insure the survivability and functionality of the system.

To achieve rapid recovery in the event of an accident, a sufficient amount of hardware components, cabling, and connectors will be stored at the mine site and at pre-determined, marked locations inside the mine. Components and hardware will be available to restore, at a minimum, 1000 feet of communication and tracking.

A leaky feeder system was chosen because of the simplicity of installation and maintenance. The simplicity of these systems will facilitate mine personnel in routine maintenance and repair. With this approach, survivability and rapid re-establishment of the communication and tracking system can be most easily accomplished, in the event of an emergency or accident.

In conjunction with the wireless communication and tracking system, the mine will also utilize the mine page phone system as a second line of defense to failure of the wireless system. An independent phone line will be maintained to the surface communication center from the working section(s). This phone line will be located in the intake airway.

The mine will put administrative procedures and protocols in place to insure that in the event of the loss of communication and/or tracking; that mine personnel can utilize the mine page phone system to communicate location and status to the designated communication personnel.

To locate mine personnel underground, an RFID tracking system will be utilized to track personnel movement. As second line of defense to the tracking system, the mine site will also utilize administrative procedures and protocols that require the personnel to check in with the designated communication personnel via the communication systems to give location, status and potential movement throughout the mine. As a third line of defense to the tracking system, a manual check-in/check-out system will be maintained at the mine surface facilities.

Occasionally miners must enter bleeders, remote, seldom used, or abandoned areas; when this occurs, an administrative process will be used to track and locate these individuals. Before a miner (s) enter a bleeder, remote, seldom used, or abandoned areas they shall contact the designated communication personnel and initiate the proper protocol.

Communication and tracking systems will be located in such a manner as to minimize exposure to potential fire hazards. To accomplish this, cable routes will be planned and installed to avoid major sources of fire potential such as hydraulic and electrical installations.

In areas where hazardous roof and rib conditions exist, supplemental supports such as timbers, cribs, and/or support jacks will be installed to protect the communication and tracking system components.

Areas of potentially explosive force pathways, such as sealed mine areas, will be considered during system planning. The system will be routed in such a manner as to minimize exposure to potential failure. In areas where system routing, by explosive hazards cannot be avoided, system hardening maybe utilized. Hardening will be accomplished by protecting the system components with pipe or conduit, burying cables, additional enclosures or such. Additionally, multiple system pathways will be considered to mitigate hazards.

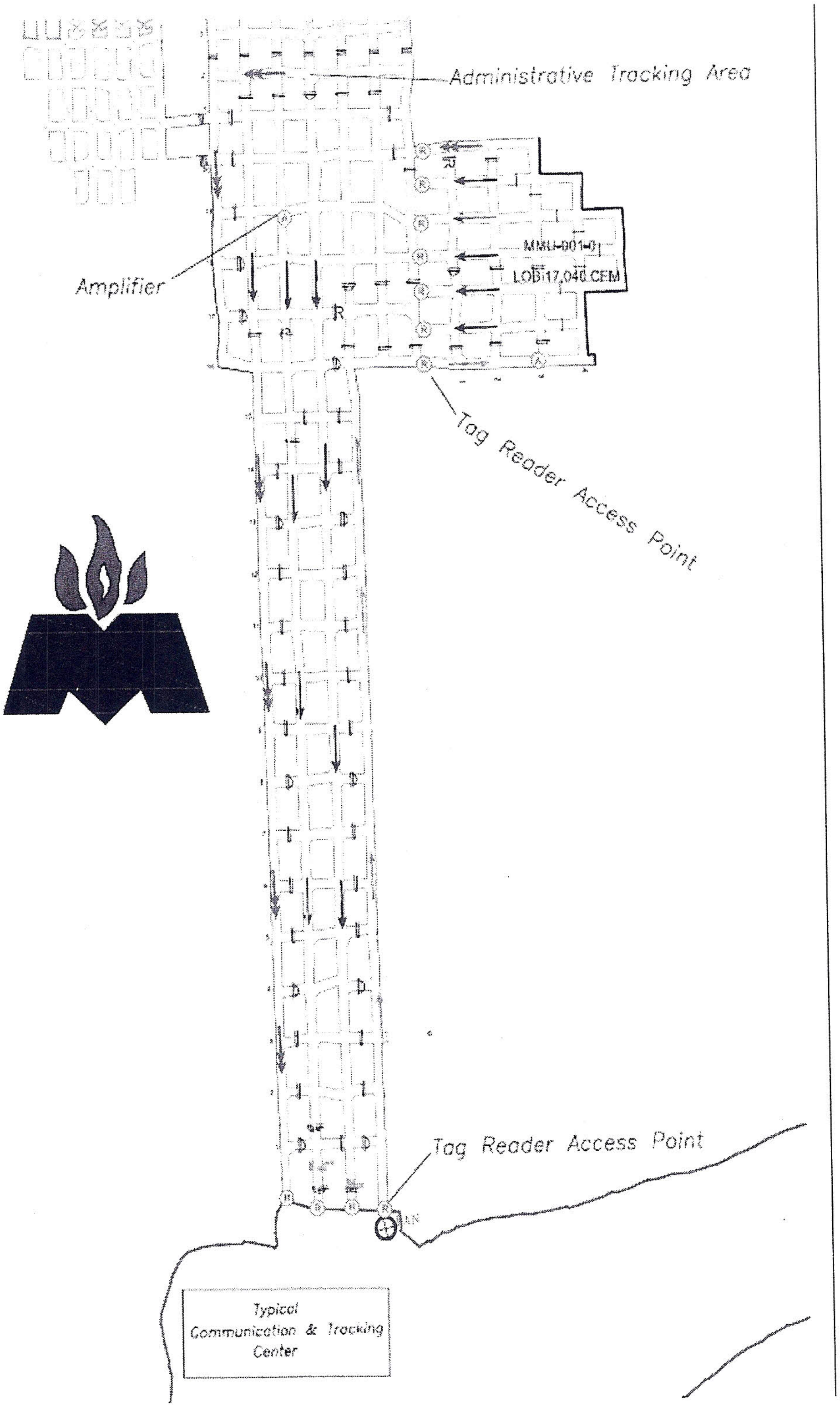
In areas where mobile equipment is used, precautions will be taken to avoid placing components of the communication and tracking system in potential areas of impacts by mining equipment. Areas of potential impact such as charging stations and travel ways will be considered during system planning.

Where possible the mine site will utilize bore holes, airshafts and other openings to the surface as additional pathway(s) to access the mine communication and tracking system in the event of an emergency or an accident. Potential mine access points will be located and identified on mine maps so as to be readily identifiable.

Emergency drilling may be utilized to provide access to the mines communication and tracking system from the surface in the event of an emergency or accident that would require such access. The mine has identified and placed under contract a drilling contractor to provide this service.

A mine map will be utilized to show the proposed location(s) of all major communication and tracking system components. The map will also show any airshafts, boreholes, and other openings to the surface that may be used to access the mines communication and tracking system. Included on this map will be the location of all emergency shelters and SCSR caches. The map will be used to aid mine rescue personnel and help determine the location of mine personnel in the event of an emergency or accident.

Typical Hardware Layout. Note: outside communication center, RFID tag readers, line amplifier and administrative area.



Tab 3

Communication & Tracking System Operations

The communication center will be located on surface. Mine management will designate a location for the system. The communication center will be setup with communication and tracking terminals available to the designated communication personnel. The designated communication personnel will monitor and initiate actions as required based on information from the communications and tracking systems in the mine. The mines communication system will be connected to a surface POTS phone line for access to outside resources and personnel.

Key to proper operation of the communication and tracking system will be the communication personnel. Personnel will have two basic duties; normal and emergency.

Normal duties of the designated communication personnel include:

- Ensure that the underground communication and tracking systems are functioning and are providing the required communication tracking information.
- Assist in coordinating ongoing mining activities.
- Provide a constant point of contact for personnel underground.

Emergency duties of the designated communication personnel include:

- Notify by proper emergency protocol all necessary parties.
- Become an integral part of rescue and coordination team.
- Provide information to emergency response personnel.
- Provide communication and tracking data as required.

The systems will provide all the necessary information for the designated communication personnel. A computer monitor will display the appropriate tracking data. The tracking data will be maintained to show the last major intersection, sub-main, the mouth of the working section, emergency shelter, or SCSR cache location, which all miners passed. A gate approach will be utilized to show miners entering and existing tracking zones. These zones will be identified on the mine map. Tracking zones will be designated during system planning. A zone will exist between natural seam limits and existing tracking zones. Zones will be created as mine works are extended.

The designated communication personnel will have means of voice communication over wireless radios. A primary radio channel will be used to monitor general mine voice traffic. The mine will also utilize the mine page phone system as a second line of defense to failure of the wireless system. An independent phone line will be maintained to the surface communication center from the working section(s). This phone line will be located in the intake airway.

The leaky feeder and tracking systems will be installed in accordance with manufacturers recommendations. All operating instructions, routine maintenance, testing, checklist, and annual inspections will be done in accordance to manufacturers recommendations.

The mine will put administrative procedures and protocols in place to insure that in the event of the loss of communication and/or tracking that mine personnel can utilize the mine page phone system to communicate location and status to the designated communication personnel. Furthermore the communication personnel will have additional duties to perform. These duties will not interfere with his duties as communications center operator.

Primary procedures in the event of the loss of communication and/or tracking:

- Notify all necessary parties of loss of communication and/or tracking.
- Provide current operational status to miners to facilitate repair.
- Interact with mine personnel during the repair process.
- Once communication/tracking is restored, verify that all systems are working as designed.

To account for mine personnel underground, the RFID tracking system will be utilized. As second line of defense to the tracking system, the mine site also utilizes administrative procedures and protocols that require the personnel to check in with the designated communication personnel via the communication systems to give location, status and potential movement throughout the mine. As a third line of defense to the tracking system, a manual check-in/check-out system will be maintained at the mine surface facilities.

In cases where miners are required to enter bleeders, remote, seldom used, or abandoned areas; an administrative process will be used to track these individuals. Before a miner or miners enter a bleeder, remote, seldom used, or abandoned areas they shall contact the designated communication personnel and initiate the proper protocol. This procedure would require the designated communication personnel to:

- Initiate the administrative tracking protocol as person(s) enter the designated areas.
- Contact the designated communication personnel at set intervals and confirm personnel are ok. These intervals will be determined based on the specific locations that will be entered.
- Designated communication personnel will maintain a log of miners who enter and exit administrative process areas.
- Where contact is not made at the required interval, the designated communication personnel will attempt to contact the miners in the administrative area. If contact cannot be made, the designated communication personnel shall initiate the proper protocol as per the emergency response procedures.

Tab 4
Training

To properly install, maintain, manage and operate the communication and tracking systems, mine personnel will be trained in the following areas.

Maintenance and repair personnel:

- System principles of operation and system regulatory requirements.
- Amplifiers, power supplies, cabling, connectors, and etc.
- System power requirements, battery backups, and cabling.
- System functionality testing and performance evaluation.
- RFID tags, tag readers, data links, cabling, connectors, and etc.
- Hardware integration into the mine to provide required and adequate coverage.
- Hardware installation to provide system survivability in the event of an accident.
- Permissibility of required components.
- Limitations and capabilities of communication and tracking systems.
- Normal operating protocols and procedures.
- Emergency operating protocols and procedures.
- Loss of communication / tracking protocols and procedures.
- Administrative zone protocols and procedures.

Communication / Tracking center operations personnel and mine management:

- System principles of operation and system regulatory requirements.
- System functionality testing and performance evaluation.
- Limitations and capabilities of communication and tracking systems.
- Normal operating protocols and procedures.
- Emergency operating protocols and procedures.
- Loss of communication / tracking protocols and procedures.
- Administrative zone protocols and procedures.
- Rescue coordination functions and information gathering required to support rescue efforts.

All mine personnel:

- System principles of operation and system regulatory requirements.
- Loss of communication / tracking protocols and procedures.
- Administrative zone protocols and procedures.

Systems training will be scheduled once the communication and tracking plan has been approved, a purchase order is issued, and compliance dates are provided based on the vendor's capabilities. All training will be completed before the systems become fully operational.

Systems training will be incorporated in new miner training, annual refreshers, hazard training (including contractors and visitors), and supervisor training.

As a minimum during these sessions the following will be discussed:

- System principles of operation and system regulatory requirements.
- Loss of communication / tracking protocols and procedures.
- Administrative zone protocols and procedures.

In the event of an emergency or accident requiring mine rescue teams to enter the mine, they will receive training on the mine specific communication and tracking system.

As a minimum during these sessions the following will be discussed:

- Functionality of the mine specific system in use.
- Communication and tracking procedures.
- Administrative process to track miners who enter bleeders, remote, seldom used, or abandoned areas.
- Radio and tracking tag operation and familiarity.

A copy of all necessary training requirements in association with the wireless communication and tracking system will be kept readily available at the mine site and the safety department. A record will be made of all system training. These records will be maintained for a period of 12 months at the mine site.

Tab 5

Proof of Order and Compliance Dates

Once the plan has been approved, a purchase order will be issued and compliance dates will be provided based on the vendor's capabilities.

State of West Virginia
Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
Ronald L. Wooten, Director
1615 Washington Street East ▪ Charleston, West Virginia ▪ 25311-2126
Telephone 304-558-1425 ▪ Fax 304-558-1282
www.wvminesafety.org

October 30, 2007

Mike Vaught
Performance Coal Company
Upper Big Branch Mine
PO Box 69
Naoma, WV 25140

Subject: Review of revised emergency communications and tracking plan submitted under WV Legislative Rule Title 56, Series 4 Legislative Rules Governing Protective Clothing and Equipment

Sir:

After the evaluation of the documentation submitted and your staff's discussions with our staff, your plan is deemed acceptable with the following modifications:

- General; remove personal information (social security numbers) from contact pages and format information per the attached August 31 memo and the guidance below.
- Tab 1; expand to insert a copy of the WV OMHS&T form GI-1 and append the email contact information for each person along with the names and contact information for vendors of communication and tracking subsystems (phones, wireless, radios, tracking, etc), if vendors not selected, the names of those being considered.
- Tab 2; expand to include a
  - Listing of all communications and tracking subsystems (pager phones, leaky feeders, tracking etc) along with a description of the role of each in the overall communication and tracking system, a

▪ **Region One** ▪ 205 Marion Square - Fairmont West Virginia 26554-2800 ▪ Telephone 304-367-2706 ▪ Fax 304-367-2707
▪ **Region Two** ▪ 891 Stewart Street - Welch, West Virginia 24801-2311 ▪ Telephone 304-436-8421 ▪ Fax 304-436-2100
▪ **Region Three** ▪ 137 Peach Court - Suite 2, Danville, West Virginia 25053 ▪ Telephone 304-369-7823 ▪Fax 304-369-7826
▪ **Region Four** ▪ 142 Industrial Drive- Oak Hill, West Virginia 25901-9714 ▪ Telephone 304-469-8100 ▪ Fax 304-469-4059

- Description of what survivability enhancements have or will be taken to ensure communication with and tracking of miners after an emergency (hardening, selective placement of components, redundant subsystems, etc), a
- Description of the process used in determining current and future location and spacing for zones and tracking points, and a
- Current map of the mine including zones, tracking points, communication subsystem elements, and the location of shelters.

- Tab 3; expand on the description concerning the operation of the communication center providing details of the duties of that staff person during normal operation, at the first indication of accident, and post accident.

- Tab 4; expand on the description of initial and recurring training for miners and staff on the various elements of the communication system and its use during normal operations and in an emergency. Include in the text a description of training for contractors and visitors, additionally, provide a description of how mine rescue teams will be trained on the use of the mine's communication and tracking system during an emergency.

These noted modifications must be submitted in two complete copies of the plan to this office no latter than November 16, 2007. Once modifications are reviewed you will receive a notice of approval.

Within 15 days of the receipt of that notice you are required to submit to this office proof of purchase of any components or services necessary to complete the communication and tracking system as approved. At the minimum this should include necessary communication and tracking equipment and installation along with routine and emergency maintenance services. If you intend to provide these services in-house then proof of qualified staff and available equipment is required. The documents provided should specify the order and delivery dates for major components and the operational date of the system as approved. The operational date will become the enforceable compliance date.

Any changes to the approved plan or proofs of purchase documentation require the submittal to this office of a request for modification.

Sincerely,

Gary S. Snyder

Inspector at Large
Office of Miners' Health and Safety

Communication & Tracking Plan Deficiencies and Corrections Required

Attachment to Notice of Deficiency August 31, 2007

General

Submit two copies of the revised plan to your regional office within 15 days of receipt of the certified letter from the Director.

Place each plan in a clear front report cover such that it provides a full view of cover page, has 3 double-prong fasteners, five tab index, and a pocket to hold a mine map behind tab two. Do not submit ring binders.

Questions should be directed to your regional office or the web site www.wvminesafety.org

Tab 1 – Emergency Contact Information

In this section please modify your submittal to include a copy of your current mine general information form "GI" found at http://www.wvminesafety.org/PDFs/GI1.pdf appending on a separate page any of the following that is not included on that form:

Name of Mine
Mine Address
Physical Location (driving directions from regional office)
Mine ID – State
Mine ID – MSHA

Company Responsible for the Plan
Contact Person
Daytime Phone #
Emergency Phone #
Email address

General Manager/Superintendent Name
Daytime Phone #
Emergency Phone #
Email address

Safety Manager/Director
Daytime Phone #
Emergency Phone #
Email address

Phone# to the Communication Center

If final selection not made include those being considered for the following:

Communication System Manufacturer(s)
Communication System Vendor(s)
Contact Person
Emergency Phone #
Email address

Tracking System Manufacturer(s)
Tracking System Vendor(s)
Contact Person
Emergency Phone #
Email address

Tab 2 – Communication-Tracking System Description

The principle deficiencies under this tab related to only describing proposed new technology. The intent of 56-4 is that mines utilize all means in an integrated manner to enhance the likelihood of survival of some communication and tracking elements following a disaster.

In this section the description must contain ALL means of communication and tracking equipment along with administrative procedures currently in place or proposed and how they collective interact to provide communication and tracking of miners during operations and following a disaster.

The information behind this tab shall describe existing and proposed communication-tracking system elements selected and provide an understanding of how all these elements work together to achieve compliance. This should include an overview of the communication-tracking system describing the structure and operations of the separate or integrated communication/tracking system(s) noting what changes to existing communication-tracking systems were required to comply with WV regulations, including but not be limited to:

- Allowing wireless tracking and wireless two way communications and tracking with each miner providing coverage in at least two separate air courses, at least one of which shall be an intake.

- Knowing the location of miners and direction of travel at key points in the escapeways, at a minimum at junctions (section, section-submain/mains intersections), so that all options of travel are covered and at distance not greater than half those between caches in escapeways. The statement should describe the criteria used in selecting these key points and coverage areas for tracking. Include a description of administrative procedures in place or proposed for checkin-checkout of individuals leaving a monitored tracking area.

- Providing examples of situations that might result in the loss of elements of the integrated communication and tracking infrastructure referring to specific locations on an included mine map. For each unique situation describe what steps are proposed to ensure survivability and/or provide for a redundant or alternative means of maintaining the communication and tracking capability. Situations of concern include but should not be limited to:

    - Potential fire source areas
        - Electrical equipment
        - Belts
        - Underground shops
    - Potential areas of explosive force pathways
        - Intersections of sealed areas
        - Intersections of completed sections
    - Potential ground control failure areas
        - Areas with known roof problems
        - Areas with known rib problems
    - Potential areas for impacts by mining equipment
        - Travel ways
        - Charging stations

Statement should be in sufficient detail that a reviewer can determine the propriety of the proposed solution and such that mine operators can use it as a template for similar situations as mining progresses.

- Providing an explanation of what steps are anticipated and what materials are pre-positioned to re-establish communication and tracking with miners who may become trapped in the event of a catastrophic disaster.

- A description of provisions made to maintain communication/tracking after loss of outside power for each of the components of the integrated communication and tracking system. The description should include details for de-powering any batteries by mine rescue teams if necessary. If power management schemes are to be employed to extend the life of backup batteries those should be described.

- A description of the communication system that is will be used in the shelter and provisions have been made to rapidly reestablish communication if lost in the accident.

- A current mine map with major communication and tracking components such that a reviewer can verify the appropriateness of the descriptions provided above. (maps do not need to be certified) Map should identify proposed zones and tracking points, path of any communication infrastructure, and the locations of amplifiers and/or nodes.

Tab 3 – Communication-Tracking System Operations

The principle deficiencies under this tab also related to only describing proposed new technology. Again, the intent of 56-4 is that mines utilize all means in an integrated manner to enhance the likelihood of survival of some communication and tracking elements following a disaster.

This tab should begin with a statement regarding how new elements of the communications and tracking system will be installed, tested and maintained. It should also discuss how these new elements will be incorporated into existing elements. This description should be in sufficient detail to allow a reviewer to determine the adequacy of the proposal and provide guidance for mine operational staff.

A combined listing of manufacturer's checklists for each type of inspection, routine, relocation, annual, etc should be presented.

Included in this tab should be copies of the operating instructions for each component of the communication and tracking system to be provided for the miner and for emergency personnel. (Technical and repair instructions intended for technical staff should not be included)

If administrative measures are included in the communication and tracking system, such as checkin-checkout procedures, they also must be described here.

This section should describe the communication center and its operation in sufficient detail to allow a reviewer to determine the adequacy of the proposal and to orient communication center staff. The description should explain how the mine will be monitored at all times during which one or more miners are underground by providing:

- Details that the system allows the communication center operator to know the location of all miners, in relation to pre-determined points, immediately prior to an event by wireless tracking/locating device in the escape-ways, normal work assignments, or notification of the communication center

- Details on checkin and checkout procedures with the communication center by miners prior to entrance and exit from bleeders and remote or seldom used areas of the mine (all times shall be logged) and what the procedures are if they do not checkin at expected times

- Details for procedures for communication center operators during normal operations and in emergencies

Tab 4 – Training

The principle deficiencies under this tab also related to only describing proposed new technology. Again, the intent of 56-4 is that mines utilize all means in an integrated manner to enhance the likelihood of survival of some communication and tracking elements following a disaster. This tab was reordered to allow correspondence to be last.

Include updated content that demonstrates that all miners, supervisors and likely emergency responders shall be trained in the use, limitations and inter-operability of all components of the communication and tracking/locating system.

A statement indicating:

- the initial training dates for implementation of the communication-tracking system
- how the communication/tracking system will be incorporated in other required training, and
- where training shall be recorded to be made available upon request

Tab 5 – Correspondence

This tab was reordered to place it at the end and include all correspondence associated with the plan.

This section should contain copies of transmittal letters to WV OMHS&T, copies of any deficiency received, and copies of approvals.

Following approval copies of purchase orders showing operational dates that were submitted to the OMHS&T regional office should be inserted. These include a copy of purchase orders for any necessary items or services required to implement the emergency communication-tracking plan. At the minimum this should be communication-tracking equipment, installation, and routine and emergency maintenance services. If the operator is doing these things in-house then proof of qualified staff and available equipment is required.

The documents should specify the following:

- Order date:
- Delivery date:
- Operational Date:

State of West Virginia
Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
Ronald L. Wooten, Director
1615 Washington Street East ▪ Charleston, West Virginia ▪ 25311-2126
Telephone 304-558-1425 ▪ Fax 304-558-1282
www.wvminesafety.org

January 22, 2008

Mike Vaught
Performance Coal Company
Upper Big Branch Mine
P. O. Box 69
Naoma, WV 25140

Subject: Review of revised emergency communications and tracking/locating plan submitted under WV Legislative Rule Title 56, Series 4 Legislative Rules Governing Protective Clothing and Equipment

Sir:

After the evaluation of the documentation submitted and your staff's discussions with our staff, your plan is determined to meet the requirements of §56-4-9 for emergency communication and tracking/locating systems.

Currently utilized communication systems and manual tracking/locating procedures shall be maintained until the operational date and shall remain the backup procedures for no more than a reasonable time in the event of any failure that result in loss of communication or tracking/locating while the system is being restored to an operational state. Such periods shall not exceed the time as is required to promptly examine the communications and or tracking/locating system and if the cause of the failure is determined during this examination, to immediately correct the same from spare equipment maintained at the mine where possible.

The mine's phone system shall be installed to each WV approved emergency shelter deployed per WV §56-4. The phones shall be supplemented by the wireless communication and tracking/locating systems, when operational, such that one or more communication option remains functional to the maximum duration for which the shelter is rated.

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▪ **Region Three** ▪ 137 Peach Court - Suite 2, Danville, West Virginia 25053 ▪ Telephone 304-369-7823 ▪Fax 304-369-7826
▪ **Region Four** ▪ 142 Industrial Drive- Oak Hill, West Virginia 25901-9714 ▪ Telephone 304-469-8100 ▪ Fax 304-469-4059

The documentation of training on emergency communications and tracking/locating systems required under WV §56-4 shall be maintained for inspection on the permitted property.

No later than February 12, 2008 you shall submit as an addendum to your plan, a copy of any contract, or purchase order, or other proof of purchase of WV approved equipment required to complete the emergency communication and tracking/locating system and for installation and ongoing maintenance. The purchase orders shall contain the delivery dates and operational date of the system as approved in this plan.

Fifteen days prior to the operational date an updated emergency communication and tracking/locating plan shall be submitted that indicates the as-built details of all elements. Thereafter the placement and status of the elements shall be included with required progress maps.

Any changes to the purchase documentation or changes in mining plans that result in significant changes in the operation of the emergency communication and tracking/locating system require the submittal to this office of a request for modification.

Under §56-4-9 the Director may require modifications to emergency communication and tracking/locating plans at any time following the investigation of a fatal accident or serious injury, if such modifications are warranted. If such a situation arrives you will be notified with requirements and the period for compliance.

Additionally the following stipulations apply to this approval:

1) No provision of this plan modifies the requirements of §56-4-9,
2) No duties assigned the miner monitoring the communication and tracking/locating systems shall interfere with those required under §56-4-9.13,
3) A copy of the approved plan shall be kept at the mine site,
4) A copy of the approved plan shall be provided to the mine rescue teams designated to provide coverage at this mine, and that
5) This plan is void upon the District Inspector's recommendation.

Sincerely,

Phillip Adkins

Safety Instructor
Office of Miners' Health, Safety and Training

Note: Attached are the rule sections relevant to this approval. A current copy of all W. Va. mine safety rules can be obtained through your regional office or downloaded from http://www.wvminesafety.org/PDFs/LawRev2007.pdf

State of West Virginia
Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
Ronald L. Wooten, Director
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Telephone 304-558-1425 • Fax 304-558-1282
www.wvminesafety.org

COMMUNICATION / TRACKING PLAN

Date September 9, 2009

Company Performance Coal Company
Address P. O. Box 69
Naoma, WV 25140

Mine UBBMC Montcoal Eagle
Permit No. U00304292

This is to acknowledge receipt of the communication and tracking plan addendum for the above named mine. The submitted addendum has been reviewed and is:

X Approved

______ Rejected **(List reasons below)**

Remarks:
Plan update (addendum), dated September 8, 2009, showing a completion date of December 31, 2009 for the installation of the communication and tracking system.

Authorized Representative

• Region One • 14 Commerce Dr., Suite 1 - Westover, West Virginia 26501 • Telephone 304-285-3268 • Fax 304-285-3275
• Region Two • 891 Stewart St. - Welch, West Virginia 24801-2311 • Telephone 304-436-8421 • Fax 304-436-2100
• Region Three • 137 Peach Court, Suite 2 - Danville, West Virginia 25053 • Telephone 304-369-7823 • Fax 304-369-7826
• Region Four • 142 Industrial Dr. - Oak Hill, West Virginia 25901-9714 • Telephone 304-469-8100 • Fax 304-469-4059

Performance ***SAFETY DEPARTMENT***

Steve Snyder
Inspector at Large, Region IV
Miners' Health, Safety and Training
142 Industrial Drive
Oak Hill, WV

09-08-09

RE: Communication and Tracking
Upper Big Branch Mine
State Permit- U-3042-92
MSHA ID 46-08436

Performance Coal Company is submitting an update to the Communication and Tracking Plan for the Upper Big Branch Mine, State Permit # U-3042-92. Due to the availability of parts and supplies the projected date of completion for the installation of the Communication and Tracking system for this mine is December 31, 2009.

Berman Cornett

Berman Cornett
Safety Director
Performance Coal

*P.O. Box 457 Whitesville, WV 25209/Marfork Road * Route 3/1 * Pettus, West Virginia 25209*
Tel (304) 854-1852 (ext40/42)/Fax (304) 854-2838

Steve Snyder
Inspector at Large, Region IV
Miners' Health, Safety and Training
142 Industrial Drive
Oak Hill, WV

09-08-09

RE: Communication and Tracking
Upper Big Branch Mine
State Permit- U-3042-92
MSHA ID 46-08436

Performance Coal Company is submitting an update to the Communication and Tracking Plan for the Upper Big Branch Mine, State Permit # U-3042-92. Due to the availability of parts and supplies the projected date of completion for the installation of the Communication and Tracking system for this mine is December 31, 2009.

Berman Cornett
Safety Director
Performance Coal

*P.O. Box 457 Whitesville, WV 25209/Marfork Road * Route 3/1 * Pettus, West Virginia 25209*
Tel (304) 854-1852 (ext40/42)/Fax (304) 854-2838

State of West Virginia

Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
Ronald L. Wooten, Director
1615 Washington Street East • Charleston, West Virginia • 25311-2126
Telephone 304-558-1425 • Fax 304-558-1282
www.wvminesafety.org

December 29, 2009

Performance Coal Company
UBB Montcoal Eagle Mine
P. O. Box 69
Naoma, WV 25140

Subject: Communication and Tracking

Dear Mr. Bowles:

Please be advised we have received and accept the December 7, 2009, and December 28, 2009, modification to your approved Communication and Tracking Plan.

We accept the modification with the following provision that "..... We anticipate delivery of the necessary equipment on or before January 31, 2010....." is changed to "....We anticipate installation of the necessary equipment on or before January 31, 2010....".

If you have questions, please contact our office at 304-469-8100.

Respectfully,

Philip W. Adkins,
Safety Instructor

Performance Coal Company

Steve Snyder
Inspector at Large Region IV
WV Office of Miners' Health, Safety and Training
142 Industrial Drive
Oak Hill, WV

12-28-09

RE: Communication and Tracking
UBB Montcoal Eagle
Permit U00304292

Performance Coal Company is requesting an extension be granted until January 31, 2010 for the completion of the modification that was requested on 12-07-09 to the Communication and Tracking Plan. This extension is being requested due to several problems that are being experienced with the installation of the Communication and Tracking Systems.

During the installation procedures of the Pyott Boone Communication Systems amplifiers fuses are blowing, tags will not communicate. A shortage of parts including monitoring/mapping, tracking tags, readers and tech support to assist in trouble shooting and training to complete the installation has occurred. Also, the severe weather has caused problems due to power outages and water problems that caused delays in the installation process.

Jonah Bowles
Safety Director
Performance Coal Company

Performance Coal Company
P.O. Box 69
Naoma, WV 25140
Tel (304) 854-1761
Fax (304) 854-3528

MARFORK SAFETY DEPARTMENT

Steve Snyder
Inspector at Large
Region IV, Oak Hill
WV Office of Miners' Health, Safety and Training

12-07-09

RE: Communication and Tracking
UBBMC Montcoal Eagle
State Permit U- 3042-92

We request that a modification of the approved WV emergency communication and tracking plan for UBBMC Montcoal Eagle Mine be approved as follow:

As of December 31, 2009, this mine will have a basic Pyott Boone Communication and Tracking Boss system installed and operational to meet the requirements of WV 56-4.

In addition to communication equipment as currently defined in the mine's approved plan the basic system will consist of the tracking computer, software, and head end tracking unit. At a minimum, a reader will be installed at each portal to track miners as they enter and exit the mine and additional readers will be installed in the two airways designated in the approved plan at locations adjacent to each third belt drive.

Tracking tags will be issued to outby miners, personnel carriers, and to a foreman and electrician or designated alternate on each section crew. As they become available from the manufacturer and within two weeks of delivery, additional tags will be issued and additional readers will be installed, at locations indicated in the approved plan. We anticipate delivery of the necessary equipment on or before January 31, 2010.

The current manual tracking procedures will remain in place until the tracking system installation is complete. However, the manual tracking procedure will be modified to include the requirement of the maintenance of a log by the communication/tracking person indicating the names of crew members and personnel carriers issued tags that are logged onto the tracking system as numbers to allow the use of temporary tags.

Jonah Bowles
Safety Director
Marfork Coal Company

P.O. Box 457 Whitesville, WV 25209/Marfork Road * Route 3/1 * Pettus, West Virginia 252??
Tel (304) 854-1852 (ext40/42)/Fax (304) 854-2838

IF-O18
Revised 3-09

Region 4-Oak Hill
134-0705-2009

STATE OF WEST VIRGINIA

OFFICE OF
MINERS' HEALTH, SAFETY AND TRAINING
1615 Washington Street East
Charleston, West Virginia 25311-2126

Copies - Company
Inspector
Assessment
Regional Office
Post
Rep of Mines

No: 26611

NOTICE OF VIOLATION

Company / Operator Performance Coal Co. Contractor: Yes ____ No ✓

Permit Number U304292 Mine Name UBB MC Montcoal Eagle

Date of Issue 8-4-09, 2009 Time 8:00 ✓ A.M. ____ P.M.

Notice is hereby given that the undersigned authorized representative of the Director of the Office of Miners' Health, Safety and Training, upon making an inspection of this mine finds that the violation referred to in West Virginia Code, Chapter ____, Article ____, Section ____ and/or West Virginia Administrative Regulation: Title 56, Series 4, Section 9.6 exists as follows:

This mine is not in compliance with the approved communication tracking plan. As of this date a fully operational communication and tracking system has not been installed.

Type of Issuance: N.O.V. ✓ Order ____

Area or equipment (if order is issued): ____

The foregoing violation shall be totally abated by 8:00 ✓ a.m. ____ p.m. on 9-15 20 09

The foregoing violation was totally abated by ____ ____ a.m. ____ p.m. on ____ 20 ____

Action taken to abate the violation: ____

Company / Operator Agent Served: Everett Hager, Andy Carlson

Authorized Representative: Gerald W. Pauley Inspector No. 134

REVIEW: In accordance with Section 22A-1-17 of the Code, an operator or any representative of the miners may apply to the Director of the Office of Miners' Health, Safety and Training for review of this notice of violation within thirty (30) days from the issued date.

VIOLATION ASSESSMENT EVALUATION

S and S Violation: ☐ **Recommend Special Assessment:** ☐

Likelihood of Occurrence: Unlikely: *(0) ✓ Reasonably likely (10) ____ Occurred (20) ____

Severity of Injury Expected: None: *(0) ____ No lost work days *(6) ✓ Lost or restricted days (11) ____

Permanently disabling (15) ____ Fatal (20) ____

* If these are checked in each category, do not go further unless a knowing violation.

# of Persons Potentially Affected: 0 (0) ____ 1 (1) ____ 2 (2) ____ 3 (4) ____ 4-5 (6) ____ 6-9 (8) ____ 9+ (10) ____

Negligence: None (0) ____ Low (10) ____ Moderate (15) ____ High (20) ____

Knowing Violation: No ____ Yes ____ Repeat ____

Good Faith in Abatement: Lack of good faith (+15%) ____

No compliance (extenuating circumstances) (0%) ____ **Extra effort (-15%)** ____

IF - 019
Revised 11/08

State of West Virginia
Office of Miners' Health, Safety and Training
1615 Washington Street, East
Charleston, West Virginia 25311-2126

Case No. 134-0705-2009 Region 4-Oak Hill

INSPECTION OF VIOLATION

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number: 26611 (was/is hereby) ______ totally abated by ______, 20 ______
______ a.m. ______ p.m. ______ (extended to) 8:00 Am 12-31, 20 09, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: Additional time is given to complete the installation of the mine tracking and communication system.

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number: ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m. ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number: ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m. ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number: ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m. ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Company/Operator Agent served: Bermay Cornett Paul Thompson Date: 9-11 20 09
Authorized Representative: Gerald W. Pauley Inspector Number 134

State of West Virginia
Office of Miners' Health, Safety and Training
1615 Washington Street, East
Charleston, West Virginia 25311-2126

4 - Oak Hill

No. 134-0765-2009

INSPECTION OF VIOLATION

Good faith in abatement: Lack of good faith (+15%) ________
No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________
Violation Number 2 of 11 was/is hereby ________ totally abated by ________, 20 ____
____ a.m. ____ p.m., ____ extended to 10:00 Am 1-31, 20 10, ________ modified to
____ Order, ________ Withdrawn.
Action taken to abate the violation: Additional time is given to complete work on the ... and communication system.

Good faith in abatement: Lack of good faith (+15%) ________
No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________
Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____
____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to
____ Order, ________ Withdrawn.
Action taken to abate the violation: ________

Good faith in abatement: Lack of good faith (+15%) ________
No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________
Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____
____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to
____ Order, ________ Withdrawn.
Action taken to abate the violation: ________

Good faith in abatement: Lack of good faith (+15%) ________
No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________
Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____
____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to
____ Order, ________ Withdrawn.
Action taken to abate the violation: ________

Good faith in abatement: Lack of good faith (+15%) ________
No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________
Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____
____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to
____ Order, ________ Withdrawn.
Action taken to abate the violation: ________

Company/Operator Agent served: Everett Hager / Paul Thompson Date: 1-7, 20 10
Authorized Representative: Gerald W. [signature] Inspector Number 134

NCF-5654 3/20/07

State of West Virginia
Office of Miners' Health, Safety and Training
1615 Washington Street, East
Charleston, West Virginia 25311-2126

4-OAK Hill
No. 134-0705-2009

INSPECTION OF VIOLATION

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number 26611 was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m., ______ extended to 8:00Am 2-15, 20 2010, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: additional time is granted to complete communication and tracking work.

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m., ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m., ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m., ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

Good faith in abatement: Lack of good faith (+15%) ______
No compliance (extenuating circumstances) (0%) ______ Extra effort (-15%) ______
Violation Number ______ was/is hereby ______ totally abated by ______, 20 ______
______ a.m. ______ p.m., ______ extended to ______, 20 ______, ______ modified to
______ Order, ______ Withdrawn.
Action taken to abate the violation: ______

...pany/Operator Agent served: Everett Haga, Gary Ma... Date: 2-1, 20 10
Authorized Representative: Gerald W. Pauley Inspector Number 134

NCF-5654 3/20/07

/02

4-Oak Hill

No. 134-0705-2009

State of West Virginia
Office of Miners' Health, Safety and Training
1615 Washington Street, East
Charleston, West Virginia 25311-2126

White - Company
Blue - Inspector
Green - Charleston
Canary - Regional Office
Pink - Post
Goldenrod - Rep. of Mines

INSPECTION OF VIOLATION

Good faith in abatement: Lack of good faith (+15%) __________
No compliance (extenuating circumstances) (0%) __________ Extra effort (-15%) __________
Violation Number 26611 was/is hereby __________ totally abated by __________, 20 ______
______ a.m. ______ p.m., ______ extended to 8:30 am March 1, 2010, __________ modified to
______ Order, __________ Withdrawn.
Action taken to abate the violation: Additional work is granted to continue installation of the Belt Feeder readers.

Good faith in abatement: Lack of good faith (+15%) __________
No compliance (extenuating circumstances) (0%) __________ Extra effort (-15%) __________
Violation Number __________ was/is hereby __________ totally abated by __________, 20 ______
______ a.m. ______ p.m., ______ extended to __________, 20 ______, __________ modified to
______ Order, __________ Withdrawn.
Action taken to abate the violation: __________

Good faith in abatement: Lack of good faith (+15%) __________
No compliance (extenuating circumstances) (0%) __________ Extra effort (-15%) __________
Violation Number __________ was/is hereby __________ totally abated by __________, 20 ______
______ a.m. ______ p.m., ______ extended to __________, 20 ______, __________ modified to
______ Order, __________ Withdrawn.
Action taken to abate the violation: __________

Good faith in abatement: Lack of good faith (+15%) __________
No compliance (extenuating circumstances) (0%) __________ Extra effort (-15%) __________
Violation Number __________ was/is hereby __________ totally abated by __________, 20 ______
______ a.m. ______ p.m., ______ extended to __________, 20 ______, __________ modified to
______ Order, __________ Withdrawn.
Action taken to abate the violation: __________

Good faith in abatement: Lack of good faith (+15%) __________
No compliance (extenuating circumstances) (0%) __________ Extra effort (-15%) __________
Violation Number __________ was/is hereby __________ totally abated by __________, 20 ______
______ a.m. ______ p.m., ______ extended to __________, 20 ______, __________ modified to
______ Order, __________ Withdrawn.
Action taken to abate the violation: __________

Company/Operator Agent served: Gary May [signature] Date: 2-16, 2010
Authorized Representative: Gerald W. [signature] Inspector Number 134

NCF-5654 6/13/02

02

4-OAK Hill

No. 134-0705-2009

State of West Virginia
Office of Miners' Health, Safety and Training

1615 Washington Street, East
Charleston, West Virginia 25311-2126

White - Company
Blue - Inspector
Green - Charleston
Canary - Regional Office
Pink - Post
Goldenrod - Rep. of Mines

INSPECTION OF VIOLATION

Good faith in abatement: Lack of good faith (+15%) ________

No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________

Violation Number 26611 was/is hereby ________ totally abated by ________, 20 ____ ____ a.m. ____ p.m., ____ extended to 8:00 am 3-1, 20 10, ________ modified to ____ Order, ________ Withdrawn.

Action taken to abate the violation: This violation extension is in conjunction with the one written on 2-16-2010. Included in work to be finished is training of the communication personnel cont. below

Good faith in abatement: Lack of good faith (+15%) ________

No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________

Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____ ____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to ____ Order, ________ Withdrawn.

Action taken to abate the violation: adequate communication from the communication center to the underground, having a communication plan at the mine, providing a mine map with the required information, cont. below

Good faith in abatement: Lack of good faith (+15%) ________

No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________

Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____ ____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to ____ Order, ________ Withdrawn.

Action taken to abate the violation: to provide a log/record of those traveling in remote areas of the mine, having phones and the installation of additional radios throughout the mine - and also at the #565R radio and shelters.

Good faith in abatement: Lack of good faith (+15%) ________

No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________

Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____ ____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to ____ Order, ________ Withdrawn.

Action taken to abate the violation: ________

Good faith in abatement: Lack of good faith (+15%) ________

No compliance (extenuating circumstances) (0%) ________ Extra effort (-15%) ________

Violation Number ________ was/is hereby ________ totally abated by ________, 20 ____ ____ a.m. ____ p.m., ____ extended to ________, 20 ____, ________ modified to ____ Order, ________ Withdrawn.

Action taken to abate the violation: ________

Wayne Brown

Company/Operator Agent served: Gary May Rick Foster Date: 2-17, 20 10

Authorized Representative: Gerald W. [illegible] Inspector Number 134

NCF-5654 6/13/02

PYOTT BOONE (Belt Boss)

30-Apr-10 This is the mine belt monitoring system that communicates outside to a PC at dispatchers office.

NOTE: Enter data in the fields indicated in BLUE, only.

This spreadsheet calculates a EST GPS clock time for a device EVENT, given two time sync data points:

ENTER:	Date	Hour	Min	Sec	-->> Excel Time (days)	
Time of device EVENT	4/5/2010	15	8	1	40273.6305671296	Time of CO alarm at 6 NORTH 99 BRK, according to Pyott Boone Log

READ RESULTS:	Date	Hour	Min	Sec	<<-- Excel Time (days)	
Corrected Time (GPS)	**4/5/2010**	**15**	**2**	**18**	**40273.6266013187**	Time of CO alarm at 6 NORTH 99 BRK, according to Pyott Boone Log (no correction made for Daylight Savings time-- apparently the PC clock already made this correction)

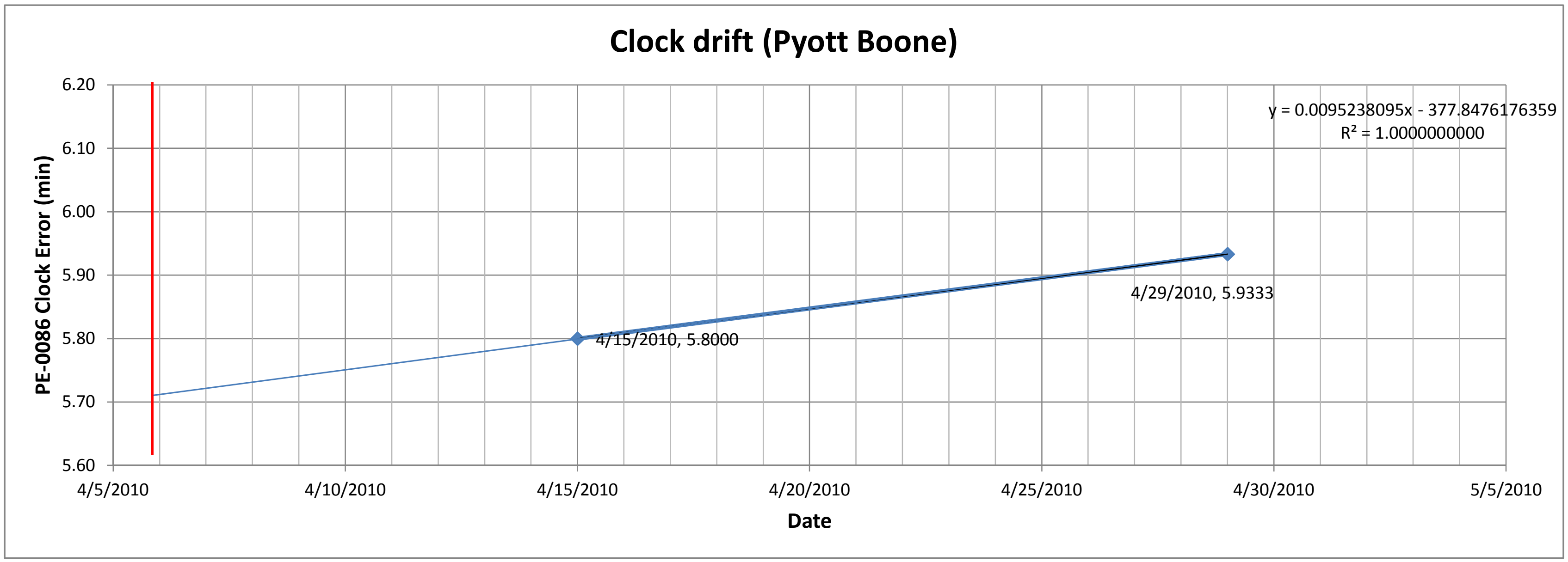
List of Time Sync Readings that have been obtained:

Device clock time					Corresponding GPS time				clock drift of DETECTOR	
Date	Hour	Min	Sec	Excel Time (minutes)	Hour	Min	Sec	Excel Time (minutes)	Total min.	sec. / day
4/15/2010	13	14	48	58008314.8000000000	13	9	0	58008309.0000000000	5.8000	
4/29/2010	11	14	56	58028354.9333333000	11	9	0	58028349.0000000000	5.9333	0.57

ENTER the linear regression values given in the upper right corner of CHART.

m= 0.0095238095

b= -377.8476176359 (equation of form: y=mx+b)



PYOTT BOONE

Summary:

- 74 units remained operational
- 51 units lost communications
- Data communicated was 2 bytes out & 2 bytes in (11 total bits + 1 extra bit)
- System running at 320 Baud
- 45 bits required during a successful communication (45/320 = ~140ms)
- 22 bits required during an unsuccessful communication (22/320 = ~69ms)
- Total time required for an unsuccessful communication is: 69ms + 210ms (port timeout with no response) = ~279ms
- Approximate time lost due to 51 units not communicating: 51 * 279ms = ~ 14.229s
- Approximate time required for 74 communicating devices: 74 * 140ms = 10.36s
- Total time for communication with all devices: 14.229s + 10.36s = 24.589s
- Total time for communication will all devices prior to priority downgrade: 24.589s * 10(Channel Dead Countdown) = ~245.89s
- Weighted Average Time – Assuming 51 units are dead and 74 units are operational: ((51 * 140ms)+(74 * 279ms))/(51+74) = .222s
- Size of scanner queue is 4 (in scan cycles)
- 9 time intervals between the 1-10 retry count
- 36 (4 (size of queue) * 9 (time intervals)) represents the number of cycles required to reach communications fail
- The average time required to reach communications fail: .222s * 36 = 8.0 s
- The average time to communications dead: 100s (channel dead countdown) + 8.0s (average time to communications fail) + .4 (uncertainty figure) = 108.4s
- 108.4s -> 1.8 min -> 1 min 48 sec

West Virginia Bureau of Commerce

Office of Miners' Health, Safety and Training

Region IV

REPORT OF A METHANE GAS IGNITION
(UNDERGROUND COAL MINE)

Performance Coal Company
UBBMC Montcoal Eagle Mine
Permit No. U-3042-92
Located near Montcoal, Raleigh County, West Virginia

January 4, 1997

By

Gary S. Snyder, Inspector-at-Large
Frank Legg, Assistant Inspector-at-Large
Randy Smith, Electrical Inspector
Gerald Pauley, Deep Mine Inspector
Clark Gillian, Deep Mine Inspector

Originating Office:

West Virginia Bureau of Commerce
Office of Miners' Health, Safety and Training
1615 Washington Street, East
Charleston, West Virginia 25311

MINE INFORMATION

COMPANY Performance Coal Company

MINE NAME UBBMC Montcoal Eagle Mine

WV PERMIT U-3042-92

ADDRESS P. O. Box 69, Naoma, West Virginia 25140

COUNTY Raleigh

DATE PERMIT ISSUED November 2, 1994

WORKING STATUS Active

LOCATION near Montcoal

UNION ______ NON-UNION Yes

DAILY PRODUCTION 11,490 clean coal tons through 1-9-97

ANNUAL PRODUCTION TO DATE 103,413 clean tons through 1-9-97

TOTAL EMPLOYEES 170

NUMBER OF SHIFTS 3

NAME OF COAL BED Eagle Seam

SEAM THICKNESS 60"

ACCIDENT INCIDENT RATE 6.20 - 1996 LOST TIME ACCIDENTS 14 - 1996

TYPE OF HAULAGE Shuttle cars/conveyor belts

WV OMHST INSPECTOR Clark Gillian

DATE OF LAST INSPECTION December 27, 1996

NOTIFIED BY C. Larry Bane

TIME OF NOTIFICATION 11:18 a.m., January 4, 1997

CMSP - ANNIVERSARY DATE November 15, 1997

CMSP - CONTACT PERSON C. Larry Bane, Safety Director

SUPPLEMENTAL INFORMATION

NOTICES/ORDERS ISSUED RELATIVE TO THIS ACCIDENT

The West Virginia Office of Miners' Health, Safety and Training issued six violations during this investigation. The following violations pertain to the accident and violation no. four is considered to be directly related to the accident:

Violation No. 1, Order of Withdrawal, Chapter 22A, Article 1A, Section 15(a):
In that an ignition has occurred at # 107 crosscut on the longwall tailgate entry (according to management) and carbon monoxide readings from 58 ppm to 208 ppm still exist at various locations, the entire mine is hereby closed until it can be determined that an imminent danger no longer exists and an investigation is completed by the Office of Miners' Health, Safety and Training. At the present time, only those persons approved to eliminate the danger shall be allowed underground; specifically thirteen employees at a location two breaks inby spad 0564 repairing a blown-out door and three employees sent to evaluate EP #2. This order was served verbally via telephone by Frank A. Legg, Assistant Inspector-at-Large to C. Larry Bane at 11:23 a.m.

Violation No. 4, Notice of Violation, Chapter 22A, Article 2, Section 4(h):

Adequate airflow is not provided in the Longwall Section bleeder system sufficient to prevent a dangerous accumulation of gas in the gob area; in-that a gas ignition occurred in the gob on January 4, 1997.

REPORT OF A METHANE GAS IGNITION
Performance Coal Company
UBBMC Montcoal Eagle Mine
Permit No. U-3042-92

GENERAL INFORMATION

This report is based on an investigation made in accordance with Chapter 22A, Article 2, Section 66 of the Mining Laws of the State of West Virginia.

A methane gas ignition, which was followed by several subsequent gas ignitions, occurred on the Longwall Section shortly after 10:00 a.m. on Saturday, January 4, 1997. The ignitions occurred in the gob area behind the face support shields near the tail of the section.

Frank Legg, Assistant Inspector-at-Large of Region IV, was notified of the accident at approximately 11:20 a.m. on January 4, 1997 by C. Larry Bane, company safety director. An official investigation was immediately started.

INVESTIGATION

The following persons were present during the on-site investigation conducted January 4, 1997:

PERFORMANCE COAL COMPANY

Pete Hendrick	President, Massey Coal Services
Joe Evans	President, Performance Coal Company
Eddie Lester	Mine Superintendent
C. Larry Bane	Safety Director
Wendell Wills	Mine Foreman
Bill Downey	Production Foreman

MINE SAFETY AND HEALTH ADMINISTRATION

Terry Price	Supervisor
Norman Elswick	Electrical Inspector
Scott Manderville	Mining Engineer
Ernie Ross, Jr.	Accident Investigator

WV OFFICE OF MINERS' HEALTH, SAFETY AND TRAINING

Gary S. Snyder	Inspector-at-Large
Frank Legg	Assistant Inspector-at-Large
Randy Smith	Electrical Inspector
Chuck Webb	Deep Mine Inspector
Jerry Pauley	Deep Mine Inspector
Clark Gillian	Deep Mine Inspector

INTERVIEWS

The following persons were present during the formal interviews conducted Sunday, January 5, 1997:

PERFORMANCE COAL COMPANY

Donna Kelly	Attorney
Pete Hendrick	President, Massey Coal Services
Joe Evans	President, Performance Coal Company
Elmer Blair*	Maintenance Foreman
Roger Scarbro*	Shield Operator
Gary Calliope*	Headgate Operator
Richard Hutchens*	Head-side Shear Operator
Jack Roles*	Section Foreman
Rick Ferrell*	Tail-side Shear Operator
David Flowers*	Electrician
James Green*	Electrician
Stanley Stewart*	Utility Man

* (Denotes persons interviewed)

MINE SAFETY AND HEALTH ADMINISTRATION

Ernie Ross, Jr.	Accident Investigator

WV OFFICE OF MINERS' HEALTH, SAFETY AND TRAINING

Gary S. Snyder	Inspector-at-Large
Frank Legg	Assistant Inspector-at-Large
Jerry Pauley	Deep Mine Inspector
Clark Gillian	Deep Mine Inspector

DESCRIPTION OF ACCIDENT

Saturday morning January 4, 1997 the dayshift crew traveled to the Longwall Section under the direction of Jack Roles, production foreman. The crew arrived on the section at approximately 7:00 a.m. and the crew consisted of nine men.

Mr. Roles made his first on-shift examination and measured 450 lfm of airflow at shield # 16 and 345 lfm at shield # 160 with no methane present. Minimum airflow requirements for this section are 200 lfm at shield # 19 and 90 lfm at shield # 160.

The shear was left at the tailgate side of the section from the owl shift. Shear operators Ricky Ferrell (tail) and Richard Hutchens (head) started loading coal going from the tail to the head. They made several cuts before stopping at the headgate side of the section to service the shear. Once the electricians completed servicing the shear, production resumed and the crew mined toward the tail on the fourth cut of the shift.

Face ventilation seemed good and face mining conditions seemed better than normal. However, the mine roof was breaking higher up than usual, and the mine roof fell several times behind the longwall shields during the morning.

The section return aircourse was obstructed with dangerous roof adjacent to the last face shield, # 176, and was blocked by a roof fall about 50 feet outby the tail of the section near spad 1266. The return aircourse was being carried as "dangered-off" in the fireboss reports for the last several days because of "bad top".

The crew completed the fourth cut by cutting out on the tail of the section at about 10:20 a.m. Ricky Ferrell was "cutting down" with the shear when the mine roof fell behind the shields and a methane ignition occurred. The ignition seemed to start in the gob area where the roof had just fallen.

Stanley Stewart had just advanced shields # 175 and # 176. He was standing at shield # 174 facing the gob and was the first person to see the ignition. He saw a red glow in the gob that was becoming brighter. Mr. Stewart pointed toward the glow and then started running toward the head. He felt heat on his legs and ran 400 to 500 feet to about midface before getting out of smoke that resulted from the ignition. Shear operators Ricky Ferrell and Richard Hutchens also saw the ignition, and flame singed hair on Mr. Ferrell's neck and arm. Mr. Hutchens saw the ignition first come from behind the shields and then saw it continue up the face line from the tail. These two shear operators also ran toward the head and said "something blew up".

Elmer Blair and James Green were changing batteries in the speaker phone near shield # 150 when the first ignition occurred. Mr. Blair felt heat from the ignition, but did not see any flash or flame. He thought the shear power cable had exploded, so he called on the speaker phone and had the face power deenergized. Mr. Blair and Jack Roles, the foreman, went to the tail to check the area after making sure everyone was headed out toward the head. Mr. Roles had also seen the ignition.

Both Mr. Roles and Mr. Blair detected six-tenths percent (.6%) methane at shield # 174 and enough carbon monoxide was present to activate the alarm of Mr. Roles LTX 310 detector. The detector normally alarms at 50 ppm carbon monoxide. There was a smell like "old works", and no fire was present.

A second ignition occurred and Mr. Blair saw a "yellowish" flash while he and Mr. Roles were examining near shield # 174. Everyone left the tail area and traveled toward the head. A third ignition occurred, which "bucked the air", when Mr. Roles and Mr. Blair reached shield # 36 as they were traveling toward the head.

Mr. Roles called outside and reported to John Hubbard, the longwall coordinator, that the section had experienced a possible methane gas ignition. The section foreman directed his crew to check and tighten the section ventilation controls, and to install back-up checks across the track and belt entries.

Mr. Roles took an air reading in the last open crosscut at the headgate and had the crew install additional curtain through the first four shields behind the stage loader. The foreman again began to make exams of the longwall face. Mr. Roles stopped his last exam at shield # 92 where he reported feeling heat. Mr. Roles came back to the head and called a report outside. Pete Hendrick instructed the foreman to bring the crew out of the mine. The crew left the section and got out of the mine at about 11:30 a.m.

FINDINGS OF FACT

1. The immediate return of the Longwall Section was obstructed with a roof fall approximately 80 feet long near spad 1266.

2. Roof falls and two certain stoppings across No. 4 and No. 5 entries of the Tailgate Section, near the MRS cut-through, known as EP # 2 were partly obstructing the gob bleeder system.

3. No back-up checks were installed in the track and belt entries of the Longwall Section prior to the accident.

4. The mine roof near the area where the ignition occurred is a hard sandstone, which readily produces sparks when tested by striking with a metal hammer.

5. Four stoppings that had been installed across No. 2 through No. 5 entries of the Tailgate Section to separate intake from return air were blown outward. Also, the track door at the mouth of the Tailgate Section was blown outward and destroyed.

6. Close examination of the No. 1 fan chart shows a number of ignitions occurred between 10 a.m. and 11:30 a.m. on January 4, 1997.

7. Samples taken by MSHA inspectors on January 4, 1997 showed large amounts of coke at shield # 176 and tail motor, at shield # 175 and shear area, and at shield # 172 and shear area.

CAUSE

Adequate airflow was not provided in the Longwall Section bleeder system sufficient to prevent a dangerous accumulation of methane gas in the gob area. It is the general thought that the gas was ignited by sparks created when the sandstone mine roof struck the longwall shields, after an unusually high roof fall.

RECOMMENDATIONS

The following recommendations are given to help prevent a similar incident from occurring on the active 2 West Longwall Section, and to enhance the future safety of the employees at this mine:

1. Permanent ventilation controls shall be installed in the No. 3 track entry and the No. 4 belt entry of the active 2 West Longwall Section and each subsequent longwall panel mined. These permanent controls shall at a minimum include a track door and a longwall belt box check to increase positive movement of air through the longwall bleeder system, and to reduce the outflow of intake air in the track and belt entries.

2. The 2 West Longwall Section face ventilation plan shall be modified to include the requirement that a back-up check curtain be maintained in the belt and track entries at a point just outby the section shield pumping station. Similar back-up check curtains shall also be utilized on each subsequent longwall panel mined.

ACKNOWLEDGEMENT

The West Virginia Office of Miners' Health, Safety and Training gratefully acknowledges the cooperation of management and employees of Performance Coal Company and the Mine Safety and Health Administration during this investigation.

Respectfully submitted,

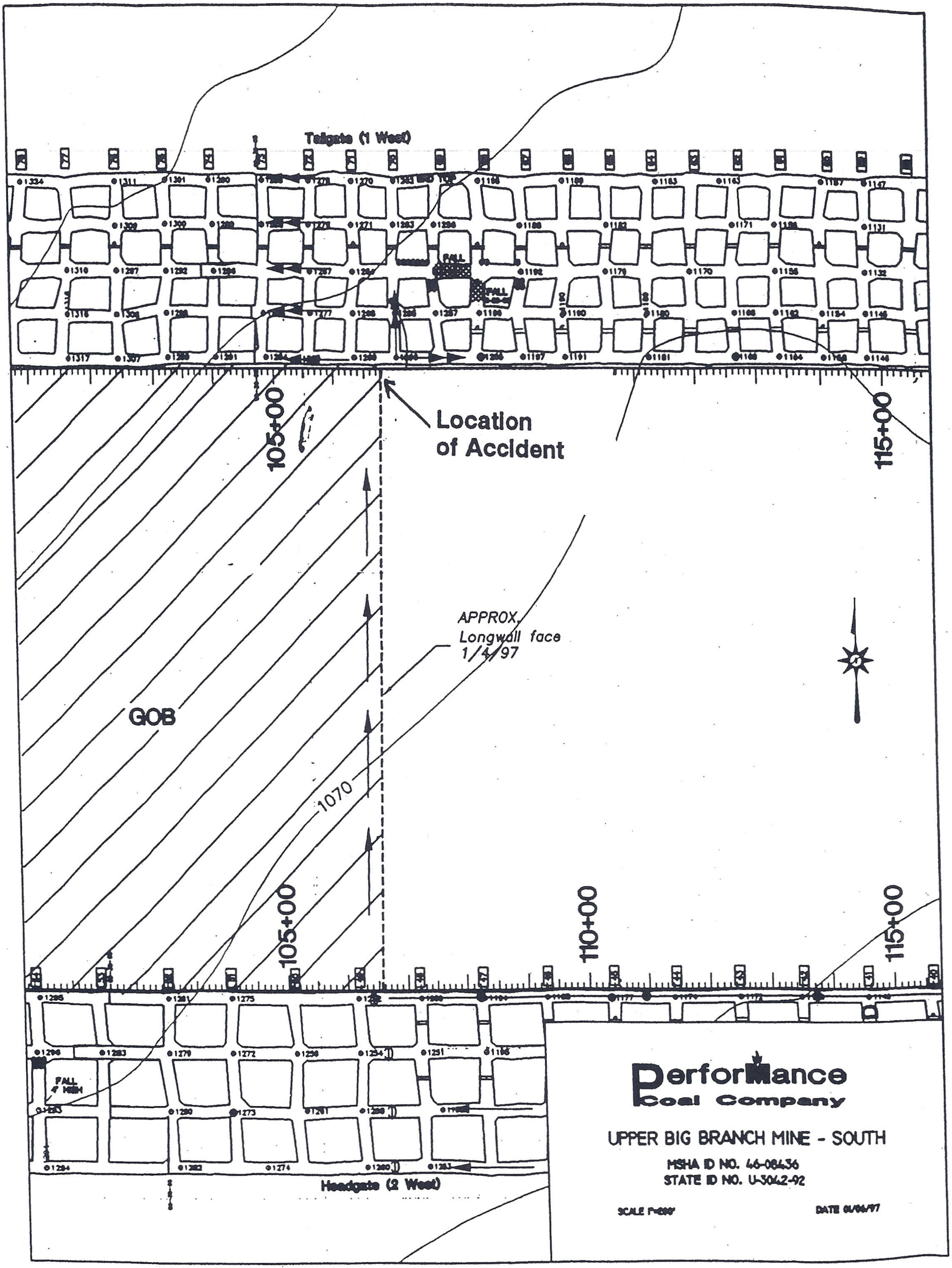
Gary S. Snyder
Inspector-at-Large

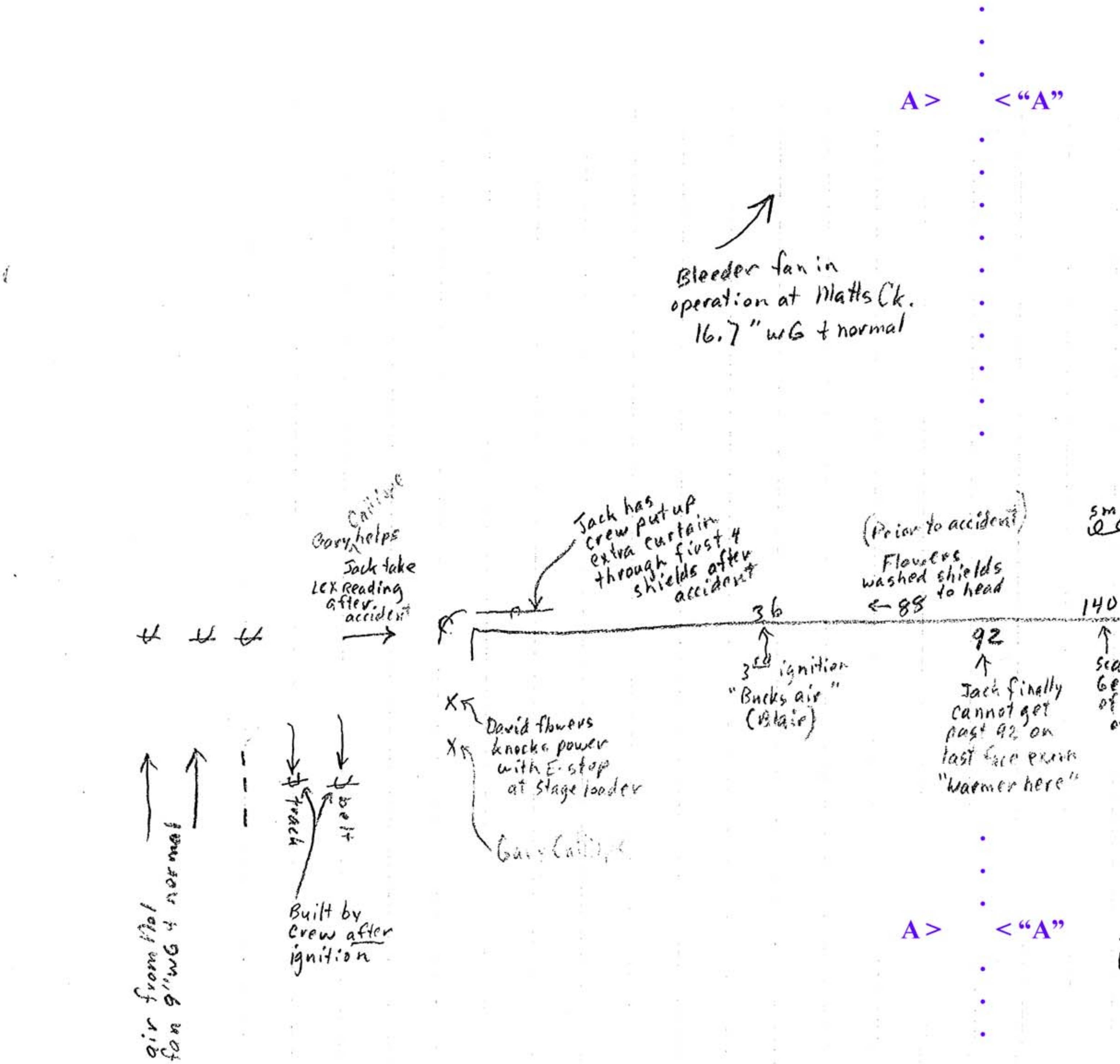
Frank Legg
Assistant Inspector-at-Large

Randy Smith
Electrical Inspector

Gerald Pauley
Deep Mine Inspector

Clark Gillian
Deep Mine Inspector

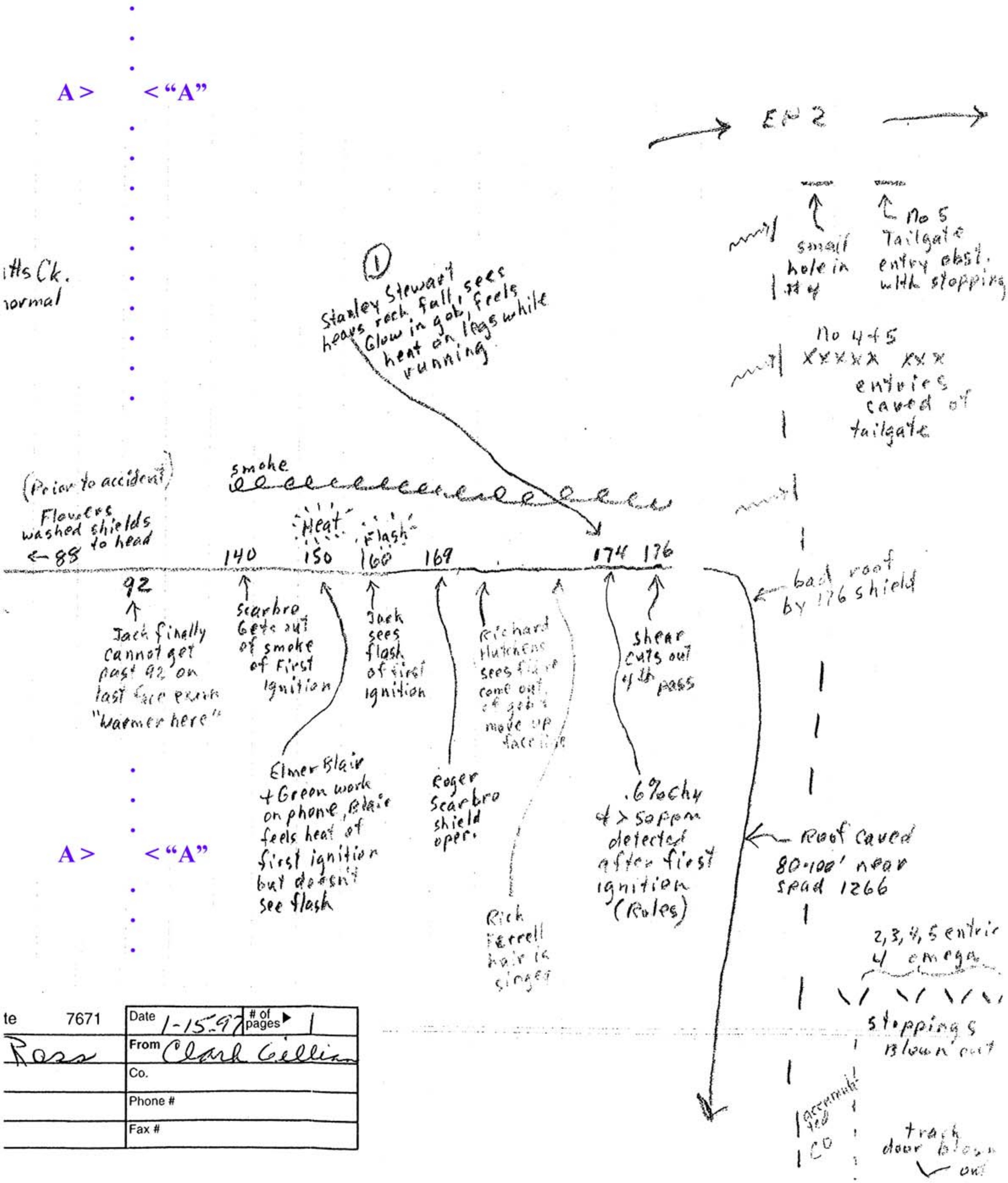

Tailgate (1 West)
Location
of Accident
105+00
115+00
APPROX.
Longwall face
1/4/97
GOB
1070
105+00
110+00
115+00
Headgate (2 West)
PerforMance
Coal Company
UPPER BIG BRANCH MINE - SOUTH
MSHA ID NO. 46-08436
STATE ID NO. U-3042-92



Post-it™ Fax Note 7671

Date 1-15-97	# pa
To Ernie Ross	From Clark
Co./Dept.	Co.
Phone #	Phone #
Fax #	Fax #

15


A >
< "A"
EP 2
small hole in
No 5 Tailgate entry obst. with stopping
itts Ck.
normal
1
Stanley Stewart hears rock fall, sees Glow in gob, feels heat on legs while running
No 4+5 XXXXX XXX entries caved at tailgate
smoke
(Prior to accident) Flowers washed shields to head
Heat
Flash
← 88
140
150
160
169
174
176
92
bad roof by 176 shield
Jack finally cannot get past 92 on last face run "warmer here"
Scarbro Gets out of smoke of First ignition
Jack sees flash of first ignition
Richard Hutchens sees flame come out of gob & move up face line
shear cuts out 4th pass
Elmer Blair + Green work on phone, Blair feels heat of first ignition but doesn't see flash
Roger Scarbro shield oper.
.6% ch4 + > 50ppm detected after first ignition (Roles)
Roof caved 80-100' near shield 1266
Rick Ferrell hair is singed
2,3,4,5 entries 4 omega
stoppings Blown out
accumulated CO
track door blown out
A >
< "A"
Date 1-15-97
# of pages 1
Ross
From Clark Gillian
Co.
Phone #
Fax #
7671

APPENDIX 4.1-1

COAL SECTION

Longwall Production Report

				HEAD	44 SHIELD	88 SHIELD	132 SHIELD	TAIL
FOREMAN	M. Webb	A/G SEAM HGT						
Mnt. Foreman	L. Ford	A/G COAL HGT						
SHIFT	Day							
DATE	4-3-10	Chain Tension						
CREW	A	FACE	10					
Man-hours		GOB	9	Total				

Depart Portal	6:00
Arrive Section	6:30
Start Production	6:40
End Production	3:45
Depart Section	4:00
Arrive Outside	4:30
Travel In	30
Travel Out	30

SHEAR CUT OUT

HEAD	TAIL
1/4	(1/4) circled
1/2	1/2
3/4	3/4
(FULL) circled	FULL

CREEP ______

PASSES	START TIME	0	20	40	60	80	100	120	140	160	176	FINISH TIME	TOTAL TIME
H-T	6:40	→									→	8:25	105
T-85	8:25					←					←	9:28	63
117-T	9:28							→			→	10:05	37
T-H	10:05	←									←	11:56	111
19-T	11:56	→									→	1:34	98
T-8	1:34	←									←	3:15	101
H-34	3:15	→	→									3:30	15
4.9	TOTAL												

TOTAL BELT DOWN TIME	0
TOTAL FT RETREAT (Passes x 3.5)	17.15
EQUIVALENT FT (Passes x 175)	857.5
CLEAN TONS (EQUIV. FT X 2.8)	2401
RAW TONS (EQUIV. FT X 8)	6860
POWER TRAIN AT XCUT #	
HEADGATE TIMBERS	Good
INTAKE CRIBS	Good
DESIGNATED SCALER	Jim Williams
RAW OIL LEVEL IN TANKER	
HEAD START	54+42
HEAD FINISH	54+52
TAIL START	54+23
TAIL FINISH	54+46

SHEAR INSERTS

HEAD	TAIL
X	X

SHEAR BITS

HEAD	TAIL
12	48
48	

TOTAL BITS 108

HEAD FT TOTAL 10

TAIL FT TOTAL 23

NEEDED SUPPLIES

- BITS
- INSERT
- TIMBERS
- (CRIBS) circled
- WEDGES
- 1/2 HEADERS
- 320 OIL
- 460 OIL
- TRANS FLUID
- HYD. OIL
- GREASE
- OTHER ______

Delay Start	Delay Stop	Total Delay	Delay Description	[illegible]	[illegible]	[illegible]
6:30	6:35	5	Meeting at Mantrip.	0	0	330
8:45	8:55	10	Cutting Bottom on Tail.	SHR	C	010
10:44	10:55	11	Spotted Bits on Tail.	SHR	S	005
12:03	12:25	22	Bit - Service on Head.	SHR	S	005
2:05	2:20	15	Cutting Bottom on Tail.	SHR	C	010
3:35	3:45	10	Bit - Service on Head.	SHR	S	005
		63	TOTAL			

Note! Use another Prod. Report if additional lines are needed

9
10
17
17-29

COMMENTS OR REMARKS

Wedged Tail one time and dropped Head to even out face.

Unit Codes		Component Codes			
ACT	ACT	Bearing Down	001	Oil Pressure	310
BO	Belts Outby	Belt/Remote	003	Oil Temperature	320
BR	Bretby	Bits//Service	005	Other	330
CO	Comtrol	Bottom	010	Rack Wheel	340
CR	Crusher	Breaker Knocked	015	Rang Arm Cyl.	350
FC	Face Conveyor	Cable	020	Cut Chain Slack	360
GB	Gate Box	Chain Broke	030	Rock	370
HD	Head Drive	CIU	040	Safety Valve	380
KP	Kamat Pump	Contactor	050	Sequence	385
LW	Longwall	Coupling	060	Shear Pin	390
MB	Mother Belt	Cowl	070	Shld - Shld Cbl	400
MR	Monorail	Cutter Motor	080	Shld - Shld Hose	410
O	Other	Cutt Torq Shft	090	SIM	420
PO	LW Power CTR	End of Limit	100	Splice	425
SHD	Shields	Fail To Extend	110	Sprocket	430
SHR	Shearer	[illegible]	[illegible]	[illegible]	440
SL	Stage loader	Final Drive	130	Unplann Retract	440
ST	4160v Starter	Flooded	135	VFD	450
SU	Storage Unit	Fouled	140		
TD	Tail Drive	Gob Off	150		
TP	Tail Piece	Ground Fault	160		
WP	Water Pump	Grd Mon Flt	170		
Category Code		Haul Torq Shft	180		
C	Cutting	Hose Blown	190		
D	Drill / Shoot	JNA	200		
E	Electrical	Lights	210		
H	Hydraulic	Line Fault	220		
M	Mechanical	Lock Out	230		
O	Other	Low Emulsion	240		
P	Power Outby	Low Raw Oil	250		
R	Push/Move	Methane Mon	260		
S	PM Service	Meth Mon Cbl	270		
T	Escapeway	Motor Down	280		
V	Ventilation	No 12470	290		
W	Water	[illegible]	[illegible]		

COAL SECTION

Longwall Production Report

FOREMAN	H Medley
Mnt. Foreman	T Estep
SHIFT	Eve
DATE	4-3-10
CREW	C
Man-hours	

	HEAD	44 SHIELD	88 SHIELD	132 SHIELD	TAIL
AVG SEAM HGT					
AVG COAL HGT					
Total					

Chain Tension
FACE 11
GOB 9

Depart Portal	3:00
Arrive Section	3:35
Start Production	4:28
End Production	11:04
Depart Section	11:30
Arrive Outside	12:00
Travel In	35
Travel Out	30

SHEAR CUT OUT

HEAD	TAIL
1/4	(1/4) circled
1/2	1/2
(3/4) circled	3/4
FULL	FULL

CREEP ______

PASSES	START TIME	0–176	FINISH TIME	TOTAL TIME
.8	4:28	34 →	5:28	60
1	5:32	←	6:41	69
1	6:46	→	8:00	74
.4	8:05	98 ←	8:50	45
.3	8:55	119 →	9:15	20
1	9:20	←	10:18	58
.2	10:22	→ 34	10:50	28
				354
4.7 TOTAL				

TOTAL BELT DOWN TIME	—
TOTAL FT RETREAT (Passes x 3.5)	16.45
EQUIVALENT FT (Passes x 175)	822.5
CLEAN TONS (EQUIV. FT X 2.8)	2303
RAW TONS (EQUIV. FT X 8)	6580
POWER TRAIN AT XCUT #	
HEADGATE TIMBERS	Good
INTAKE CRIBS	Good
DESIGNATED SCALER	D Shears
RAW OIL LEVEL IN TANKER	
HEAD START	54+52
HEAD FINISH	54+65
TAIL START	54+46
TAIL FINISH	54+69

SHEAR INSERTS

HEAD	TAIL
—	—

SHEAR BITS

HEAD	TAIL
48	48
34	48

TOTAL BITS 178
HEAD FT TOTAL 13
TAIL FT TOTAL 23

NEEDED SUPPLIES

- BITS
- INSERT
- TIMBERS
- CRIBS
- WEDGES
- 1/2 HEADERS
- 320 OIL
- 460 OIL
- TRANS FLUID
- HYD. OIL
- GREASE
- OTHER ______

Delay Start	Delay Stop	Total Delay	Delay Description	Unit Code	Category Code	Comp. Code
3:05	3:10	5	switching rides	O	O	330
3:35	3:45	10	Safety meeting	O	O	330
3:55	4:15	20	Bits + Service	SHR	S	005
4:15	4:28	13	Getting Rock off HD	HD	O	370
6:18	6:30	12	76 shield back of Ram Broke	SHD	M	330
6:56	7:15	19	Bits	SHR	S	005
8:30	8:40	10	Rock behind Shear	SHR	C	370
10:25	10:40	15	Head End Cutter shaft	SHR	M	090
10:50	11:04	14	Clean up + Spot Chain	LW	M	330
		118 TOTAL				

Note! Use another Prod. Report if additional lines are needed

COMMENTS OR REMARKS

Set Additional support + set up things outside

Unit Codes

ACT	ACT
BO	Belts Outby
BR	Bretby
CO	Comtrol
CR	Crusher
FC	Face Conveyor
GB	Gate Box
HD	Head Drive
KP	Kamat Pump
LW	Longwall
MB	Mother Belt
MR	Monorail
O	Other
PC	LW Power CTR
SHD	Shields
SHR	Shearer
SL	Stage loader
ST	4160v Starter
SU	Storage Unit
TD	Tail Drive
TP	Tail Piece
WP	Water Pump

Category Code

C	Cutting
D	Drill / Shoot
E	Electrical
H	Hydraulic
M	Mechanical
O	Other
P	Power Outby
R	Push/Move
S	PM Service
T	Escapeway
V	Ventilation
W	Water
Z	PM

Component Codes

Bearing Down	001	Oil Pressure	310
Belt/Remote	003	Oil Temperature	320
Bits//Service	005	Other	330
Bottom	010	Rack Wheel	340
Breaker Knocked	015	Rang Arm Cyl.	350
Cable	020	Cut Chain Slack	360
Chain Broke	030	Rock	370
CIU	040	Safety Valve	380
Contactor	050	Sequence	385
Coupling	060	Shear Pin	390
Cowl	070	Shld - Shld Cbl	400
Cutter Motor	080	Shld - Shld Hose	410
Cutt Torq Shft	090	SIM	420
End of Limit	100	Splice	425
Fail To Extend	110	Sprocket	430
Fell	120	Top	440
Final Drive	130	Unplann Retract	440
Flooded	135	VFD	450
Fouled	140		
Gob Off	150		
Ground Fault	160		
Grd Mon Flt	170		
Haul Torq Shft	180		
Hose Blown	190		
JNA	200		
Lights	210		
Line Fault	220		
Lock Out	230		
Low Emulsion	240		
Low Raw Oil	250		
Methane Mon	260		
Meth Mon Cbl	270		
Motor Down	280		
No 12470	290		
No 4160	295		
No PLC Comm	30[illegible]		

COAL SECTION

Longwall Production Report

FOREMAN	M. Well
Mnt. Foreman	B. Bailey
SHIFT	Day
DATE	3-31-10
CREW	A
Man-hours	

AVG SEAM HGT ______
AVG COAL HGT ______

Chain Tension
FACE 12
GOB 12

	HEAD	44 SHIELD	88 SHIELD	132 SHIELD	TAIL
Total					

Depart Portal	6:00
Arrive Section	6:35
Start Production	6:50
End Production	3:55
Depart Section	4:10
Arrive Outside	4:45
Travel In	35
Travel Out	35

SHEAR CUT OUT

HEAD	TAIL
1/4	1/4
1/2	1/2
3/4 (circled)	3/4
FULL	FULL (circled)

CREEP ______

PASSES	START TIME	0 20 40 60 80 100 120 140 160 176	FINISH TIME	TOTAL TIME
34-T	6:50	→	8:05	75
T-H	8:05	←	9:50	105
H-T	9:50	→	11:45	115
T-H	11:45	←	1:31	106
H-T	1:31	→	3:25	114
T-140	3:25	←	3:55	30
5	TOTAL			

TOTAL BELT DOWN TIME	
TOTAL FT RETREAT (Passes x 3.5)	17.5
EQUIVALENT FT (Passes x 175)	875
CLEAN TONS (EQUIV. FT X 2.8)	2450
RAW TONS (EQUIV. FT X 8)	7000
POWER TRAIN AT XCUT #	
HEADGATE TIMBERS	Good
INTAKE CRIBS	Good
DESIGNATED SCALER	Jim Williams
RAW OIL LEVEL IN TANKER	
HEAD START	53+49
HEAD FINISH	53+63
TAIL START	53+44
TAIL FINISH	53+65

SHEAR INSERTS

HEAD	TAIL
(crossed out)	

SHEAR BITS

HEAD	TAIL
18	48
18	12
12	24
18	

TOTAL BITS ______
HEAD FT TOTAL 14
TAIL FT TOTAL 21

NEEDED SUPPLIES
- BITS
- INSERTS (circled)
- TIMBERS
- CRIBS
- WEDGES
- 1/2 HEADERS
- 320 OIL
- 460 OIL
- TRANS FLUID
- HYD. OIL
- GREASE
- OTHER ______

Delay Start	Delay Stop	Total Delay	Delay Description	Unit Code	Category Code	Comp. Code
6:35	6:45	10	Safety Meeting at Mantrip	O	O	330
8:20	8:31	11	Set Bits on the Tail	SHR	S	005
10:14	10:42	28	Bits Service on the Head	SHR	S	005
12:20	12:34	14	Set Bits on Tail	SHR	S	005
1:50	2:10	20	Bits Service at the Head	SHR	S	005
		83	TOTAL			

Note! Use another Prod. Report if additional lines are needed

COMMENTS OR REMARKS

Unit Codes	
ACT	ACT
BO	Belts Outby
BR	Bretby
CO	Comtrol
CR	Crusher
FC	Face Conveyor
GB	Gate Box
HD	Head Drive
KP	Kamat Pump
LW	Longwall
MB	Mother Belt
MR	Monorail
O	Other
PC	LW Power CTR
SHD	Shields
SHR	Shearer
SL	Stage loader
ST	4160v Starter
SU	Storage Unit
TD	Tail Drive
TP	Tail Piece
WP	Water Pump

Category Code	
C	Cutting
D	Drill / Shoot
E	Electrical
H	Hydraulic
M	Mechanical
O	Other
P	Power Outby
R	Push/Move
S	PM Service
T	Escapeway
V	Ventilation
W	Water
Z	PM

Component Codes			
Bearing Down	001	Oil Pressure	310
Belt/Remote	003	Oil Temperature	320
Bits//Service	005	Other	330
Bottom	010	Rack Wheel	340
Breaker Knocked	015	Rang Arm Cyl.	350
Cable	020	Cut Chain Slack	360
Chain Broke	030	Rock	370
CIU	040	Safety Valve	380
Contactor	050	Sequence	385
Coupling	060	Shear Pin	390
Cowl	070	Shld - Shld Cbl	400
Cutter Motor	080	Shld - Shld Hose	410
Cutt Torq Shft	090	SIM	420
End of Limit	100	Splice	425
Fail To Extend	110	Sprocket	430
Fell	120	Top	440
Final Drive	130	Unplann Retract	440
Flooded	135	VFD	450
Fouled	140		
Gob Off	150		
Ground Fault	160		
Grd Mon Flt	170		
Haul Torq Shft	180		
Hose Blown	190		
JNA	200		
Lights	210		
Line Fault	220		
Lock Out	230		
Low Emulsion	240		
Low Raw Oil	250		
Methane Mon	260		
Meth Mon Cbl	270		
Motor Down	280		
No 12470	290		
No 4160	295		
No PLC Comm	300		

COAL SECTION

Longwall Production Report

FOREMAN	R. Lane
Mnt. Foreman	G. Skeens
SHIFT	EVE
DATE	3-31-10
CREW	B
Man-hours	

AVG SEAM HGT ______
AVG COAL HGT ______

Chain Tension
FACE 10
GOB 8
Total

HEAD	44 SHIELD	88 SHIELD	132 SHIELD	TAIL

Depart Portal	3:00
Arrive Section	335
Start Production	350
End Production	1035
Depart Section	10:50
Arrive Outside	11:35
Travel In	35
Travel Out	45

SHEAR CUT OUT

HEAD	TAIL
1/4	1/4
1/2	1/2
3/4	3/4
FULL (circled)	FULL (circled)

CREEP ______

PASSES	START TIME		FINISH TIME	TOTAL TIME
.8	350	←	521	91
1	521	→	700	99
1	700	←	857	117
1	857	→	1035	98
3.8 TOTAL				

TOTAL BELT DOWN TIME	34
TOTAL FT RETREAT (Passes x 3.5)	13.3
EQUIVALENT FT (Passes x 175)	665
CLEAN TONS (EQUIV. FT X 2.8)	1862
RAW TONS (EQUIV. FT X 8)	5320
POWER TRAIN AT XCUT #	
HEADGATE TIMBERS	Good
INTAKE CRIBS	Good
DESIGNATED SCALER	C Bell
RAW OIL LEVEL IN TANKER	
HEAD START	53+63
HEAD FINISH	53+77
TAIL START	53+65
TAIL FINISH	53+75

SHEAR INSERTS

HEAD	TAIL
0	0

SHEAR BITS

HEAD	TAIL
48	48
48	48

TOTAL BITS 192
HEAD FT TOTAL 14
TAIL FT TOTAL 10

NEEDED SUPPLIES
BITS
INSERT
TIMBERS
CRIBS
WEDGES
1/2 HEADERS
320 OIL
460 OIL
TRANS FLUID
HYD. OIL
GREASE
OTHER ______

			Delay Description			
335	345	10	Saftey Talk	O	O	330
438	445	7	Rock in Bretby	BR	O	370
540	600	20	Bits Service check chain	SHR	S	005
742	816	34	Ellis 3 off fire supression	BO	O	330
918	942	24	Bits + service	SHR	S	005
		95 TOTAL				

Note! Use another Prod. Report if additional lines are needed

COMMENTS OR REMARKS
Shut down early to cut belt channel outby

Unit Codes

Code	Unit
ACT	ACT
BO	Belts Outby
BR	Bretby
CO	Comtrol
CR	Crusher
FC	Face Conveyor
GB	Gate Box
HD	Head Drive
KP	Kamat Pump
LW	Longwall
MB	Mother Belt
MR	Monorail
O	Other
PC	LW Power CTR
SHD	Shields
SHR	Shearer
SL	Stage Loader
ST	4160v Starter
SU	Storage Unit
TD	Tail Drive
TP	Tail Piece
WP	Water Pump

Category Code

Code	Category
C	Cutting
D	Drill / Shoot
E	Electrical
H	Hydraulic
M	Mechanics
O	Other
P	Power Outby
R	Push/Move
S	PM Service
T	Escapeway
	Ventilation

Component Codes

Component	Code	Component	Code
Bearing Down	001	Oil Pressure	310
Belt/Remote	003	Oil Temperature	320
Bits//Service	005	Other	330
Bottom	010	Rack Wheel	340
Breaker Knocked	015	Rang Arm Cyl.	350
Cable	020	Cut Chain Slack	360
Chain Broke	030	Rock	370
CIU	040	Safety Valve	380
Contactor	050	Sequence	385
Coupling	060	Shear Pin	390
Cowl	070	Shld - Shld Cb.	400
Cutter Motor	080	Shld - Shld Hose	410
Cutt Torq Shft.	090	SIM	420
End of Limit	100	Splice	425
Fail To Extend	110	Sprocket	430
[illegible]	[illegible]	[illegible]	440
Final Drive	130	Unplann Repair	440
Flooded	135	VFD	450
Fouled	140		
Gob Off	150		
Ground Fault	160		
Grd Mon Flt	170		
Haul Torq Shft.	180		
Hose Blown	190		
JNA	200		
Lights	210		
Line Fault	220		
Lock Out	230		
Low Emulsion	240		
Low Raw Oil	250		
Methane Mon	260		
Meth Mon Cbl.	270		
Motor Down	280		
[illegible]	[illegible]		

COAL SECTION

Longwall Production Report

	HEAD	44 SHIELD	88 SHIELD	132 SHIELD	TAIL
AVG SEAM HGT					
AVG COAL HGT					
Total					

FOREMAN R.Lane
Mnt. Foreman G.Skeens
SHIFT EVE
DATE 3-30-10
CREW 3
Man-hours

Chain Tension
FACE 10
GOB 9

Depart Portal 300
Arrive Section 333
Start Production 350
End Production 1240
Depart Section 12:50
Arrive Outside 125
Travel In 33
Travel Out 35

SHEAR CUT OUT

HEAD	TAIL
1/4	1/4
1/2	1/2
(3/4) circled	3/4
FULL	(FULL) circled

CREEP ______

PASSES	START TIME					FINISH TIME	TOTAL TIME
.3	350			129 →		445	55
.6	445		62 ←			556	71
.5	556		80 →			648	52
1	648	←				948	180
1	948	—				1115	87
1	1115	←				1222	65
.2	1222	→ 34					
4.6	TOTAL						

TOTAL BELT DOWN TIME 0
TOTAL FT RETREAT (Passes x 3.5) 16.1
EQUIVALENT FT (Passes x 175) 805
CLEAN TONS (EQUIV. FT X 2.8) 2254
RAW TONS (EQUIV. FT X 8) 6440
POWER TRAIN AT XCUT #
HEADGATE TIMBERS Good
INTAKE CRIBS Good
DESIGNATED SCALER C.Bell
RAW OIL LEVEL IN TANKER

HEAD START 53+35
HEAD FINISH 53+49
TAIL START 53+23
TAIL FINISH 53+44
HEAD FT TOTAL 14
TAIL FT TOTAL 21
TOTAL BITS 180

SHEAR INSERTS

HEAD	TAIL
0	0

SHEAR BITS

HEAD	TAIL
42	42
48	48

NEEDED SUPPLIES
- BITS
- INSERT
- TIMBERS
- CRIBS
- WEDGES
- 1/2 HEADERS
- 320 OIL
- 460 OIL
- TRANS FLUID
- HYD. OIL (circled)
- GREASE
- OTHER ______

			Delay Description			
333	343	10	Saftey Talk	0	0	330
413	428	15	Terminator on Tail wires out	0	E	330
655	715	20	Bits	SHR	S	005
745	810	25	Busted hose 142 shield	SHD	H	190
912	936	24	Bits service check chain	SHR	S	005
		94	TOTAL			

Note: Use another Prod. Report if additional lines are needed.

COMMENTS OR REMARKS

Unit Codes

Code	Unit
ACT	ACT
BO	Belts Outby
BR	Bretby
CO	Control
CR	Crusher
FC	Face Conveyor
GB	Gate Box
HD	Head Drive
KP	Kamat Pump
LW	Longwall
MB	Mother Belt
MR	Monorail
O	Other
PC	LW Power CTR
SHD	Shields
SHR	Shearer
SL	Stage loader
ST	4160v Starter
SU	Storage Unit
TD	Tail Drive
TP	Tail Piece
WP	Water Pump

Category Code

Code	Category
C	Cutting
D	Drill / Shoot
E	Electrical
H	Hydraulic
M	Mechanical
O	Other
P	Power Outby
R	Push/Move
S	PM Service
	Escapeway
	Ventilation

Component Codes

Component	Code	Component	Code
Bearing Down	001	Oil Pressure	310
Belt/Remote	003	Oil Temperature	320
Bits/Service	005	Other	330
Bottom	010	Rack Wheel	340
Breaker Knocked	015	Rang Arm Cyl.	350
Cable	020	Cut Chain Slack	360
Chain Broke	030	Rock	370
CIU	040	Safety Valve	380
Contactor	050	Sequence	385
Coupling	060	Shear Pin	390
Cowl	070	Shld - Shld Cb.	400
Cutter Motor	080	Shld - Shld Hose	410
Cutt Torq Shft	090	SIM	420
End of Limit	100	Splice	425
Fail To Extend	110	Sprocket	430
[illegible]	120	[illegible]	440
Final Drive	130	Undercut Retract	445
Flooded	135	VFD	450
Fouled	140		
Gob Off	150		
Ground Fault	160		
Grd Mon Flt	170		
Haul Torq Shft	180		
Hose Blown	190		
JNA	200		
Lights	210		
Line Fault	220		
Lock Out	230		
Low Emulsion	240		
Low Raw Oil	250		
Methane Mon	260		
Meth Mon Ob	270		
Motor Down	280		
[illegible]	[illegible]		

APPENDIX 4.3-1

EFFECTIVENESS OF A WATER BARRIER IN STOPPING THE EXPLOSION

in the INBY REACHES of #21 HEADGATE

The explosion in the #21 Headgate entries did not propagate far past the #22 Crossover. Study of this area shows that flame was extinguished and the explosion forces subsided to extinction shortly after crossing a water-filled depression and a gob pile just south of the regulator between #22 Tailgate and #21 Headgate in the crosscut south of spad 24471. While the mine region outby is entirely soot-covered, and shows evidence of heat and locally high pressure, evidence of heat and soot are conspicuously absent within 4 breaks inby BRK 31 (see **Figures 1, 2**) and for as far inby (toward the Bandytown Fan) as it was safe to travel and examine. Previous research[1] has demonstrated that rock rubble (gob) barriers are effective in attenuating and mitigating explosion forces. Other prior research describes the use of water barriers as an effective means of mitigating an explosion as water is dispersed by the preceding blast wave, breaking the fuel supply and quenching the following combustion.[2]

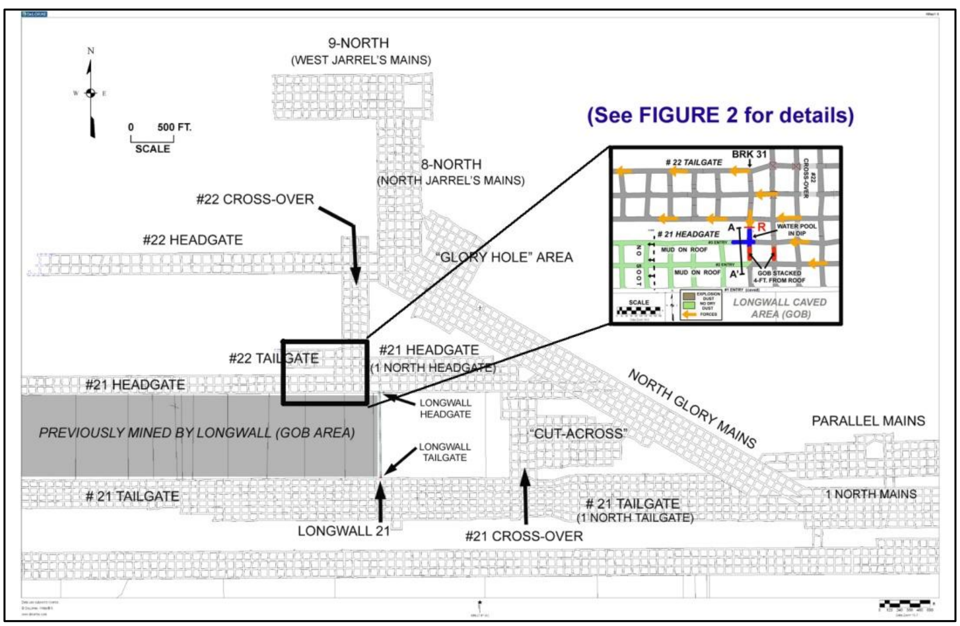


Figure 1. Index map locating the area of interest. See **Figure 2** for details.

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1 *Passive mine blast attenuators constructed of rock rubble for protecting ventilation seals*, M.J. Sapko, M.R.Hieb, et.al. SME, 2009.

2 Liebman, I. and Richmond J K. Suppression of Coal Dust Explosions by Passive Water Barriers in a Single Entry Mine, Report of Investigation 7815, Bureau of Mines, 1974

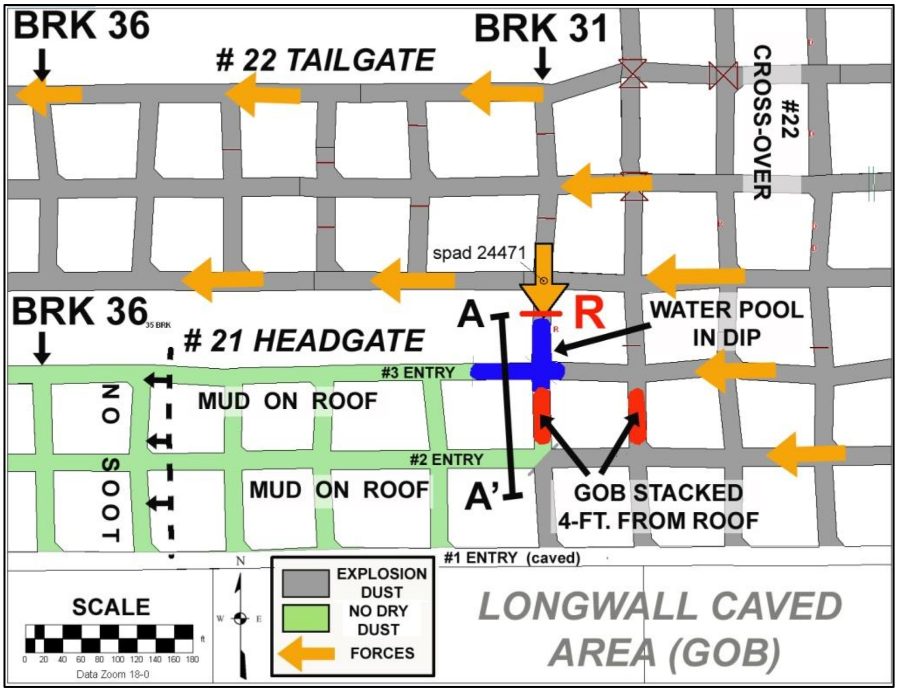

Figure 2. West of the #22 Cross-over explosion forces entered #21 Headgate from the North, via the regulator at BRK 31 (also the location of evaluation point EP-65). Upon encountering the water-filled dip in the #3 entry, water was picked up and dispersed into the #2 entry, where flame was extinguished and explosion propagation subsided to extinction.

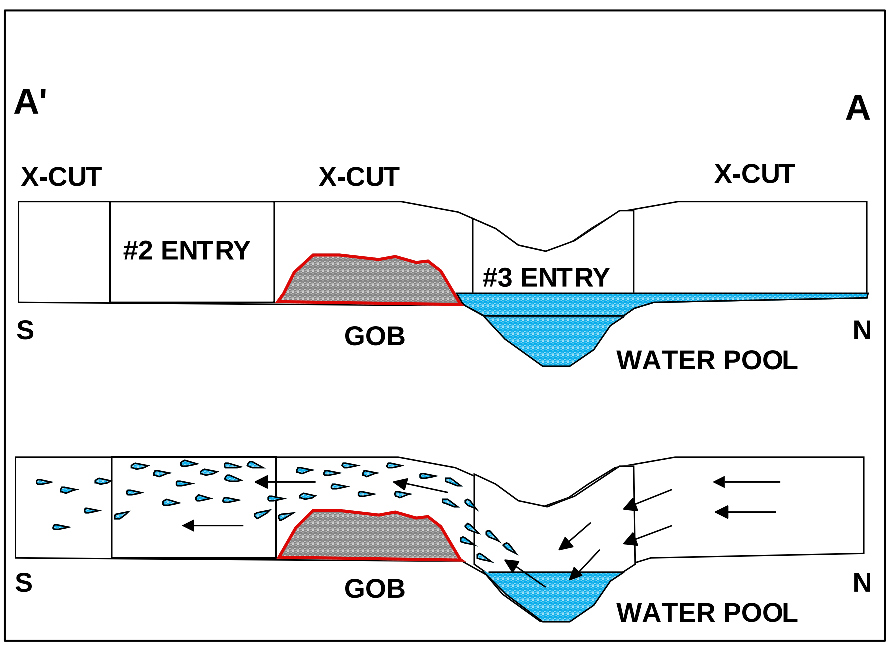

Figure 3. Profile view along A-A' (looking West) showing how the explosion forces from the north are thought to have picked up water and dispersed it across the gob in the crosscut to between #3 and #2 entries. The mine roof and roof bolts were coated in mud west of BRK 31, and explosion forces quickly subsided to extinction, inby (west toward the exhaust fan located at Bandytown).

Path of the Explosion

In the western half of the #21 Headgate between the #21 Cross-over and the #22 Cross-over the path of the explosion was east-to-west, with the leading edge following the north solid rib (the #5 entry). West of the #22 Cross-over the 5-entry system of #21 Headgate dropped the two entries on the right (north), and became a 3-entry system. A parallel set of 3 entries just to the north had been started a few weeks before the explosion (#22 Tailgate). Because of the northern location of the explosion's leading edge the first arrival of explosion forces west of the #22 Crossover entered #22 Tailgate first, then at BRK 31 (see **Figure 2**) entered #21 Headgate through a connecting crosscut. These forces traveled south, crossing a water-filled depression and a gob pile[3], dispersing water into the crosscut to the south and into the #2 entry. An instant later, explosion forces from the east entered this same water hole through the #3 entry, and also entered the open, unobstructed #2 entry.[4] Rather than impacted dust on roof structures, the dust was deposited as thick mud (see **Figure 4A, 4B**).

Figure 4A. (LEFT) Impacted "mud" on east side of header board across entry #2, between BRK 32 and 33, and about 70 feet inby spad 22806.

Figure 4B. (RIGHT) Impacted "mud" on north side of roof bolt in entry #2 between BRK 31 and 32, and about 40 feet outby spad 22806 (view looking north).

The heads of roof bolts show mud "cone" deposits on their windward side. In the BRK 31 crosscut between #3 and #2 entries these cones were pointed north. In the BRK 31 #2 entry intersection the cones point north in the middle of the intersection but in the west edge of the intersection they are oriented NE as they persist in pointing to the windward direction of forces which came through BRK #31. Between BRK 31 and 32 in the #2 entries, the cones are pointed due east. Similar cones were found in the #3 entry.

3 The gob was stacked to within 4-ft. of the roof.
4 The #1 entry is adjacent to the longwall gob and was caved shut.

The water dispersal was effective in quenching flame in the #2 entry, even though the mine floor was level in this area and is not believed to have held standing water at the time of the explosion. Mud coated the mine roof for approximately 400 feet of the entries lying to the west, but their crosscuts contained little or no mud. By the time explosion forces reached BRK 36 the overpressures were insufficient to breach stoppings[5] and heat was insufficient to melt plastic garbage bags hanging from the mine roof (see **Figure 5A, 5B**). A 2.5-inch diameter plastic rock dust hose that was hanging transverse to the #2 entry with nylon rope ties was unaffected by heat. Further inby there was no evidence of damage from heat or explosion overpressures for as far as roof and water conditions permitted safe travel and examination.[6]

Figure 5A. (LEFT) A plastic trash bag hung from a roof bolt; crosscut between #2 and #3 entries, at BRK 35, (view looking north), being just inby spad 22806.

Figure 5B. (RIGHT) A 2.5 inch diameter plastic rock dusting hose stretched across entry #2; BRK 34, (view looking north), being also at the intersection of spad 22828.

From this and other evidence investigators concluded that the explosion forces subsided to extinction in #21 Headgate between break 31 and break 35.

Explosions have been known to traverse passageways where 200 or more feet of standing pools of water were on the floor[7], so it is unlikely that all standing pools of water on a level mine floor provide protection against explosions. But water barriers where the water can be dispersed by forces have been found to quench propagating dust explosions.[8] The gob pile and downward-sloping roof contours may have created sufficient turbulence to direct air and disperse water into

5 Prior research indicates concrete block stoppings begin to fail at approximately 2 psi.

6 Mapping was terminated west of 40 BRK.

7 Nagy, J. The Explosion Hazard in Mining, Informational Report 1119, Mine Safety and Health Administration, Department of Labor, page 43

8 Liebman, I. and Richmond J K. Suppression of Coal Dust Explosions by Passive Water Barriers in a Single Entry Mine, Report of Investigation 7815, Bureau of Mines, 1974

the #2 entry from the north crosscut by increasing the velocity and turbulence, due to the reduction in cross-sectional area and slope of the mine roof.

This example seems to validate the idea that water dispersion into explosion flame is effective in arresting the propagation of a coal mine dust explosion. The question remains if the explosion may have run out of fuel at this location and would have decayed anyway, but based on the evidence we don't think so. Additional research into the application and effectiveness of water barriers as a supplemental explosion mitigation tool against future explosions may be warranted.

VICTIM INFORMATIONAL DATA SHEET

NAME Edward D. Jones

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 50 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 29 years

EXPERIENCE AT THIS MINE 12.8 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Section Foreman

REGULAR OCCUPATION Section Foreman

COAL MINER'S CERTIFICATION 36525-94

OTHER CERTIFICATIONS Shot Firer 4-4591, Dust Sampling 9/96
Methane/Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 12-29-08

ANNUAL REFRESHER 2-23-10

TASK TRAINING 9-24-09

EQUIPMENT TRAINING RECEIVED ON: Roof Control
Methane Dust Control

VICTIM INFORMATIONAL DATA SHEET

NAME Adam K. Morgan

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 21 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 8 weeks.

EXPERIENCE AT THIS MINE 8 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Underground Apprentice LW

REGULAR OCCUPATION Underground Apprentice LW

COAL MINER'S CERTIFICATION 2-12821

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER

TASK TRAINING 2-10-10

EQUIPMENT TRAINING RECEIVED ON: 35C Fairchild Scoop

VICTIM INFORMATIONAL DATA SHEET

NAME Carl C. Acord

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 52 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 33 years

EXPERIENCE AT THIS MINE 48 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 PER DAY 8

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION NRWG 181-A

OTHER CERTIFICATIONS Shot Firer 4-4724

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED 12-8-94

NEWLY EMPLOYED EXP. MINER 1-30-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-22-10

EQUIPMENT TRAINING RECEIVED ON: Roof Bolter

10SC Shuttle Car

VICTIM INFORMATIONAL DATA SHEET

NAME Charles T. Davis

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 51 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 32 years

EXPERIENCE AT THIS MINE 8 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Longwall Foreman

REGULAR OCCUPATION Longwall Foreman

COAL MINER'S CERTIFICATION 38322-06

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 10-22-09

ANNUAL REFRESHER 3-27-10

TASK TRAINING 10-2-09 / 9-24-09 (AMS System)

EQUIPMENT TRAINING RECEIVED ON: 5-9-09

Fairchild

Forklift

Shield Hauler

Shield Recovery

Mule Operator

Shear Operator 9-26-09

Fire Drill
Donn SCSR
2nd Escapeway } 10-2-09

VICTIM INFORMATIONAL DATA SHEET

NAME Cory T. Davis

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 20 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 22 weeks

EXPERIENCE AT THIS MINE 22 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Underground Apprentice / LW 90 days

REGULAR OCCUPATION Underground Apprentice / LW 90 days

COAL MINER'S CERTIFICATION 4-18847

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 10-27-09

ANNUAL REFRESHER 3-26-10

TASK TRAINING 10-28-10

EQUIPMENT TRAINING RECEIVED ON: Lock and Tag

Cleaning Belt

VICTIM INFORMATIONAL DATA SHEET

NAME Christopher L. Bell, Sr.

ADDRESS [redacted]

PHONE NO. [redacted]

AGE 33 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 32 weeks

EXPERIENCE AT THIS MINE 32 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Longwall Utility

REGULAR OCCUPATION Longwall Utility

COAL MINER'S CERTIFICATION 3-17129

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 2-17-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 2-17-10

EQUIPMENT TRAINING RECEIVED ON: Strata Shelter Training
Brookville Mantrip 7-7-09
Mine Map 7-7-09
Experienced Miner 7-7-09
AMS System 9-24-09
Fire Drill, Donn SCSR, 2nd Escapeway } 10-2-09

VICTIM INFORMATIONAL DATA SHEET

NAME Dillard E. Persinger

ADDRESS [redacted]

[redacted]ELEPHONE NO. [redacted]

AGE 32 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 1.7 years

EXPERIENCE AT THIS MINE 1.7 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shield Operator Longwall

REGULAR OCCUPATION Shield Operator Longwall

COAL MINER'S CERTIFICATION 4-12181

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 6-1-09

EQUIPMENT TRAINING RECEIVED ON: Fairchild

Brookville Mantrip

Shield Hauler

AMS System 9-26-09

Fire Drill

Donn SCSR } 10-2-09

2nd Escapeway

VICTIM INFORMATIONAL DATA SHEET

NAME Deward A. Scott

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 58 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 38 years

EXPERIENCE AT THIS MINE 48 Weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shuttle Car Operator

REGULAR OCCUPATION Shuttle Car Operator

COAL MINER'S CERTIFICATION K-5005

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-30-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-30-10

EQUIPMENT TRAINING RECEIVED ON: Fletcher Roof Bolter

Shuttle Car

Brookville Mantrip

VICTIM INFORMATIONAL DATA SHEET

NAME Gary W. Quarles

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 33 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 14 years

EXPERIENCE AT THIS MINE 8.2 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shear Machine Longwall

REGULAR OCCUPATION Shear Machine Longwall

COAL MINER'S CERTIFICATION 8-9798A

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 1-5-09

EQUIPMENT TRAINING RECEIVED ON: Roof and Rib Inspection

AMS System 9-26-09

Dust Control 9-1-09

Fire Drill

Donn SCSR 10-2-09

2nd Escapeway

VICTIM INFORMATIONAL DATA SHEET

NAME Gregory S. Brock

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 47 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 5 years

EXPERIENCE AT THIS MINE 5 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Electrician

REGULAR OCCUPATION Electrician (3-481)

COAL MINER'S CERTIFICATION 4-11002

OTHER CERTIFICATIONS Methane / Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 12-14-07

ANNUAL REFRESHER 2-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Lock and Tag

VICTIM INFORMATIONAL DATA SHEET

NAME Grover D. Skeens

ADDRESS [redacted]

[redacted] TELEPHONE NO [redacted]

AGE 57 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 33 years

EXPERIENCE AT THIS MINE 14 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Maintenance Foreman Longwall

REGULAR OCCUPATION Maintenance Foreman Longwall

COAL MINER'S CERTIFICATION 34952-85

OTHER CERTIFICATIONS Electrician LO-2870

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED 3-11-96

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 1-5-09

EQUIPMENT TRAINING RECEIVED ON: Roof and Rib Inspector

AMS System 9-26-09

Dust Control 9-1-09

Firedrill

Donn SCSR } 10-2-09

2nd Escapeway

VICTIM INFORMATIONAL DATA SHEET

NAME Howard D. Payne, Jr.

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 53 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 12 years

EXPERIENCE AT THIS MINE 11.1 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 2 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION 8-4669

OTHER CERTIFICATIONS Methane/Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-8-99

ANNUAL REFRESHER 2-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Roof Bolter

VICTIM INFORMATIONAL DATA SHEET

NAME James E. Mooney

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 51 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 32 years 24 weeks

EXPERIENCE AT THIS MINE 13 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shuttle Car Operator

REGULAR OCCUPATION Shuttle Car Operator

COAL MINER'S CERTIFICATION K-786-A

OTHER CERTIFICATIONS Methane / Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-7-2000

ANNUAL REFRESHER 2-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Shuttle Car

VICTIM INFORMATIONAL DATA SHEET

NAME Jason M. Atkins

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 25 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 5 years

EXPERIENCE AT THIS MINE 48 Weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION 3-15199

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-27-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-25-10

EQUIPMENT TRAINING RECEIVED ON: Roof Bolter

Fairchild Scoop

VICTIM INFORMATIONAL DATA SHEET

NAME Joe Marcum

ADDRESS [redacted] TELEPHONE NO. [redacted]

AGE 57 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 32 years

EXPERIENCE AT THIS MINE 15.4 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Continuous Miner Operator

REGULAR OCCUPATION Continuous Miner Operator

COAL MINER'S CERTIFICATION L-7741

OTHER CERTIFICATIONS Methane / Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED 11-28-94

NEWLY EMPLOYED EXP. MINER

ANNUAL REFRESHER 2-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Shuttle Car

VICTIM INFORMATIONAL DATA SHEET

NAME Rex L. Mullins

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 50 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 20 years

EXPERIENCE AT THIS MINE 6.8 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Headgate Operator Longwall

REGULAR OCCUPATION Headgate Operator Longwall

COAL MINER'S CERTIFICATION 3-8663-A

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 1-13-09

EQUIPMENT TRAINING RECEIVED ON: Stageloader
Shield Hauler
Shield Recovery
Shield Operator
Fairchild
AMS System 9-26-09
Dust Control 9-1-09
Firedrill
Donn SCSR
2nd Escapeway
} 10-2-09

VICTIM INFORMATIONAL DATA SHEET

NAME Nicolas D. McCroskey

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 26 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 3 years

EXPERIENCE AT THIS MINE 1.5 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Electrician

REGULAR OCCUPATION Electrician

COAL MINER'S CERTIFICATION 4-11695

OTHER CERTIFICATIONS 4-786 Electrical

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-1-10

ANNUAL REFRESHER 3-26-10

TASK TRAINING 5-22-09

EQUIPMENT TRAINING RECEIVED ON: Shield Operator
Shield Hauler
Shear Operator 9-26-09
Stageloader Operator 9-26-09
Dust Control 9-1-09
Shield Rebuild 5-20-09
AMS System 9-24-09
Fire Drill
Donn SCSE
2nd Escapeway
} 10-2-09

VICTIM INFORMATIONAL DATA SHEET

NAME Joel R. Price

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 55 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 35 years

EXPERIENCE AT THIS MINE 2.5 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shear Machine Op Longwall

REGULAR OCCUPATION Shear Machine Op Longwall

COAL MINER'S CERTIFICATION N-7150

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 7-16-04

ANNUAL REFRESHER 3-26-10

TASK TRAINING 5-7-09

EQUIPMENT TRAINING RECEIVED ON: Shield Recovery
Use of Torches
AMS System 9-26-09
Dust Control
Firedrill
Donn SCSR } 10-2-09
2nd Escapeway

VICTIM INFORMATIONAL DATA SHEET

NAME Joshua S. Napper

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 25 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 8 weeks

EXPERIENCE AT THIS MINE 8 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Underground Apprentice Longwall

REGULAR OCCUPATION Underground Apprentice Longwall

COAL MINER'S CERTIFICATION 4-19775

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 2-4-10

ANNUAL REFRESHER 3-27-10

TASK TRAINING 2-4-10

EQUIPMENT TRAINING RECEIVED ON: Strata Shelter

VICTIM INFORMATIONAL DATA SHEET

NAME Michael L. Elswick

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 57 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 39 years

EXPERIENCE AT THIS MINE 1 week

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Fireboss

REGULAR OCCUPATION Fireboss

COAL MINER'S CERTIFICATION A-3068

OTHER CERTIFICATIONS Foreman - number unable to read

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-31-10

ANNUAL REFRESHER

TASK TRAINING 3-31-10

EQUIPMENT TRAINING RECEIVED ON: Strata Shelter

VICTIM INFORMATIONAL DATA SHEET

NAME Benny R. Willingham

ADDRESS [redacted]

TELEPHONE NO. [redacted]

AGE 61 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 34 years

EXPERIENCE AT THIS MINE 48 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION N-7286

OTHER CERTIFICATIONS N/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED 12-30-94

NEWLY EMPLOYED EXP. MINER 1-29-10

ANNUAL REFRESHER 3-27-10

TASK TRAINING 1-22-10

EQUIPMENT TRAINING RECEIVED ON: Scoop

Roof Bolter

VICTIM INFORMATIONAL DATA SHEET

NAME James K. Woods

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 54 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 36 years

EXPERIENCE AT THIS MINE 48 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Electrician

REGULAR OCCUPATION Electrician

COAL MINER'S CERTIFICATION NKWG-3540

OTHER CERTIFICATIONS 37383-01

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-27-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-22-10

EQUIPMENT TRAINING RECEIVED ON: Brookville Mantrip

Scoop

VICTIM INFORMATIONAL DATA SHEET

NAME Timothy Blake

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 56 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 37 years

EXPERIENCE AT THIS MINE 48 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION n-2925

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-30-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-29-10

EQUIPMENT TRAINING RECEIVED ON: Fletcher Roof Bolter

Fairchild Scoop

VICTIM INFORMATIONAL DATA SHEET

NAME Kenneth A. Chapman

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 53 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 28 years

EXPERIENCE AT THIS MINE 1.2 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Roof Bolt Operator

REGULAR OCCUPATION Roof Bolt Operator

COAL MINER'S CERTIFICATION NRWG-8657A

OTHER CERTIFICATIONS Methane/Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-24-09

ANNUAL REFRESHER 2-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Roof Bolter

VICTIM INFORMATIONAL DATA SHEET

NAME William R. Lynch

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 59 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 34 years

EXPERIENCE AT THIS MINE 48 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shuttle Car Operator

REGULAR OCCUPATION Shuttle Car Operator

COAL MINER'S CERTIFICATION K-4794

OTHER CERTIFICATIONS n/A

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-29-10

ANNUAL REFRESHER 3-13-2010

TASK TRAINING 1-30-10

EQUIPMENT TRAINING RECEIVED ON: Shuttle Car

Brookville Mantrip

VICTIM INFORMATIONAL DATA SHEET

NAME William I. Griffith

ADDRESS [redacted]

TELEPHONE NO. [redacted]

AGE 54 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 36 years

EXPERIENCE AT THIS MINE 14.1 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Continuous Miner Operator

REGULAR OCCUPATION Continuous Miner Operator

COAL MINER'S CERTIFICATION n-5014

OTHER CERTIFICATIONS Methane / Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-24-09

ANNUAL REFRESHER 3-23-10

TASK TRAINING 1-24-09

EQUIPMENT TRAINING RECEIVED ON: Continuous Miner

VICTIM INFORMATIONAL DATA SHEET

NAME Steven Harrah

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 40 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 9 years

EXPERIENCE AT THIS MINE 48 Weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Section Foreman

REGULAR OCCUPATION Section Foreman

COAL MINER'S CERTIFICATION 1231-A

OTHER CERTIFICATIONS Shot Firer 4-4760

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 3-19-09

ANNUAL REFRESHER 3-13-10

TASK TRAINING 3-21-09

EQUIPMENT TRAINING RECEIVED ON: Supply Motor

Scoop

Continuous Miner

Cat Bolter

Fletcher Roof Bolter

Mantrip

SCSR Outby Chamber 5-20-09

VICTIM INFORMATIONAL DATA SHEET

NAME Ronald L. Maynor

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 31 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 3 years 24 weeks

EXPERIENCE AT THIS MINE 3.1 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Scoop Operator

REGULAR OCCUPATION Scoop Operator

COAL MINER'S CERTIFICATION

OTHER CERTIFICATIONS

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 2-3-07

ANNUAL REFRESHER 2-23-10

TASK TRAINING 2-6-08

EQUIPMENT TRAINING RECEIVED ON: Scoop

Bobcat

VICTIM INFORMATIONAL DATA SHEET

NAME Robert Clark

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 41 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 11 years

EXPERIENCE AT THIS MINE 44 Weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Continuous Miner Operator

REGULAR OCCUPATION Continuous Miner Operator

COAL MINER'S CERTIFICATION 4-10142

OTHER CERTIFICATIONS Mine Foreman 38598-07

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 1-30-10

ANNUAL REFRESHER 3-13-10

TASK TRAINING 1-29-10

EQUIPMENT TRAINING RECEIVED ON: Brookville Mantrip

Mantrip

Forklift 1-17-09

Fairchild 1-17-09

Hydraulic Chainsaw 1-17-09

Belts 1-17-09

VICTIM INFORMATIONAL DATA SHEET

NAME Ricky L. Workman

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 50 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 9 years

EXPERIENCE AT THIS MINE 7.9 years

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 48 hours PER DAY 8 hours

LENGTH OF SHIFTS AT THIS MINE 8 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Shuttle Car Operator

REGULAR OCCUPATION Shuttle Car Operator

COAL MINER'S CERTIFICATION 4-10195

OTHER CERTIFICATIONS Methane / Oxygen Deficiency 3/2007

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 5-1-08

ANNUAL REFRESHER 2-23-10

TASK TRAINING 9-30-09

EQUIPMENT TRAINING RECEIVED ON: Fletcher

Fairchild

Brookville Mantrip

Forklift

VICTIM INFORMATIONAL DATA SHEET

NAME Richard Lane

ADDRESS [redacted]

[redacted] TELEPHONE NO. [redacted]

AGE 45 SOCIAL SECURITY NUMBER [redacted]

TOTAL MINING EXPERIENCE 8 years

EXPERIENCE AT THIS MINE 36 weeks

AVERAGE NUMBER OF DAYS WORKED PER WEEK 6 days.

AVERAGE NUMBER OF HOURS WORKED PER WEEK 60 hours PER DAY 10 hours

LENGTH OF SHIFTS AT THIS MINE 10 hours TRAVEL TIME TO/FROM WORK [redacted]

OCCUPATION AT TIME OF ACCIDENT Longwall Foreman

REGULAR OCCUPATION Longwall Foreman

COAL MINER'S CERTIFICATION 1357-A

OTHER CERTIFICATIONS Shot Firer 3-4358

VICTIM'S TRAINING RECORD

DATE RECEIVED - NEWLY EMPLOYED

NEWLY EMPLOYED EXP. MINER 5-11-09

ANNUAL REFRESHER 3-26-10

TASK TRAINING 5-12-09

EQUIPMENT TRAINING RECEIVED ON: Supply Motor

Fire Drill 10-2-09

Donn SCSR 10-2-09

2nd Escapeway 10-2-09

AMS System 9-24-09

PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

Use Indelible Pencil or Ink

DATE 3-1-10 SHIFT: EVE 600 AM OR PM TO 800 AM OR PM ON-SHIFT EXAM. 800 AM OR PM TO 1100 AM OR PM PRE-SHIFT EXAM.

Was this report phoned to outside Yes ✓ No ___ By Whom J. Skaggs Time 10:00 AM or PM

Report received by: William Campbell 1354-A
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
Ellis #4	needs Dusted, needs cleaned from 101-Drift	BC	✓		
Ellis #5	Needs Spot cleaned & Dusted	BC	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	Needs cleaned from 10brk-Head, Dusted, Takeup needs added cleaning	BC	✓		
NORTH NO. 5	needs Dusted	BC	✓		
NORTH NO. 6	needs spotcleaned 90-tail & Dusted	BC	✓		
NORTH NO. 7	Tail needs added cleaning	BC	✓		
Longwall	needs spot cleaned & Dusted	JS	✓		
GLORY HOLE	D-Box & Pump - clear at Exam				
H622	At Tail needs Jacks set on offside	JS	✓		
[illegible]	Walkway & Belt needs cleaned & Dusted				
Tailgate 22	needs guard behind Discharge Needs Trash cleaned up around Head & Dusted	JS	✓		
H623	IDLE, NO Preshift, No Power	JS	✓		

***FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS**

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% CH_4, 0% CO, 20.8% O_2 Detected
Track/Travelways, P.C's, D-Box's, chargers, Pumps & visual check of CO's
All Clear at Exam

SIGNED BY: William Campbell 1354-A
Belt Examiners and Certificate Numbers
[signature] 32471
Belt Examiners and Certificate Numbers

COUNTERSIGNED BY T. Moore 33357
Mine Foreman Certificate No. Superintendent Certificate No.

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Use Indelible Pencil or Ink

PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

DATE 3-1-10 SHIFT: owl 1100 AM OR PM TO 300 AM OR PM ON-SHIFT EXAM. 300 AM OR PM TO 600 AM OR PM PRE-SHIFT EXAM.

Was this report phoned to outside Yes____ No____ By Whom________________ Time________ AM or PM

Report received by:________________
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
Ellis#4	needs dusted, needs cleaned from 101-Drift	BC	✓		
#Ellis#5	tail needs added cleaning, needs spot cleaned & dusted	BC	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	Needs cleaned from 10 brk - Head	BC			
NORTH NO. 5	Needs Dusted	BC	✓		
NORTH NO. 6	Needs spot cleaned & Dusted	BC	✓		
NORTH NO. 7	Needs spot clean & Dusted	JS	✓		
Longwall	Need spot clean & Dusted	JS	✓		
GLORY HOLE	PC & D Box OK	JS	✓		
HG 20 # 1	Needs walkway clean & Dusted	JS	✓		
HG 23 #	Idle No Preshift	JS	✓		

*FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% CH4, 0% CO, 20.8% O2 Detected

Track/Travelways, D-Box's, P.C's, Pumps, Chargers & CO's all clean at Time of Exam

SIGNED BY: William Campbell 13544 Johnny Neely 33472
Belt Examiners and Certificate Numbers

[signature] 32476
Belt Examiners and Certificate Numbers

COUNTERSIGNED BY T. Moore 33359
Mine Foreman Certificate No. Superintendent Certificate No.

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Scott Halstead 37567

Use Indelible Pencil or Ink

PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

DATE 3-23-10 SHIFT: DAY ___ AM OR PM TO ___ AM OR PM 12:00 AM OR PM TO 3:00 AM OR PM

ON-SHIFT EXAM. PRE-SHIFT EXAM.

Was this report phoned to outside Yes ✓ No ___ By Whom John Neely Time 2:40 AM or PM

Report received by: Russell Gunnoe
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
Ellis 4	Needs Dusted	RG	✓		
Ellis 5	Needs spot cleaned 27-29, Needs Dusted	RG	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	Needs Spot Cleaned 37-tail Needs cleaned Drive-Discharge	RG SH	✓		
NORTH NO. 5	Takeup Needs Add Cleaning, Needs Spot Cleaned 60-Flowthru	SH			
NORTH NO. 6	Needs Spot Cleaned 87-tail	SH	✓		
NORTH NO. 7	Needs Dusted	JN	✓		
Longwall	Mother Drive Area Needs Cleaned, Belt Needs Some Spot Clean	SH	✓		
GLORY HOLE	D-Box & Pump OK	JN	✓		
TG-22 NO. 1	Needs cleaned & Dusted	JN	✓		
TG-22 NO. 2	Needs Dusted	JN	✓		
HG-22 #1	Needs Dusted, Needs Rib Roll cleaned up in walkway	JN	✓		

*FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% CH_4, 20.8% O_2, 0ppm CO at time of exam

TRAvelways, Power Centers, D-Boxes, chargers OK at time of exam

Visual check of CO monitors OK at time of exam

[signature] 1539A [signature] 32476

SIGNED BY: Russell Gunnoe 1536-A
Belt Examiners and Certificate Numbers

Scott Halstead 37567

Johnny Neely 33472

Belt Examiners and Certificate Numbers

COUNTERSIGNED BY [signature] 33359

Mine Foreman Certificate No. Superintendent Certificate No.

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se Indelible Pencil or Ink

PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

DATE 4-1-10 SHIFT: DAY ____ AM OR PM TO ____ AM OR PM 12:00 AM OR PM TO 3:00 AM OR PM

ON-SHIFT EXAM. PRE-SHIFT EXAM.

Was this report phoned to outside Yes ✓ No ___ By Whom John Bickford/Mike Elswick Time 2:30 AM or PM

Report received by: Russell Gunnoe
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
Ellis 4	Needs Dusted	RG	✓		
Ellis 5	Needs Spot cleaned 10 to 7 bak, Needs Dusted	RG	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	Tail Need Add. cleaning / Needs Additional cleaning Drive to Discharge	RG	✓		
NORTH NO. 5	Needs Spot Cleaned 60-Flowthru, TAKeup Needs Cleaned	SH	✓		
NORTH NO. 6	Needs Spot Cleaned & Dusted	SH	✓		
NORTH NO. 7	Needs Dusted	ME	✓		
Longwall	Needs Dusted	ME	✓		
GLORY HOLE	D-Box + Pump OK	ME	✓		
TG-22 NO. 1	Needs spot cleaned + Dusted	JAB	✓		
TG-22 NO. 2	Needs Dusted, Tail needs Add. cleaning	JAB	✓		
HG-22 #1	Needs add. cleaning + Dusted (working on dusting)	JAB	✓		

*FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% CH_4, 20.8% O_2, 0 ppm CO at time of exam
Travelways, Power Centers, D-Boxes, chargers OK at time of ex
Visual check of CO monitors OK at time of exam

[illegible] 1539A

John [illegible] 32476

SIGNED BY: Russell Gunnoe 1536-A
Belt Examiners and Certificate Numbers

Scott Halstead 37567

John Bickford 26176
Belt Examiners and Certificate Numbers

Michael Elswick 31521

COUNTERSIGNED BY T. Moore 33359
Mine Foreman Certificate No. Superintendent Certificate No.

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PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

Use Indelible Pencil or Ink

DATE 4.5.10 SHIFT: Day ______ AM OR PM TO ______ AM OR PM 300 AM OR PM TO 600 AM OR PM

ON-SHIFT EXAM. PRE-SHIFT EXAM.

Was this report phoned to outside Yes____ No____ By Whom______________ Time__________ AM or PM

Report received by: ______________________
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
4 ELLIS	NEEDS Added Dusting	JS	✓		
5 ELLIS	NEEDS DUSTED	JS	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	NEEDS SPOT CLEAN & DUSTED	JS	✓		
NORTH NO. 5	Needs spot cleaned 60 to flowthru	JAB	✓		
NORTH NO. 6	Needs spot cleaned & dusted	JAB	✓		
NORTH NO. 7	Needs dusted	JN	✓		
Lg Wall	Needs spot cleaned	LB	✓		
GLORY HOLE	D. Box & Pump ok	JN	✓		
TG NO. 1	Need spot cleaned & spot dusted	JN	✓		
TG NO. 2	None observed	JN	✓		

*FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% ch4 0% CO + 20.8% O_2 detected

PC's, Track, Travelways, chargers, Pumps + 'D' Box's clean at time of exam

Visual check of CO's OK

SIGNED BY: John Bickford 26176 Johnny Neely 33472 [signature] 38927
Belt Examiners and Certificate Numbers

[signature] 32476
Belt Examiners and Certificate Numbers

COUNTERSIGNED BY ______ ______ ______ ______

Mine Foreman Certificate No. Superintendent Certificate No.

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Mike [signature] 31521 Scott Halstead 37567

Use Indelible Pencil or Ink

PRE-SHIFT
EXAMINATION OF BELT CONVEYORS

DATE 4-5-10 SHIFT: DAY ______ AM OR PM TO ______ AM OR PM 12:00 AM OR (PM) TO 3:00 AM OR (PM)

ON-SHIFT EXAM. PRE-SHIFT EXAM.

Was this report phoned to outside Yes ✓ No ____ By Whom Mike Elswick Time 2:30 AM or (PM)

Report received by: Scott Halstead 37567
Signed

BELTS	VIOLATION AND OTHER HAZARDOUS CONDITIONS OBSERVED	EXAMINER	PRE-SHIFT	COUNT SIGN	*FIRE RUN
Ellis #4	Needs Added Dusting	SH	✓		
Ellis #5	Needs Dusted	SH	✓		
NORTH NO. 2					
NORTH NO. 3					
NORTH NO. 4	Needs Spot Cleaned & Dusted	SH	✓		
NORTH NO. 5	Needs Spot Cleaned 60-flowthru	SH	✓		
NORTH NO. 6	Needs Spot Cleaned & Dusted	SH	✓		
NORTH NO. 7	Belt needs Dusted	M.E.			
Longwall	Needs Spot Cleaned & Dusted	SH	✓		
GLORY HOLE	D.Box & Pump - OK	ME			
TG NO. 1	needs Dusted	M.E.			
TG NO. 2	tail Needs Cleaned	M.E.			
HG 22	Belt needs Spot Cleaned & Dusted	M.E.			

*FIRE RUN EXAMINATION: AFTER LAST PRODUCTION SHIFT OF WEEK, BEFORE HOLIDAY AND VACATIONS

(ITEMS NOT A HAZARD BUT NEEDING ADDITIONAL ATTENTION) REMARKS:

0% CH^4, 20.8% O^2, 0ppm CO Detected at EXAM
Power Centers, D-Box's, Chargers, *track & Travel ways Clean at EXAM
Visual CK of CO Monitors-Clear

SIGNED BY: Scott Halstead 37527
Belt Examiners and Certificate Numbers

Belt Examiners and Certificate Numbers

COUNTERSIGNED BY ______ ______ ______ ______
Mine Foreman | Certificate No. | Superintendent | Certificate No.

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Individuals who Exercised their Fifth Amendment Rights

Chris Adkins
Rob Asbury
Chris Blanchard
Don Blankenship
Elizabeth Chamberlin
Greg Clay[1]
Jamie Ferguson
Gary Frampton
Rick Foster
Everett Hager
Eric Lilly
Gary May
Paul McCombs
Terry Moore
Rick Nicolau[2]
Wayne Persinger
Jack Roles
Bill Ross
Jason Whitehead

[1] Participated in one interview then asserted his Fifth Amendment rights when requested to come in for a second interview
[2] Initially asserted his Fifth Amendment rights then later agreed to a voluntary interview.

APPENDIX 7.9-1

SAMPLING AND ANALYSIS of MINE DUSTS

Dust analysis methods have been used in previous mine explosion investigations to determine the amount of coke produced in the explosion and also to access concentrations of rock dust that existed prior to the explosion. The principle tests for these determinations are the Alcohol Coke Test and the test for Total Incombustible Content (TIC). Two types of dust samples were collected: 1) perimeter dust samples of floor, roof, and ribs ("dust band samples"), and 2) impacted dust samples from cavities and stationary mine structure surfaces.

Perimeter dust sampling (dust band sampling)

In July 2010 the mine dusts covering the ribs, roof, and floor were sampled under the protocols of the Joint Investigation. These samples are commonly referred to as "dust band samples" or "band samples." The collection and analysis of these samples was directed by MSHA.

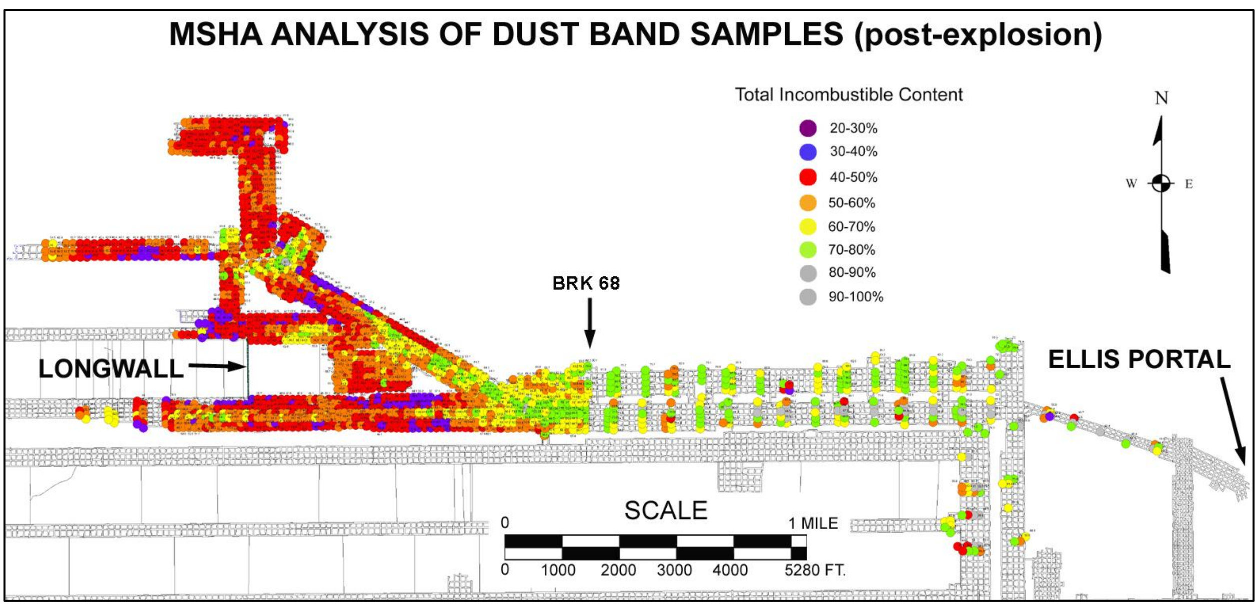


Figure 1. General location map for the majority of the "post-explosion" dust band samples collected during the investigation. The collection and analysis of these samples was directed by MSHA.

For the areas inby BRK 68 band samples were collected in most entries between each set of crosscuts throughout most of the accessible, dry area (see **Figure 1**). In areas outby BRK 68 samples were also taken in the entries, but the sample lines were spaced at increments of approximately five crosscuts.

The following is a brief summary of the technique used:

Samples were collected from the mixed dust on the floor, roof and ribs according to procedures established by MSHA. The MSHA instructions specify the following: "Collect samples of mixed dust by the band or perimeter method from the entry or room, including a 1-inch depth of the material on the floor. The dusts from the roof, ribs, and floor are combined into one "band" sample. If the amount collected is more than required it is split by thoroughly mixing the sample, then cutting it by the "cone and quarter" method. Occasionally, it may be necessary to take more than one strip, but in such case, the total width of the strip must be the same for the roof, each combined rib, and floor sample.[1]

This same method of sampling is used to determine compliance with the rock dusting requirements during enforcement inspections.

Sampling procedures used very early in the research required roof and rib samples to be collected separately from floor samples. The process has been simplified to reduce the number of samples needed and the perimeter sample combines the large amount of floor sample with the lesser amount but potentially more reactive fine dust from the ribs and roof. The end result may not adequately evaluate the impact of the rib dust. The sample may indicate sufficient incombustible but dust on the ribs might be sufficient to propagate an explosion.

The MSHA laboratory at Mount Hope, West Virginia uses a slow-ashing technique where the sample is heated to 515^{o} C for 2 ½ hours to determine the incombustible content.

When samples are taken after an explosion the samples are also subjected to the "alcohol coke test." For this test about 1 gram of the sample was placed in a test tube and about 15 mL of denatured alcohol was added and the sample stirred to ensure all particles were wetted then an additional 5 mL of alcohol was used to wash down the sides of the test tube. After about 5 minutes a visual observation was made to classify based on the amount of coked material floating on the surface (see **Figure 3)** for the classification.

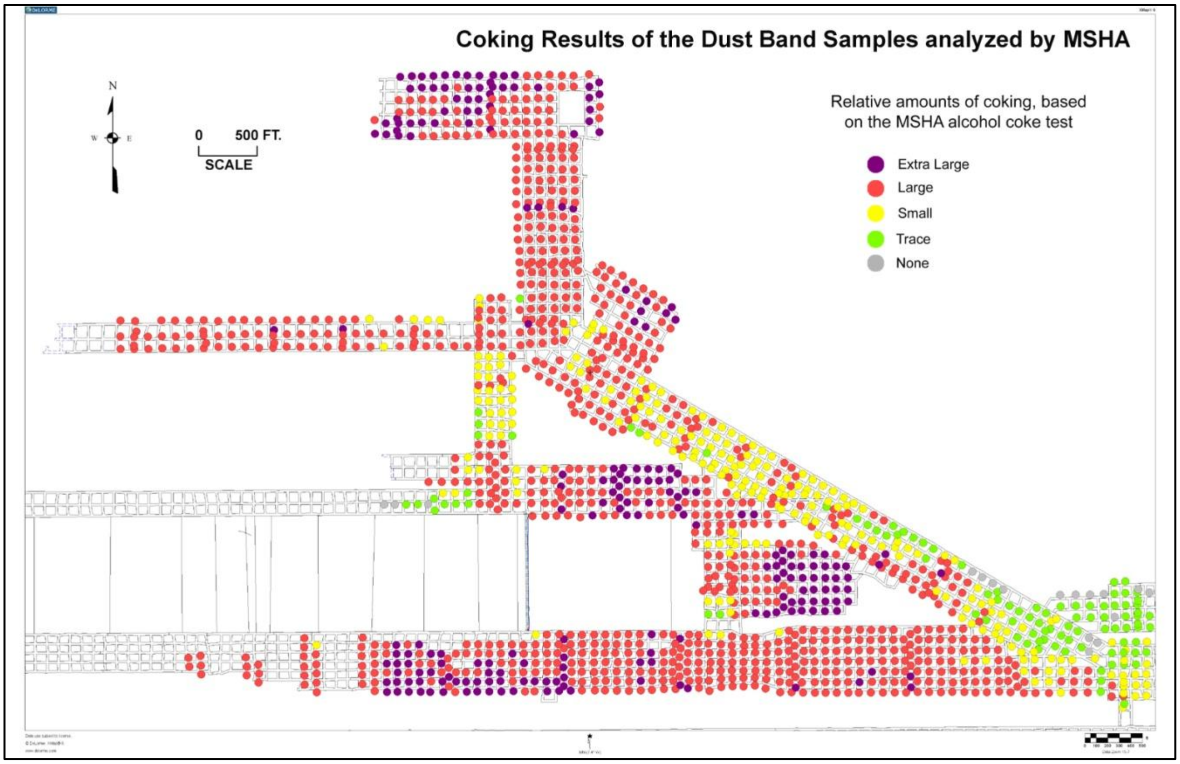
The Bureau of Mines and MSHA have used these sampling procedures for many years. These procedures are also used by the Bureau and NIOSH in dust explosion research.

The total incombustible content (TIC) and coke content of the samples collected by the Joint Investigation and analyzed by MSHA are illustrated with **Maps 1A** and **1B.**

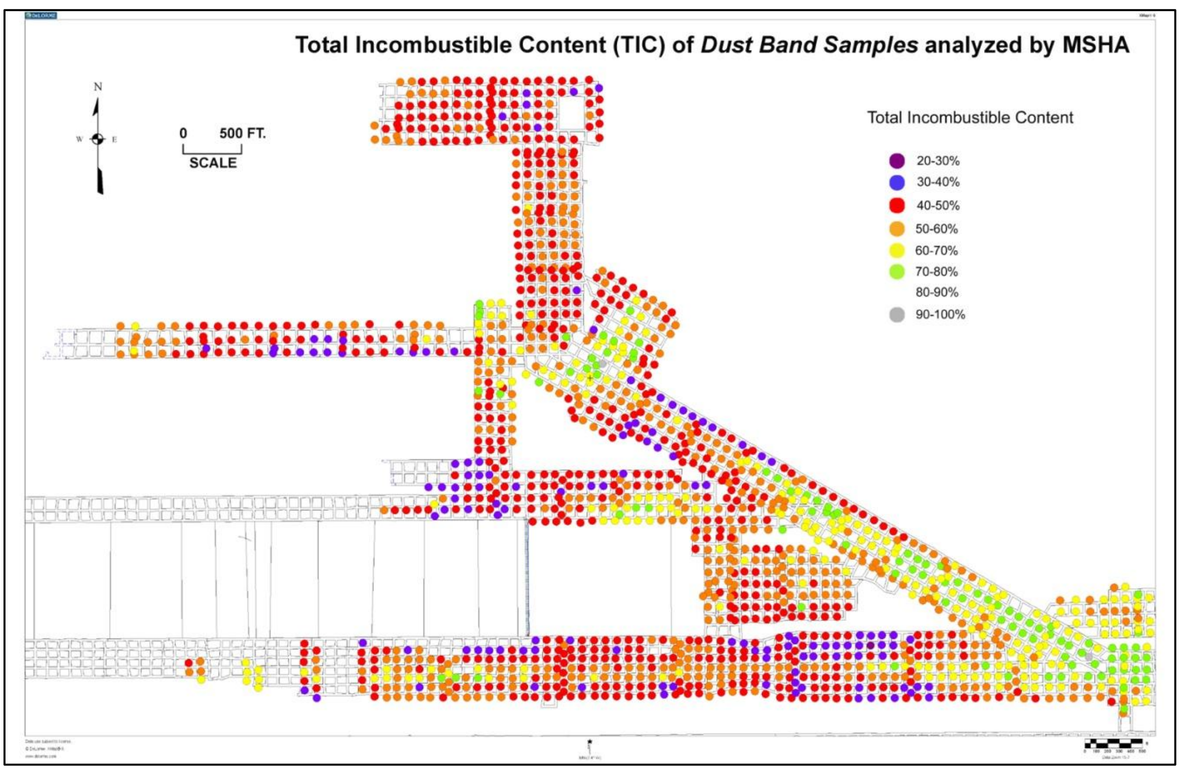
It should be mentioned that the test procedure for the alcohol coke test is qualitative, and a variation of one tier of difference by different technicians using the same procedure is possible.

---

[1] MSHA Handbook Series, January 2006, Handbook Number PH06-V-1.



Map 1A. Results of MSHA dust band sample analyses (first round); Coke Content



Map 1B. Results of MSHA dust band sample analyses (first round); Total Incombustible Content

For example, in classifying the coke dispersion patterns in a test tube (see **Figure 3**) one operator might classify what he views as a "small" quantity of coke, while another operator might call it a "trace". It would be much less common to be two tiers off, for example, a "small" amount vs. "none."

The force of a dust explosion creates wind velocities which exceed hurricane winds and these winds displace and relocate fine coal and other dusts throughout the explosion area. It is quite possible that unburned coal would be relocated and deposited, or uncovered as upper layers are blown away, where it could be collected and be contained in the band samples. This is the primary reason that the Bureau of Mines historically, in their disaster investigations did not base the original composition of mine dusts from analysis of samples collected after the explosion.[2]

We have also learned from research that rock dust can be decomposed in the high temperatures of a dust explosion and some of the rock dust would be reduced to CO_2 leaving CaO (calcium oxide) with a weight loss approaching 50% .[3] However, research finds that some of this weight loss is regained as the CaO (calcium oxide) hydrates to $Ca(OH)_2$ (calcium hydroxide) in the presence of moisture.[4] The slow-ashing procedure used in the laboratory analysis uses a temperature above the decomposition temperature of calcium hydroxide and again a weight loss can occur as the calcium hydroxide returns to calcium oxide.[5] These factors cause concern about the relation between pre-explosion and post-explosion sample analysis to determine the pre-explosion incombustible content. At this point we are not sure of the physical factors involved and believe a need exists for further research.

The coke analysis is useful because the presence of coke indicates flame; however the boundary of the flame cannot be precisely determined because particles of coke may have been transported by the winds of the explosion to locations beyond the extent of the flame.[6]

Dusts were airborne during the explosion, carried about by the explosion dynamics, and impacted or deposited throughout the explosion area. These dusts were found in crevices, on equipment surfaces, longwall hydraulic supports, and most on the surfaces of roof bolts protruding beneath roof bolt plates. Samples of the impacted dusts were collected and a similar analysis provided another source of information about the TIC and coke.

---

[2] Nagy, J., Mitchell, D., Experimental Coal-Dust and Gas Explosions, Bureau of Mines RI 6344.
[3] Man, C.K., Teacoach, K.A., How Does Limestone Rock Dust Prevent Coal Dust Explosions in Coal Mines , NIOSH, Pittsburgh, Pa.
[4] Ilangairatnam, G., Thermogravimetric Analysis of Coal, Char, Limestone, and Rock Dust, Report submitted for Masters in Mechanical Engineering for Imperial College, London, 2005
[5] Thermal Decomposition of Nanoparticulate Ca(OH)2-Anomalous Effects, National Research Council, Canada, NRCC-45602
[6] Man, C.K., et al, Determining Flame Travel Measurements From Experimental Coal Dust Explosions, NIOSH, Pittsburgh, Pa.

Mapping of "Impacted Dust"

The MSHA-dominated Joint Investigative underground Flames and Forces effort was concluded on September 12, 2010, and from that point forward the state of West Virginia (WVOMHS&T) conducted a detailed, systematic mapping effort. This included mapping and limited sampling[7] of impacted dust from various structures across the explosion region. The locations of these samples are shown on the *West Virginia Flames and Forces Map.* Dust deposits on roof bolt heads were the structures most thoroughly documented, but also included were standing jacks, roof header boards, belt rollers, water line couplers, shield cylinder legs, and a few others. Deposits of impacted dust formed on both square and cylindrical surfaces, and the shape of these deposits varied with their surface geometry and size.

A set of symbols and notations were developed to document the geometries of these various dust deposits, based on the type of structure involved, and the orientation and placement of the dust (**Figure 2**).

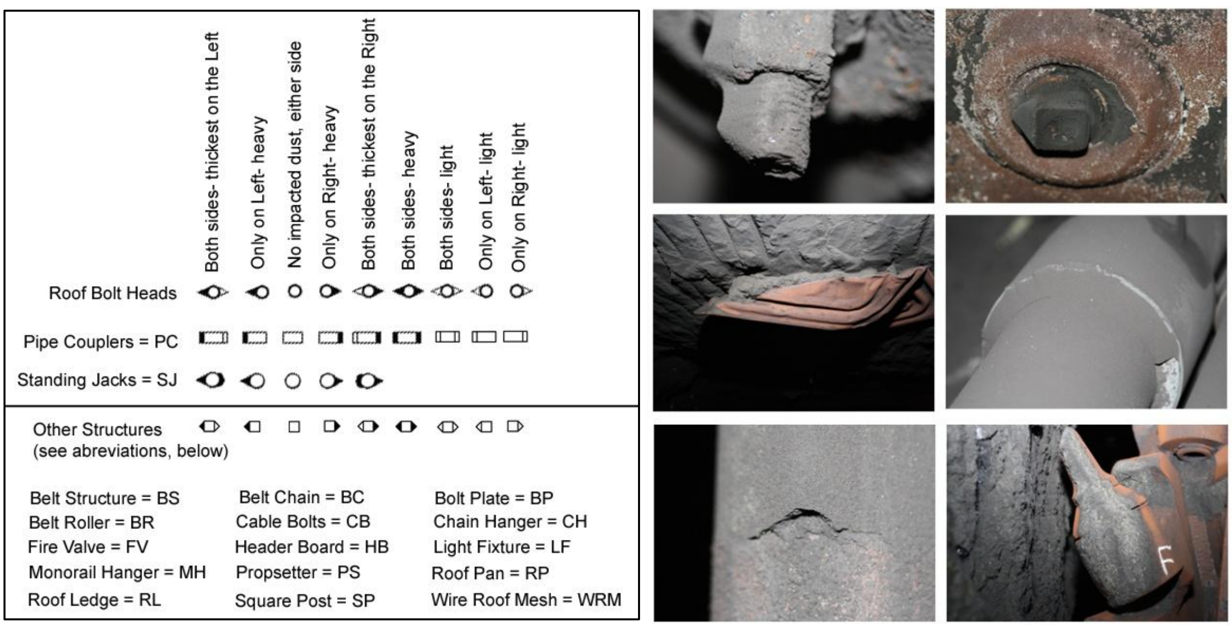


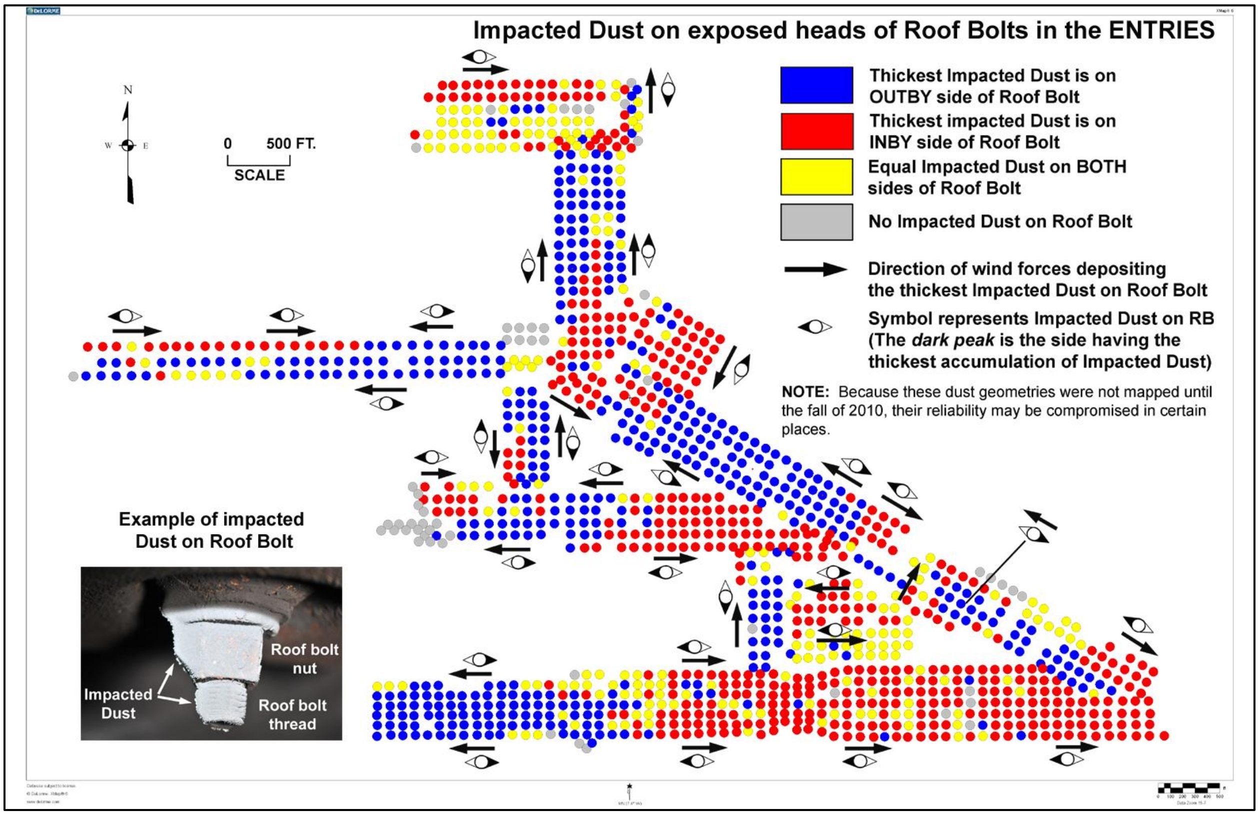
Figure 2. (LEFT): The map symbols shown were used in the *West Virginia Flames and Forces Map* to depict the orientations and size of impacted dusts deposited on protruding or standing structures by explosion air currents. (RIGHT): Some examples of impacted dust deposits on roof bolt structures, a pipeline coupler, a standing jack, and a shearer bit.

Small cylinders of approximately ¾-inch diameters (such as the protruding, threaded heads of torque tension roof bolts) often had dust accumulations on two sides--one side heavy, the other light. Cylinders that were larger than about 1.5 inches (such as sand jacks) tended to have a single longitudinal wedge on one side, and a thin dusting on ½ circumference of the opposite side, with clean zones separating the wedge from the region of thin dust (see **Appendix 7.9-3**).

7 The coking and total incombustible analyses appear in **Exhibit 1**.

Other structures had their own geometries of deposition, but it was the cylindrical structures that were most useful. The majority of the dust deposits discussed here were from roof bolts.

The mapping effort focused initially on roof bolts, because of their ubiquity across the entire explosion region. The relative size and placement direction of the deposits were noted and recorded, using symbolism described previously. Observed trends in the direction of the heavy side of dust accumulations are shown in **Map 2.** The side of the bolt with the greater amount of impacted dust was the side sampled. Investigators believe that the side hit by the strongest wind forces of the explosion accumulated the thickest impacted dust.[8]



Map 2. This is a summary map of impacted dust deposits which formed on roof bolt heads. The relative thickness and geometry of the impacted dust deposits are determined and plotted to delineate deposition trends. Progressive deterioration over time somewhat compromised the effort to accurately document them.

Care had to be exercised in mapping, because sometimes the thicker accumulations had already dropped off. This complicated the determination of certain dust geometries. The roof bolts were most problematic, and it would have been far better to map these features as early in the

[8] Standing cylinders larger than 1.5 inches in diameter are different in that they collect "Impacted 'V' Dust Cones" on the windward side of the final wind forces. See **Appendix 7.9-3** for an explanation.

investigation as possible. The larger cylindrical structures also rapidly shed their dust accumulations, but their remnants were easier to identify.

Sampling of "Impacted Dust"

Although the impacted dust was mapped in most of the accessible areas, sampling was performed at selected locations. These were laid out as profile lines and most were near junctions where air-courses intersect or split, and at other locations of interest, such as the longwall region of #21 Tailgate (see **Map 3A** and **3B**). Most of the dust samples were of roof bolt heads, but a few other structures were sampled as well.

The tools WVOMHS&T used to collect impacted dust samples consisted of a fine, short-bristled hand brush, a knife, a steel tray or non-porous container, and airtight plastic bags. Each sample was collected by lightly brushing the sample into a steel or plastic tray. Care was taken so as to not remove the sample deeper than the impacted dust deposit itself. If the impacted dust was of a relatively large amount, a knife would be used to slice the sample and allow it to drop into the tray.

After the sample was collected it was visually inspected. If contaminates such as rust were observed, these contaminates were removed using the knife, or the sample was discarded and a neighboring location re-sampled. Efforts were made to not touch the sample or let outside sources contaminate the sample. Individual bolts between adjacent intersections in entries and crosscuts were combined to represent that particular location, similar to the way roof pan records were organized. Prior to placing the sample into a zip-lock plastic bag, the bag was labeled with 1) date of sampling, 2) sample location, 3) what the sample was taken from, and 4) quantity of sample sources (e.g. number of roof bolts, etc.). After collection, the bagged sample was placed in a container for protection and the sample tools wiped clean before the next sampling.

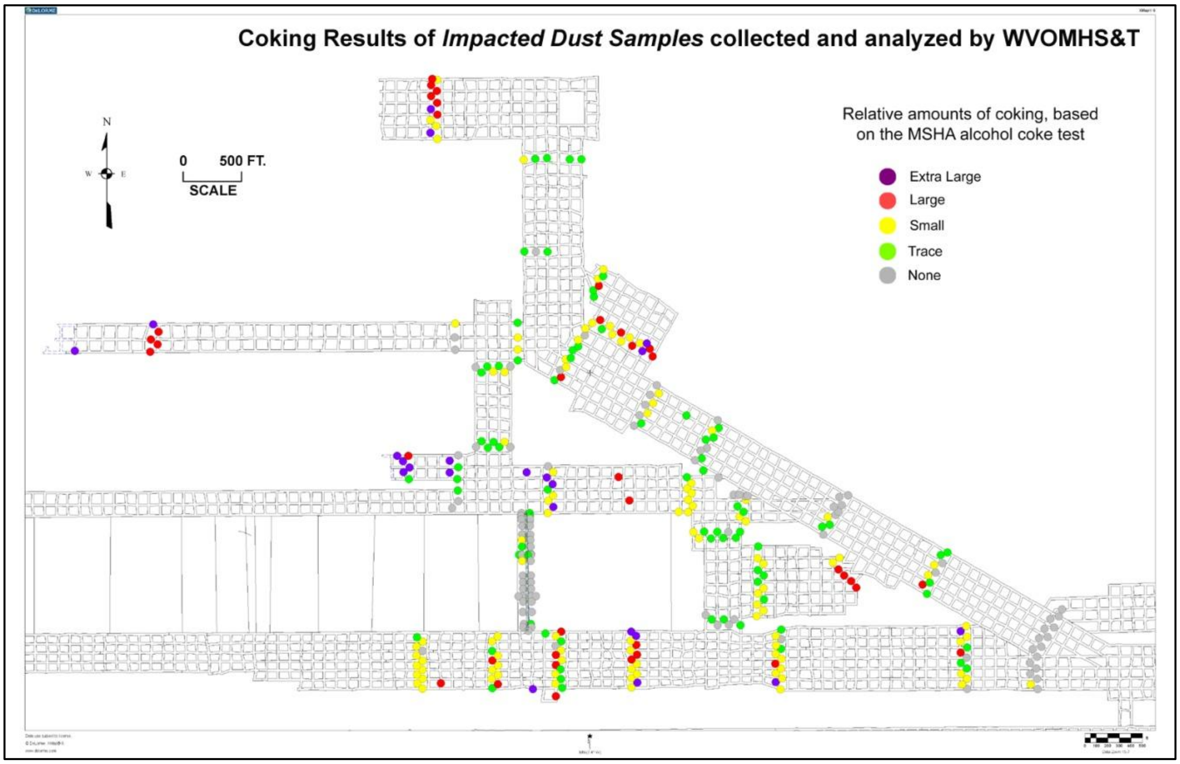
Samples were double-bagged and sometimes triple-bagged in air-tight bags until the time they were analyzed.

Analyses of "Impacted Dust" samples

Map 3A illustrates the results of alcohol coke tests performed on impacted dust samples along various sampling profiles, using the general test procedure.[9] The samples were collected separately from entries and crosscuts in the locations shown. Although the test procedures for

[9] "Post-explosion observation of experimental mine and laboratory coal dust explosions;" K.L. Cashdollar, E.S Weiss, T.G. Montgomery, and J.E. Going

coke are fundamentally the same, there are differences in the amount of coke described in our impacted dust samples, compared to the MSHA band samples.



Map 3A. WVOMHS&T impacted dust sample results: Alcohol Coke Test (TIC)

The reasons for the differences are not known with certainty, but it is speculated that samples of impacted dust captured by the moving air currents during the explosion may contain less coke than band samples which include dusts which settle to the floor.

Areas of stagnant air may skew coke test results by allowing local accumulations of fine suspended soot after the explosion. This might be understood more clearly by observing areas where stringers or filaments develop after an explosion, which have been associated with suspended soot in stagnant air.

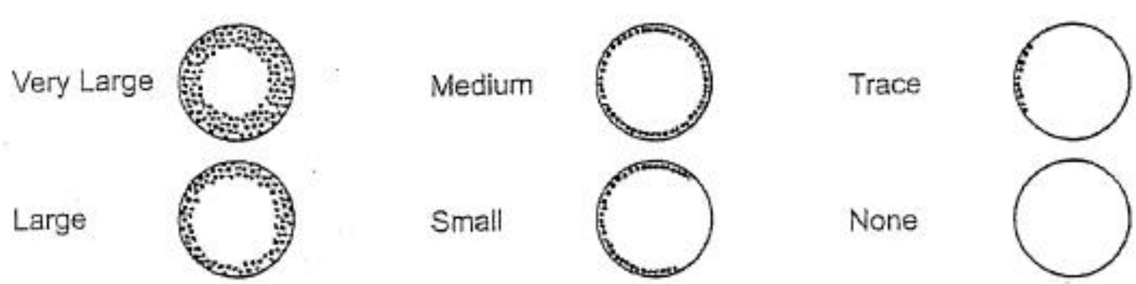
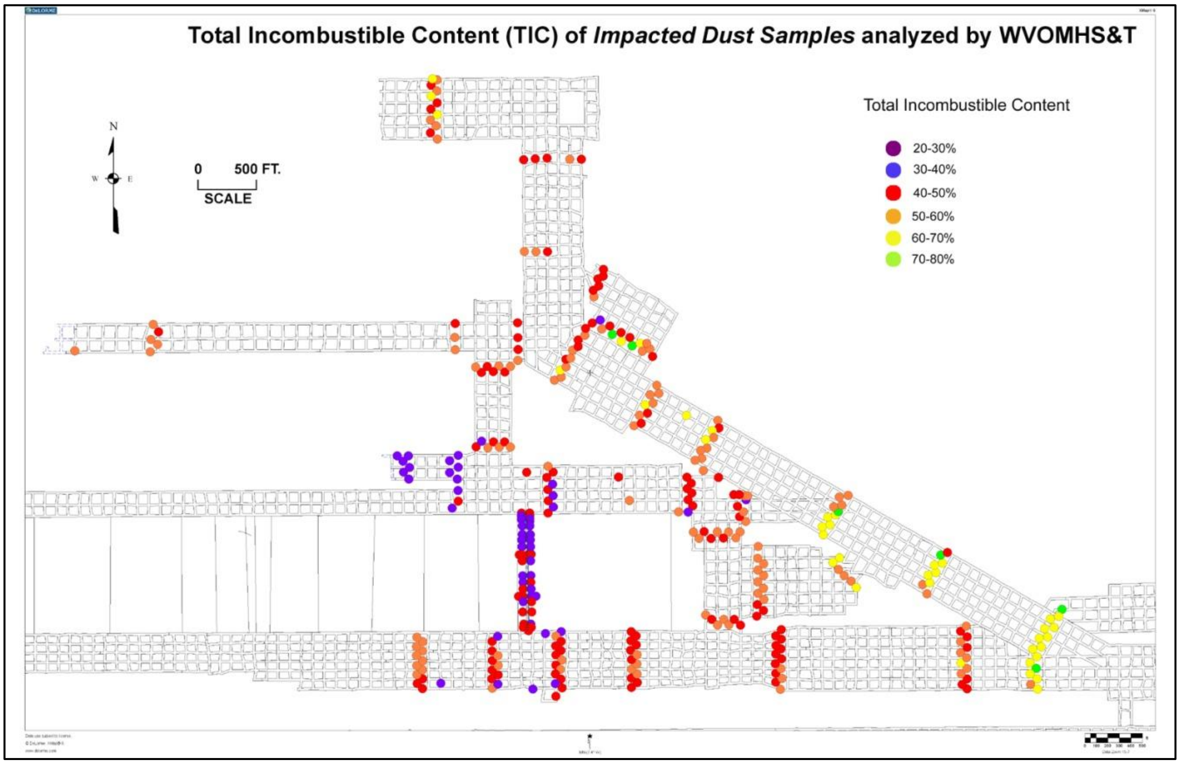


Figure 3. Qualitative ranking of coke content from dust samples is by observation in a test tube.

Map 3B illustrates the results of the total incombustible content (TIC) performed on post-explosion impacted dust samples, using the low-temperature ash testing procedure (LTA),[10] which is fundamentally the same test procedure used by MSHA for the band sample testing. The TIC analyses of the MSHA dust band samples (see **Map 1B** and **3B)** and WVOMHS&T impacted dust samples are similar.



Map 3B. WVOMHS&T impacted dust sample results: Total Incombustible Content (TIC)

As a point of reference, the band-type mine dust samples collected by the MSHA inspector, are screened during collection, using a 10-mesh screen (about 0.065 inches), and the minus 10-mesh portion is retained and sent to the laboratory. The laboratory further screens the sample through a 20 mesh screen (about 0.033 inches) retaining the 20 mesh portion. About 1 gram of this portion is used in the analysis. The portion is weighed, heated for 1 hour at 110^{o} C, and weighed again to calculate the moisture. Then the sample is heated at 515^{0} C for 2 ½ hours. The remaining residue is assumed to be ash. Using the weights before and after the moisture and ash is calculated. The combined sum of moisture and ash is the incombustible.

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10 Ibid.

The temperature 515^{o} C was chosen because tests have shown it will not decompose rock dust. This testing procedure has been used for years in coal mine inspections in evaluating whether rock dusting is adequate, and its application has been validated for that purpose. However, there are questions relating to determining incombustible content of mine dust samples collected after an explosion, where the rock dust has been subjected to high temperatures of a coal dust explosion.

Longwall Coke Evidence

The first few shields and the headgate and tailgate showed a trace of coke in the impacted dust samples taken there. There is a conspicuous lack of coking on the rest of the longwall, except between Shields 41 and 72, where coke was found in amounts ranging from a trace to medium. At Shield 62 the gob side of the leveling jack was sampled, and also the floor behind the shields at the gob were sampled, and these showed trace amounts of coke (see **Map 4**).

Coke was found in trace to medium amounts on the ***south side*** of cylinder legs between Shields 41 and 72. No coke was found on their north sides. See **Appendix 7.9-5** for a discussion of initial explosion forces behind the shields traveling north from the tailgate region of the longwall that were apparently detoured into the longwall at approximately this location.

Cenospheres

The presence of round, hollow ash-rich spheres in the impacted dust samples collected by WVOMHS&T provide evidence that coal combustion was involve in the explosion. These particles are of microscopic in size (about 10-50 microns in diameter) and are sometimes referred to as cenospheres (meaning, "empty" spheres). The fact that they are hollow is one of their most diagnostic traits linking them to coal combustion. They are indicative of the burning of coal particles.

The examination found heating was sufficient to melt the surface of particles producing rounded edges and a smooth wrinkled skin, and they had produced sufficient vapor pressure through degassing and coal decomposition so as to create blisters and blow-holes. Particles and fragments showing a higher degree of heating were those which featured the skeletal remains of the original particles. The particles with the highest degree of heating were those exhibiting a thin spherical shell and empty interior. The scenario of cenosphere formation during coal combustion is generally accepted.[11]

[11] V.B. Fenelonov, et.al., The Properties of Cenospheres and the Mechanism of Their Formation During High-Temperature Coal Combustion at Thermal Power Plants,

Approximately 65 samples were examined using a scanning electron microscope (SEM) during August to November, 2011.

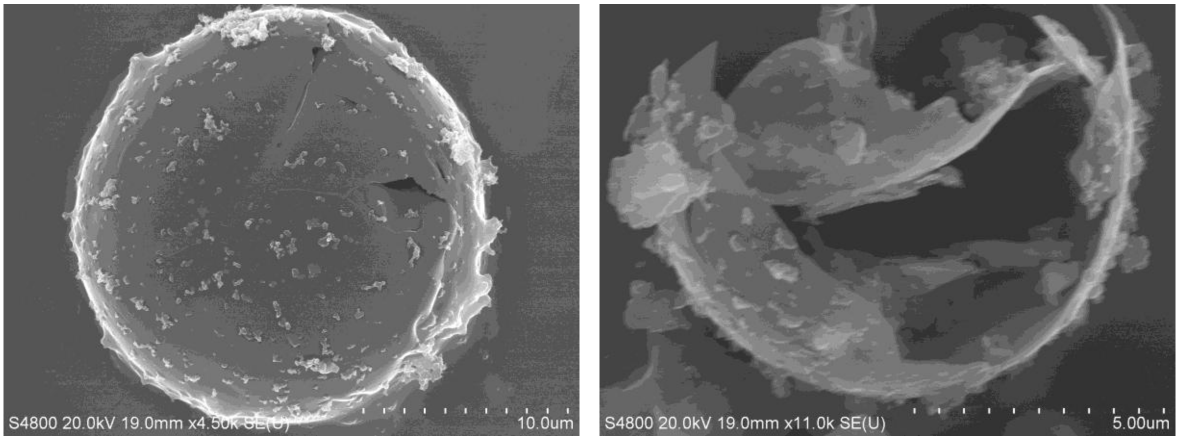
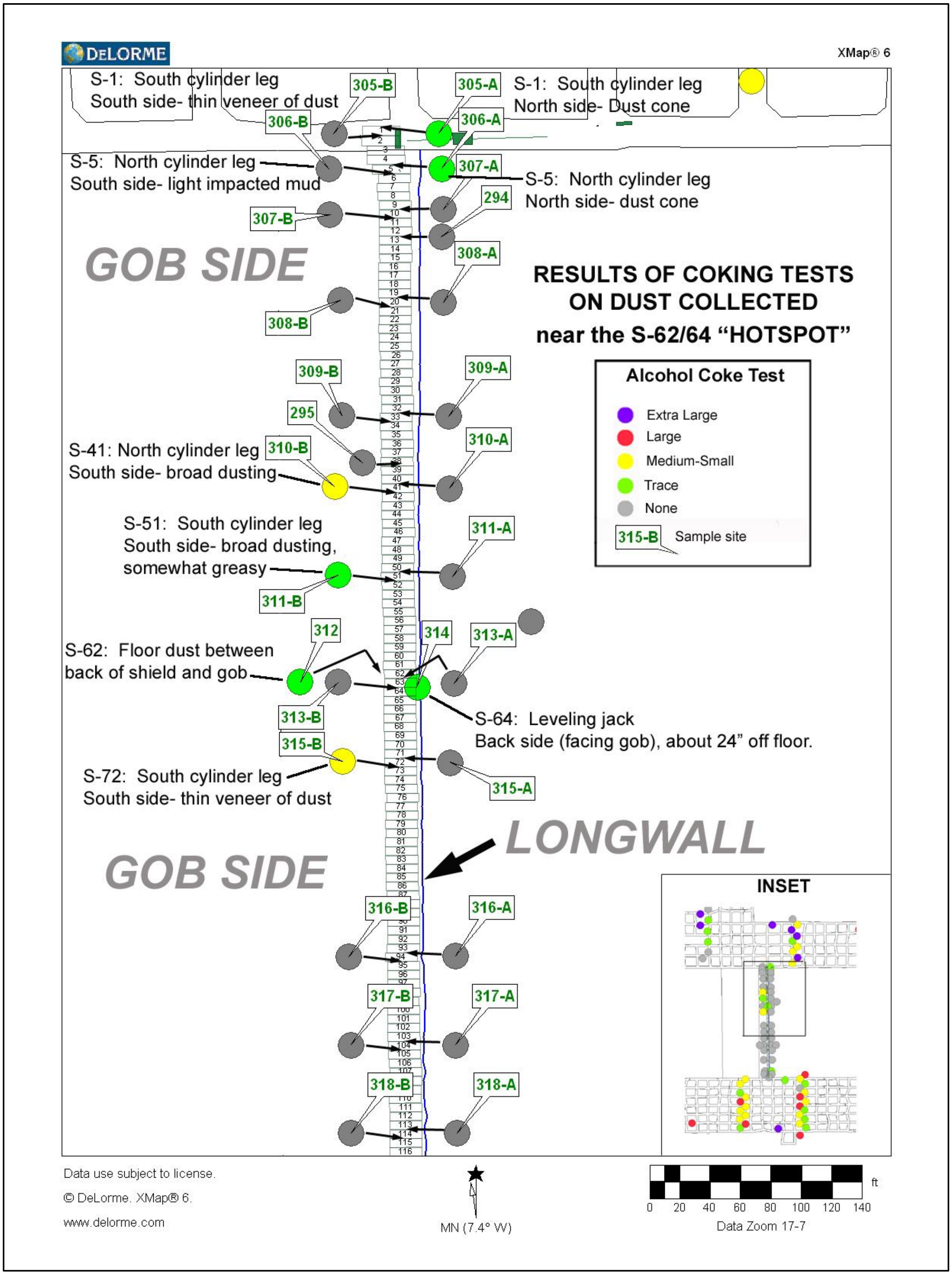


Figure 4. (LEFT) Microscopic, hollow ash rich spheres (cenospheres) are formed during high temperature coal combustion. (RIGHT) The fact that they have thin shells and are hollow is diagnostic. These samples came from the impacted dust samples collected in the explosion region. All of the samples examined contained some cenospheres.

Cenospheres were found in the impacted dust samples from shield cylinder legs and other structures on the Longwall, although their numbers were fewer than for samples collected and examined from other locations across the explosion region of UBB. Coking was generally absent on the Longwall, except between shields 41 and 72 and in the headgate and tailgate areas. Incombustible content was very low along the length of the Longwall. Together, these data suggest that relatively minor amounts of dust were brought in from outside the Longwall during the explosion. For details of the SEM examination for cenospheres by NIOSH: (see **Appendix 8.2-3** and **8.2-4)**



Map 4. Analysis of impacted dust for coke content on the longwall showed the highest amounts between Shield 41 and Shield 72.

APPENDIX 7.9-1 EXHIBIT 1

WVOMHS&T IMPACTED DUST SAMPLES. SUMMARY OF RESULTS BY G&C LABS, 2011

NOTE: Lat/Log coordinates are WGS-84

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
1	37.942147	-81.588106	1.15	65.87	66.64	60-70	1.60	8.40	None
2	37.942086	-81.588352	1.08	86.67	67.40	60-70	0.55	99.45	None
3	37.941884	-81.588240	1.15	66.68	67.46	60-70	0.90	99.10	None
4	37.941857	-81.588526	1.18	63.55	64.31	60-70	1.84	98.16	None
5	37.941661	-81.588437	1.16	64.24	64.99	60-70	0.00	100.00	None
6	37.941633	-81.588691	1.12	62.88	63.59	60-70	2.34	97.86	None
7	37.941429	-81.588623	1.20	63.85	65.83	60-70	1.05	98.95	None
8	37.941376	-81.588879	1.37	80.33	61.17	60-70	0.41	99.59	None
9	37.942681	-81.592053	1.78	56.85	57.96	50-60	5.19	94.81	Trace
10	37.942895	-81.592182	1.86	54.23	55.15	50-60	0.50	99.50	Large
11	37.942943	-81.591966	1.75	52.61	63.72	60-70	0.29	99.71	Trace
12	37.943125	-81.592016	1.81	60.39	61.36	60-70	0.20	99.80	Medium
13	37.943182	-81.591791	1.44	62.71	68.70	60-70	3.22	96.78	None
14	37.943360	-81.591833	1.35	64.08	64.96	60-70	0.53	99.47	Medium
15	37.943403	-81.591588	1.11	68.92	69.69	60-70	0.93	99.07	None
16	37.943594	-81.591644	1.23	69.16	70.02	70-80	1.99	98.01	Trace
17	37.943655	-81.591441	1.81	45.10	45.93	40-50	2.71	97.29	Trace
18	37.944077	-81.595158	1.76	61.81	62.92	60-70	2.26	97.74	None
19	37.944260	-81.595194	1.04	61.87	62.52	60-70	1.79	98.21	Trace
20	37.944306	-81.594961	1.71	67.69	68.87	60-70	5.07	94.93	Trace
21	37.944485	-81.595025	1.56	68.29	69.37	60-70	0.53	99.47	Small
22	37.944542	-81.594793	1.43	64.10	65.03	60-70	0.29	99.10	None
23	37.944623	-81.594713	0.96	75.83	79.59	70-80	0.42	99.58	None
24	37.944734	-81.594846	1.44	57.23	58.07	50-60	0.00	100.00	None
25	37.944774	-81.594605	1.53	58.17	59.07	50-60	0.00	100.00	None
26	37.944963	-81.594678	1.47	55.00	55.82	50-60	1.90	98.20	None
27	37.945002	-81.594417	2.00	52.34	53.41	50-60	2.06	97.94	None
28	37.946772	-81.598320	1.97	53.26	54.33	50-60	2.12	97.88	None
29	37.946589	-81.598291	1.70	43.25	44.00	40-50	1.82	98.18	Trace
30	37.946533	-81.598492	1.65	59.82	60.82	60-70	2.09	97.91	Medium
31	37.946368	-81.598447	1.45	54.81	55.62	50-60	0.42	99.58	Trace
32	37.946319	-81.598683	1.63	62.43	63.46	60-70	4.85	95.15	Trace
33	37.946117	-81.598648	1.73	54.52	55.48	50-60	1.85	98.15	None
34	37.946060	-81.598839	1.63	55.45	56.27	50-60	0.73	99.27	None
35	37.945872	-81.598805	1.57	51.22	52.09	50-60	1.67	98.33	Trace
36	37.945829	-81.599001	1.98	51.16	52.19	50-60	1.74	98.26	None
37	37.946889	-81.599261	1.84	64.17	65.37	60-70	0.00	100.00	Trace
38	37.940426	-81.596446	2.03	51.77	52.84	50-60	4.88	95.12	Medium
39	37.940596	-81.596584	1.84	48.33	49.24	40-50	2.02	97.98	Very Large
40	37.940686	-81.596398	1.95	52.07	53.11	50-60	1.66	98.34	Medium
41	37.940804	-81.596586	2.07	42.69	43.59	40-50	3.90	96.10	Medium
42	37.940913	-81.596425	1.82	52.75	53.73	50-60	3.52	96.48	Small
43	37.941027	-81.596597	1.74	43.97	44.75	40-50	1.73	98.27	Large
44	37.941144	-81.596408	1.68	48.72	49.55	40-50	0.07	99.93	Small
45	37.941258	-81.596581	1.71	46.50	47.31	40-50	0.86	99.14	Medium
46	37.941379	-81.596425	1.77	48.96	49.84	40-50	0.00	100.00	Trace
47	37.941464	-81.596575	1.86	42.12	42.92	40-50	0.83	99.17	Medium
48	37.941609	-81.596420	2.15	44.96	45.95	40-50	0.60	99.40	None
49	37.941687	-81.596585	1.99	41.99	42.84	40-50	2.15	97.85	Small
50	37.941836	-81.596417	1.84	45.05	45.89	40-50	1.26	98.74	Trace
51	37.940434	-81.603865	2.54	15.01	15.40	30-40	80.30	19.70	Very Large

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
52	37.940468	-81.600910	2.63	45.55	46.78	40-50	2.14	97.86	Small
53	37.940584	-81.600733	2.63	47.77	49.06	40-50	3.72	96.28	Very Large
54	37.940687	-81.600918	2.27	46.22	47.29	40-50	5.25	94.75	Medium
55	37.940790	-81.600741	1.74	56.38	57.38	50-60	4.08	95.92	Medium
56	37.940904	-81.600911	1.69	54.06	54.99	50-60	7.31	92.69	Small
57	37.941024	-81.600745	1.82	55.07	56.09	50-60	2.66	97.34	Medium
58	37.941128	-81.600907	1.88	48.72	49.65	40-50	8.56	91.44	Large
59	37.941240	-81.600744	2.16	49.91	51.01	50-60	15.19	84.81	Large
60	37.941347	-81.600934	2.24	44.03	45.04	40-50	0.89	99.11	Medium
61	37.941474	-81.600759	2.53	44.08	45.22	40-50	1.59	98.41	Large
62	37.941571	-81.600932	2.92	41.59	42.84	40-50	0.00	100.00	Medium
63	37.941687	-81.600771	3.09	41.41	42.73	40-50	1.37	98.63	Very Large
64	37.941785	-81.600915	2.17	48.40	46.41	40-50	0.00	100.00	Very Large
65	37.945432	-81.599249	1.82	42.98	43.78	40-50	3.39	96.61	Trace
66	37.945289	-81.599112	2.13	43.01	43.95	40-50	1.08	9.92	Small
67	37.945160	-81.599242	1.71	45.30	46.09	40-50	37.87	62.13	Medium
68	37.945056	-81.599098	2.01	41.82	42.68	40-50	0	100	Medium
69	37.944898	-81.599209	2.15	42.52	43.45	40-50	0.59	99.41	Small
70	37.944755	-81.599073	1.95	44.12	45.00	40-50	46.13	53.87	Small
71	37.944608	-81.599215	1.90	38.84	39.59	30-40	1.57	98.43	Small
72	37.945433	-81.601295	1.97	45.25	46.16	40-50	76.72	23.28	Large
73	37.945546	-81.604052	1.74	42.75	43.51	40-50	30.91	69.09	Very Large
74	37.945117	-81.606111	1.81	33.78	34.40	30-40	5.42	94.58	Trace
75	37.944864	-81.606100	1.70	39.33	40.01	40-50	3.64	96.36	None
76	37.944700	-81.606282	1.55	34.51	35.05	30-40	4.11	95.89	None
77	37.940455	-81.605076	3.43	55.83	57.81	50-60	30.93	69.07	Trace
78	37.940547	-81.604911	2.35	36.94	37.83	30-40	0.23	99.77	Large
79	37.940672	-81.605098	2.60	42.05	43.17	40-50	26.55	73.45	Medium
80	37.940767	-81.604908	2.68	44.29	45.51	40-50	4.05	95.95	Medium
81	37.940883	-81.605087	1.88	48.66	49.59	40-50	0.99	99.01	Medium
82	37.940989	-81.604902	2.24	56.82	58.12	50-60	5.60	94.40	Medium
83	37.941108	-81.605077	1.73	46.61	47.43	40-50	9.56	90.44	Large
84	37.941222	-81.604911	1.93	50.44	51.43	50-60	0.00	100.00	Medium
85	37.941332	-81.605087	1.87	46.42	47.27	40-50	0.00	100.00	Trace
86	37.941555	-81.605085	2.18	47.51	48.57	40-50	6.62	93.38	Medium
87	37.941674	-81.604918	2.05	39.14	39.96	30-40	0.00	100.00	Small
88	37.941787	-81.603012	2.15	35.85	36.64	30-40	0.00	100.00	Large
89	37.941682	-81.603173	1.51	57.76	58.65	50-60	2.59	97.41	Medium
90	37.941555	-81.603014	2.40	40.44	41.43	40-50	0.00	100.00	Trace
91	37.941449	-81.603180	2.13	44.86	45.84	40-50	5.45	94.55	None
92	37.941344	-81.603024	2.20	45.09	46.10	40-50	2.07	97.93	Small
93	37.941235	-81.603175	2.11	45.19	46.16	40-50	3.69	96.31	Large
94	37.941115	-81.602992	1.88	49.43	50.38	50-60	0.00	100.00	Medium
95	37.940997	-81.603176	1.86	48.48	49.40	40-50	2.48	97.52	Large
96	37.940898	-81.603032	1.82	51.73	52.69	50-60	9.01	90.99	Trace
97	37.940786	-81.603189	2.44	47.74	48.03	40-50	7.50	92.50	Medium
98	37.940668	-81.603019	2.19	45.45	46.46	40-50	4.83	95.17	Trace
99	37.940558	-81.603188	2.16	38.88	39.74	30-40	30.73	69.27	Medium
100	37.940459	-81.602984	2.18	45.45	46.46	40-50	4.83	95.17	Trace
101	37.940263	-81.603175	2.37	43.00	44.04	40-50	2.53	97.47	Large
102	37.942179	-81.598684	1.34	55.68	56.44	50-60	10.00	90.00	None
103	37.942073	-81.598501	1.51	47.38	48.11	40-50	1.25	98.75	Trace
104	37.941942	-81.598327	1.45	58.10	58.95	50-60	0.00	100.00	None
105	37.942076	-81.598141	1.29	51.04	51.71	50-60	6.19	93.81	Trace
106	37.941950	-81.597986	1.70	51.43	52.32	50-60	0.00	100.00	None
107	37.942077	-81.597831	1.47	47.30	48.01	40-50	3.34	96.66	None

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
108	37.941937	-81.597640	2.55	44.39	45.55	40-50	13.47	86.53	Trace
109	37.942153	-81.597154	2.18	42.94	43.90	40-50	0.26	99.74	Small
110	37.942283	-81.596955	1.92	47.34	48.27	40-50	0.00	100.00	Small
111	37.942424	-81.597138	2.09	48.22	49.25	40-50	1.88	98.12	Small
112	37.942546	-81.596941	1.79	51.22	52.15	50-60	0.00	100.00	Trace
113	37.942687	-81.597121	1.86	49.29	50.22	50-60	0.00	100.00	Small
114	37.942810	-81.596954	1.66	51.85	52.73	50-60	0.20	99.80	Small
115	37.942966	-81.597129	1.46	49.38	50.42	50-60	0.00	100.00	Trace
116	37.943113	-81.596948	1.56	50.84	51.65	50-60	2.74	97.26	Trace
117	37.943235	-81.597127	1.62	53.62	54.50	50-60	0.55	99.45	Trace
118	37.943383	-81.596949	1.54	54.04	54.89	50-60	0.93	99.07	Small
119	37.943518	-81.597126	1.54	55.73	56.60	50-60	0.36	99.64	Small
120	37.943795	-81.597113	1.56	50.67	51.47	50-60	0.00	100.00	Trace
121	37.944141	-81.597652	1.86	54.92	55.96	50-60	2.26	97.74	Trace
122	37.944001	-81.597783	1.71	50.21	51.08	50-60	0.00	100.00	Trace
123	37.944134	-81.598006	1.73	51.11	52.01	50-60	0.00	100.00	None
124	37.943993	-81.598159	1.74	48.56	49.42	40-50	0.38	99.62	Trace
125	37.944141	-81.598339	1.91	50.92	51.91	50-60	5.08	94.92	Trace
126	37.943983	-81.598524	1.84	48.29	49.20	40-50	0.00	100.00	Trace
127	37.944150	-81.598729	2.01	43.71	44.61	40-50	1.99	98.01	Trace
128	37.943987	-81.598882	1.91	51.09	52.08	50-60	3.15	96.85	Medium
129	37.944139	-81.599055	2.24	50.16	51.30	50-60	2.57	97.43	Small
130	37.943529	-81.594671	1.60	62.61	63.63	60-70	0.00	100.00	Medium
131	37.943420	-81.594877	1.58	62.40	63.40	60-70	0.00	100.00	Small
132	37.943254	-81.594708	2.22	56.00	57.27	50-60	0.23	99.77	Large
133	37.943112	-81.594535	2.48	54.69	56.08	50-60	0.00	100.00	Large
134	37.942979	-81.594323	2.36	53.77	55.07	50-60	0.00	100.00	Large
135	37.942828	-81.594172	2.64	58.74	60.23	60-70	0.17	99.83	Large
136	37.946146	-81.605568	1.60	45.88	46.63	40-50	3.05	96.95	None
137	37.946281	-81.605400	1.71	35.44	36.06	30-40	0.05	99.95	Trace
138	37.946128	-81.605214	1.81	50.23	51.16	50-60	0.00	100.00	Trace
139	37.946262	-81.605045	1.62	41.97	42.66	40-50	0.63	99.37	Trace
140	37.946142	-81.604869	1.86	50.64	51.60	50-60	0.21	99.79	Trace
141	37.946261	-81.604713	1.69	43.32	44.06	40-50	0.00	100.00	Medium
142	37.946143	-81.604535	1.63	51.56	52.41	50-60	0.00	100.00	None
143	37.949073	-81.604322	2.35	43.33	44.37	40-50	1.70	98.30	Trace
144	37.948726	-81.604312	2.23	41.71	42.66	40-50	0.00	100.00	Medium
145	37.948442	-81.604311	2.06	43.68	44.60	40-50	6.97	93.03	Medium
146	37.948189	-81.604317	2.11	49.40	50.46	50-60	0.00	100.00	Trace
147	37.948042	-81.604539	2.47	54.61	55.99	50-60	0.00	100.00	None
148	37.947911	-81.604707	1.77	45.48	46.30	40-50	1.26	98.74	Small
149	37.948054	-81.604886	2.41	51.13	52.39	50-60	0.00	100.00	Trace
150	37.947923	-81.605052	1.20	41.99	42.50	40-50	75.79	24.21	Small
151	37.948042	-81.605231	1.40	45.73	46.38	40-50	73.11	26.89	Trace
152	37.947899	-81.605403	2.07	43.58	44.50	40-50	0.74	99.26	Trace
153	37.948025	-81.605582	1.28	49.39	50.03	50-60	14.12	85.88	None
154	37.940443	-81.607169	2.80	41.94	43.15	40-50	3.25	96.75	Medium
155	37.940563	-81.607328	2.55	43.81	44.96	40-50	1.22	98.78	Medium
156	37.940673	-81.607166	2.46	42.28	43.35	40-50	3.09	95.91	Small
157	37.940769	-81.607337	2.98	49.90	51.43	50-60	6.66	93.34	Medium
158	37.940884	-81.607171	1.85	55.13	56.17	50-60	0.90	99.10	Medium
159	37.940987	-81.607343	2.16	52.56	53.72	50-60	0.00	100.00	Small
160	37.941099	-81.607165	2.18	56.71	57.97	50-60	0.16	99.84	Medium
161	37.941221	-81.607350	1.99	58.31	59.49	50-60	32.57	67.43	Small
162	37.941329	-81.607171	2.74	53.47	54.98	50-60	8.46	91.54	None
163	37.941432	-81.607349	2.56	50.73	52.06	50-60	0.00	100.00	Medium

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
164	37.941549	-81.607164	2.55	51.85	53.21	50-60	7.90	92.10	Medium
165	37.941655	-81.607340	2.31	51.43	52.65	50-60	0.57	99.43	Trace
166	37.940570	-81.606621	2.19	23.66	24.19	30-40	71.69	28.31	Large
167	37.948411	-81.617593	1.75	53.08	54.03	50-60	57.72	42.28	Very Large
168	37.944386	-81.597479	2.12	55.12	56.31	50-60	0.29	99.71	Medium
169	37.944497	-81.597670	1.93	45.62	46.52	40-50	1.41	98.59	Medium
170	37.944611	-81.597548	1.93	50.94	51.94	50-60	1.70	98.30	Trace
171	37.944744	-81.597733	2.36	46.47	47.59	40-50	1.43	98.57	Trace
172	37.944896	-81.597472	1.83	38.87	39.59	30-40	23.87	76.13	Small
173	37.944988	-81.597510	2.17	49.62	50.72	50-60	0.00	100.00	None
174	37.944989	-81.597427	2.11	51.60	52.71	50-60	2.23	97.77	None
175	37.945017	-81.597842	1.97	44.28	45.17	40-50	0.21	99.79	None
176	37.945016	-81.597677	1.92	44.86	45.74	40-50	5.68	94.32	None
177	37.945425	-81.598303	1.89	39.84	40.61	40-50	0.17	99.83	None
178	37.945586	-81.598755	1.33	56.09	56.85	50-60	20.70	79.30	Trace
179	37.940439	-81.590850	2.74	44.79	46.05	40-50	1.60	98.40	None
180	37.940539	-81.591003	2.49	46.51	47.70	40-50	1.95	98.05	Medium
181	37.940673	-81.590847	2.48	42.04	43.11	40-50	1.25	98.75	Medium
182	37.940795	-81.591029	1.91	55.75	56.84	50-60	0.09	99.91	Small
183	37.940919	-81.590856	1.81	57.28	58.34	50-60	65.42	99.48	Trace
184	37.941051	-81.591036	1.65	64.34	65.42	60-70	0.66	99.34	Trace
185	37.941170	-81.590860	2.01	55.22	56.35	50-60	0.99	99.01	None
186	37.941290	-81.591047	1.93	51.89	52.91	50-60	12.51	87.49	Large
187	37.941412	-81.590852	2.29	44.42	45.46	40-50	0.00	100.00	Trace
188	37.941549	-81.591042	2.08	51.17	52.26	50-60	0.00	100.00	Small
189	37.941662	-81.590851	2.18	40.13	41.02	40-50	8.96	91.04	Medium
190	37.941798	-81.591042	2.09	42.13	43.03	40-50	7.45	92.55	Very Large
191	37.941916	-81.590878	1.91	55.13	56.20	50-60	0.00	100.00	Medium
192	37.944588	-81.603414	2.20	44.82	45.83	40-50	6.71	93.29	Medium
193	37.944726	-81.603249	2.16	27.53	28.14	30-40	82.46	17.54	Very Large
194	37.944877	-81.603401	1.90	48.09	49.02	40-50	1.20	98.80	Small
195	37.944998	-81.603259	2.16	38.34	38.19	30-40	1.84	98.16	Small
196	37.945140	-81.603416	1.95	43.24	44.10	40-50	0.66	99.34	Trace
197	37.945266	-81.603271	1.84	38.34	39.06	30-40	10.45	89.55	Very Large
198	37.945423	-81.603443	1.96	42.44	43.29	40-50	58.89	41.11	Very Large
199	37.945552	-81.603257	2.10	45.09	46.01	40-50	0.50	99.50	Medium
200	37.945687	-81.603410	1.77	50.89	51.60	50-60	0.00	100.00	None
201	37.945934	-81.607927	1.98	10.46	10.67	30-40	88.69	11.31	Very Large
202	37.949034	-81.615241	2.07	49.76	50.81	50-60	22.11	77.89	Very Large
203	37.948858	-81.615085	1.27	41.47	42.00	40-50	40.96	59.04	Large
204	37.948680	-81.615314	2.06	57.66	58.87	50-60	78.37	21.63	Large
205	37.948564	-81.615108	2.62	55.66	57.16	50-60	0.82	99.18	Large
206	37.948391	-81.615333	2.32	50.20	51.39	50-60	13.80	86.20	Large
207	37.954807	-81.606735	2.75	52.35	53.83	50-60	0.00	100.00	Medium
208	37.954679	-81.606912	3.79	44.81	46.58	40-50	1.49	98.51	Large
209	37.954831	-81.606876	2.17	67.63	69.13	60-70	38.07	61.93	Large
210	37.954542	-81.606741	3.33	50.15	51.88	50-60	1.16	98.84	Large
211	37.954425	-81.606916	3.01	58.95	60.78	60-70	2.03	97.97	Large
212	37.954267	-81.606734	2.28	45.41	46.47	40-50	1.94	98.06	Large
213	37.954115	-81.606921	3.77	39.36	40.90	40-50	0.85	99.15	Very Large
214	37.953857	-81.606934	3.55	52.84	54.78	50-60	0.81	99.19	Medium
215	37.953984	-81.606728	3.72	58.76	61.03	60-70	1.37	98.63	Large
216	37.953719	-81.606762	2.27	50.54	51.71	50-60	6.38	93.62	Medium
217	37.953560	-81.606937	3.19	48.33	49.92	40-50	0.00	100.00	Very Large
218	37.953410	-81.606728	2.34	50.62	51.83	50-60	0.97	99.03	Small
219	37.943617	-81.603990	2.36	48.53	49.70	40-50	6.05	93.95	Not E M

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
220	37.943527	-81.604197	1.38	34.29	34.77	30-40	1.13	98.87	None
221	*37.943619*	*-81.603845*	0.00	0.00	100.00		100.00	0.00	No -20 M
222	37.942309	-81.588004	1.38	73.64	74.67	70-80	6.96	93.04	None
223	37.941195	-81.588760	1.48	64.03	64.99	60-70	0.99	99.01	None
224	37.941053	-81.588968	1.14	64.91	65.66	60-70	4.21	95.79	None
225	37.940921	-81.588776	1.31	69.14	70.06	70-80	1.20	98.80	None
226	37.940794	-81.588961	1.41	62.77	63.77	60-70	0.44	99.56	None
227	37.940675	-81.588748	1.57	64.62	65.65	60-70	0.33	99.67	None
228	37.940540	-81.588944	1.52	53.88	54.71	50-60	1.19	98.81	Medium
229	37.940430	-81.588739	1.59	62.28	63.29	60-70	3.03	96.97	None
230	37.946645	-81.600832	2.00	49.02	50.02	50-60	0.86	99.14	None
231	37.946700	-81.600616	1.83	41.31	42.08	40-50	2.18	97.82	Trace
232	37.946893	-81.600670	2.03	56.04	57.20	50-60	0.00	100.00	None
233	37.946943	-81.600428	1.86	44.63	45.48	40-50	2.52	97.48	Medium
234	37.947142	-81.600497	2.12	59.74	61.03	60-70	1.14	98.86	None
235	37.947177	-81.600262	1.74	52.65	53.58	50-60	0.26	99.74	Small
236	37.947376	-81.600351	2.01	58.08	59.27	50-60	2.99	97.01	None
237	37.947407	-81.600090	4.35	49.13	51.36	50-60	0.22	99.78	Medium
238	37.947602	-81.600149	2.55	49.89	51.20	50-60	1.78	98.22	None
239	37.947723	-81.603213	2.57	55.06	56.51	50-60	18.73	81.27	Trace
240	37.947793	-81.603018	2.38	53.81	55.12	50-60	3.34	96.66	Large
241	37.947955	-81.603040	2.72	59.25	60.91	60-70	11.24	88.76	None
242	37.948033	-81.602870	2.28	49.72	50.88	50-60	3.32	96.68	Small
243	37.948216	-81.602878	2.29	47.76	48.88	40-50	4.52	95.48	Medium
244	37.948244	-81.602731	1.67	50.38	51.24	50-60	23.22	76.78	Trace
245	37.948427	-81.602672	2.36	52.25	53.51	50-60	9.03	90.97	Trace
246	37.948513	-81.602508	1.49	48.30	49.03	40-50	57.74	42.26	Trace
247	37.948669	-81.602508	2.43	43.81	44.90	40-50	26.56	73.44	Medium
248	37.948776	-81.602306	2.02	58.31	59.51	50-60	65.57	34.43	None
249	37.948942	-81.602288	2.40	47.79	48.97	40-50	35.84	64.16	Small
250	37.949071	-81.602085	2.23	40.97	41.90	40-50	15.44	84.56	Medium
251	37.949141	-81.601847	2.92	38.05	39.19	30-40	6.94	93.06	Large
252	37.948927	-81.601801	1.83	53.33	54.32	50-60	37.16	62.84	Trace
253	37.948995	-81.601554	2.71	39.61	40.71	40-50	0.64	99.36	Medium
254	37.948798	-81.601485	1.41	70.57	71.58	70-80	62.88	37.12	Small
255	37.948842	-81.601223	2.46	48.05	49.26	40-50	7.17	92.83	Large
256	37.948636	-81.601213	2.65	63.79	65.53	60-70	9.06	90.94	Medium
257	37.948730	-81.600960	2.67	42.32	43.48	40-50	2.62	97.38	Medium
258	37.948534	-81.600888	1.35	71.62	72.60	70-80	0.41	99.59	Large
259	37.948592	-81.600649	1.99	59.42	60.63	60-70	18.19	81.81	Medium
260	37.948404	-81.600579	2.05	49.49	50.53	50-60	43.06	56.94	Very Large
261	37.948460	-81.600361	2.39	56.82	58.21	50-60	0.56	99.44	Large
262	37.948277	-81.600273	3.12	39.56	40.83	40-50	13.35	86.65	Large
263	37.949689	-81.602037	2.75	48.72	50.10	50-60	22.96	77.04	Trace
264	37.949843	-81.602054	2.23	46.93	48.00	40-50	2.42	97.58	Trace
265	37.949946	-81.601889	2.76	44.41	45.67	40-50	18.42	81.58	Large
266	37.950112	-81.601914	2.72	47.64	48.97	40-50	2.53	97.47	Small
267	37.950177	-81.601755	2.15	42.93	43.87	40-50	2.18	97.82	Trace
268	37.950337	-81.601751	2.41	45.23	46.35	40-50	2.24	97.76	Small
269	37.945387	-81.606128	1.99	32.30	32.96	30-40	40.79	59.21	Trace
270	37.945537	-81.606355	1.91	34.49	35.16	30-40	50.48	49.52	Very Large
271	37.945665	-81.606099	1.67	30.09	30.60	30-40	2.24	97.76	Trace
272	37.945818	-81.606357	2.13	29.11	29.74	30-40	23.74	76.26	Very Large
273	37.945943	-81.606104	1.74	37.32	37.98	30-40	24.15	75.85	None
274	37.945387	-81.607581	1.77	34.03	34.64	30-40	80.61	19.39	Trace
275	37.945548	-81.607743	2.53	30.10	30.88	30-40	0.76	99.24	Very Large

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
276	37.945660	-81.607560	2.69	35.71	36.70	30-40	26.92	73.08	Very Large
277	37.945810	-81.607754	2.25	34.92	35.72	30-40	39.50	60.50	Very Large
278	37.945936	-81.607596	1.68	21.02	21.38	30-40	61.00	39.00	Large
279	37.948437	-81.606190	2.48	51.96	53.28	50-60	5.76	94.24	None
280	37.948729	-81.606208	2.14	49.95	51.04	50-60	1.60	98.40	None
281	37.949057	-81.606190	1.67	42.85	43.58	40-50	10.75	89.25	Small
282	37.952921	-81.604141	2.19	46.02	47.05	40-50	0.83	99.17	Medium
283	37.952946	-81.603795	2.18	45.60	46.62	40-50	0.00	100.00	Trace
284	37.952959	-81.603436	2.12	45.97	46.97	40-50	8.17	91.83	Trace
285	37.952943	-81.603101							
286	37.952931	-81.602755	2.78	48.64	50.03	50-60	4.39	95.61	Trace
287	37.952933	-81.602412	2.98	44.53	45.90	40-50	13.37	86.63	Trace
288	37.950757	-81.604121	2.52	50.47	51.77	50-60	0.00	100.00	Trace
289	37.950751	-81.603773	2.34	50.55	51.76	50-60	3.07	96.93	None
290	37.950751	-81.603423	2.59	45.52	46.73	40-50	5.33	94.67	Trace
291	37.950749	-81.603087	2.05	43.03	43.93	40-50	1.88	98.12	Medium
292	37.950744	-81.602741	2.14	48.06	49.11	40-50	0.00	100.00	Small
293	37.950776	-81.602383	3.39	51.30	53.10	50-60	7.07	92.93	None
294	37.944400	-81.603956	1.45	25.20	25.57	30-40	9.77	90.23	None
295	37.943995	-81.604135	1.34	32.48	32.92	30-40	12.78	87.22	None
296	37.941741	-81.603488	1.28	35.48	35.94	30-40	38.35	61.65	Trace
297	37.944615	-81.599494	2.74	58.11	59.75	50-60	1.92	98.08	Small
298	37.944880	-81.600973	2.84	53.13	54.68	50-60	1.15	98.85	Large
299	37.942455	-81.604189	1.4	46.11	46.76	40-50	18.98	81.02	None
300-A	37.942266	-81.603881	1.17	51.38	51.99	50-60	25.24	74.76	None
300-B	37.942265	-81.604206	1.54	33.81	34.34	30-40	11.1	88.9	None
301	37.942057	-81.604180	1.29	38.3	38.8	30-40	4.08	95.92	None
302	37.942029	-81.603866	1.5	41.57	42.2	40-50	4.11	95.89	Trace
303-A	37.941967	-81.604180	1.45	41.35	41.96	40-50	1.74	98.26	Trace
303-B	37.941967	-81.604180	1.93	36.51	37.23	30-40	1.74	98.26	Trace
304-A	37.941951	-81.604177	1.42	45.45	46.1	40-50	5.9	94.1	None
304-B	37.941953	-81.603867	1.63	37.59	38.21	30-40	11.1	88.9	None
305-A	37.944586	-81.603961	1.62	44.22	45.04	40-50	0.50	99.50	Trace
305-B	37.944585	-81.604201	2.03	42.05	42.92	40-50	0.00	100.00	None
306-A	37.944523	-81.603954	1.89	43.50	44.34	40-50	0.93	99.07	Trace
306-B	37.944522	-81.604213	1.70	35.03	35.64	30-40	10.10	89.90	None
307-A	37.944449	-81.603951	1.73	29.19	29.70	30-40	19.92	80.08	None
307-B	37.944440	-81.604209	1.85	31.61	32.21	30-40	6.42	93.58	None
308-A	37.944283	-81.603951	1.58	26.65	27.08	30-40	12.34	87.66	None
308-B	37.944287	-81.604185	2.00	37.67	38.44	30-40	0.00	100.00	None
309-A	37.944078	-81.603939	1.54	29.41	29.87	30-40	10.71	89.29	None
309-B	37.944079	-81.604182	1.95	37.24	37.98	30-40	0.00	100.00	None
310-A	37.943949	-81.603937	1.59	33.04	33.57	30-40	3.24	96.76	None
310-B	37.943952	-81.604199	1.93	38.85	39.61	30-40	2.36	97.64	Small
311-A	37.943791	-81.603930	1.38	30.89	31.32	30-40	13.27	86.73	None
311-B	37.943793	-81.604190	1.97	33.03	33.69	30-40	0.00	100.00	Trace
312	37.943602	-81.604276	1.35	40.31	40.86	40-50	7.29	92.71	Trace
313-A	37.943599	-81.603927	1.56	41.29	41.94	40-50	0.00	100.00	None
313-B	37.943600	-81.604190	1.58	41.73	42.40	40-50	0.00	100.00	None
314	37.943592	-81.604011	1.44	40.70	41.29	40-50	34.89	65.11	Trace
315-A	37.943457	-81.603935	1.58	33.08	33.61	30-40	1.65	98.35	None
315-B	37.943458	-81.604180	1.58	40.15	40.79	40-50	0.54	99.46	Medium
316-A	37.943109	-81.603923	1.64	36.18	36.78	30-40	0.84	99.16	None
316-B	37.943108	-81.604167	1.61	38.42	39.05	30-40	0.33	99.67	None
317-A	37.942950	-81.603923	1.80	40.02	40.75	40-50	0.00	100.00	None
317-B	37.942950	-81.604162	1.53	37.10	37.68	30-40	4.02	95.98	None

Sample	LAT	LONG	Moisture	As-Rec.	Dry	TIC Range	% of +20M	% of -20M	Coke Test
318-A	37.942792	-81.603920	1.69	33.98	34.56	30-40	0.28	99.72	None
318-B	37.942792	-81.604162	1.22	46.57	47.15	40-50	3.71	96.29	None
319-A	37.942619	-81.603913	1.73	33.26	33.85	30-40	0.98	99.02	None
319-B	37.942617	-81.604165	1.58	40.69	41.34	40-50	2.40	97.60	None
320-A	37.942625	-81.603770	1.76	29.37	29.90	30-40	12.36	87.64	None
320-B	37.942620	-81.604292	1.49	47.69	48.41	40-50	13.27	86.73	None
321-A	37.942491	-81.604156	1.80	38.90	39.61	30-40	0.00	100.00	None
321-B	37.942491	-81.603906	1.39	46.32	46.97	40-50	2.95	97.04	None
322-A	37.942250	-81.604168	1.80	40.02	40.75	40-50	0.00	100.00	None
322-B	37.942252	-81.603894	1.36	44.78	45.40	40-50	10.80	89.20	None
323-A	37.941965	-81.603922	1.98	38.14	38.91	30-40	1.21	98.79	Trace
323-B	37.941967	-81.604136	1.22	46.57	47.15	40-50	3.71	96.29	None
324-A	37.941889	-81.603913	1.77	41.61	42.36	40-50	0.00	100.00	None
324-B	37.941888	-81.604153	1.21	47.52	48.10	40-50	2.74	97.26	None
325-A	37.941807	-81.603998	1.60	29.91	30.40	30-40	39.45	80.55	Trace
325-B	37.941807	-81.603998	1.55	43.20	43.88	40-50	3.84	96.16	None
325-C	37.941807	-81.603998	2.48	47.89	49.11	40-50	10.30	89.70	None
325-D	37.941807	-81.603998	2.64	47.39	48.68	40-50	7.18	92.82	None
325-E	37.941807	-81.603998	1.67	42.95	43.68	40-50	5.52	94.48	None
325-F	37.941807	-81.603998	1.67	42.58	43.30	40-50	5.06	94.94	None
325-G	37.941807	-81.603998	1.61	40.00	40.65	40-50	8.38	91.62	None
325-H	37.941807	-81.603998	1.51	31.03	31.51	30-40	13.68	86.32	Trace
325-I	37.941807	-81.603998	2.53	50.61	51.92	50-60	25.98	74.02	None
325-J	37.941807	-81.603998	2.67	41.93	43.08	40-50	13.13	86.87	None
325-K	37.941807	-81.603998	3.02	51.06	52.65	50-60	19.77	80.23	None
326	37.941807	-81.603998	1.25	49.28	49.90	40-50	40.94	59.06	None
327	37.941807	-81.603998	1.32	44.97	45.57	40-50	39.58	60.42	None
328									
329	37.941807	-81.603998	1.44	41.94	42.55	40-50	33.32	66.68	None
330	37.948587	-81.600451	2.3	50.24	51.42	50-60	0.23	99.77	Very Large

APPENDIX 7.9-2

USING ROOF PANS AS INDICATORS of WIND PRESSURE and HEAT

Roof pans are pre-shaped thin steel plates, about 1/32-inch thick, used with roof bolts to add supplemental passive support to reduce the amount of rock spalling that can occur between roof bolts over time. When roof pans are used they are usually installed between a bolt plate[1] and the mine roof during the roof bolting cycle. Sometimes, they are used in supplemental bolting of mine ribs. They are embossed in some manner to increase their rigidity to bending and usually have a very thin coating of rust preventative material, such as zinc (galvanized).

Deformation of the pans caused by the wind forces during a mine explosion provides useful information about the direction and magnitude of the explosion forces. Roof pans may also have some value as indicators of heating in that high temperatures of the explosion may vaporize the thin rust preventative coating resulting in more rust over time to those particular pans. Their ubiquity across the explosion region of the mine made them useful as a comparative tool and so they were documented and classified by WVOMHS&T as part of this report.

Figure 1. (LEFT) Example of round pan (pizza pan). (RIGHT) Example of square pan (spider plate).

Figure 1 illustrates two types of roof pans used at the UBB: A round pan approximately 18 inches across (called a *pizza pan* or *pie pan*) and a square pan approximately 18" x 18," (also known as a *spider plate* or *R2 pan*). Both types of pans were used in this mine, typically as a single line of pans over the miner operator's position in the entry or crosscut as it was being advanced [2] (see **Figure 2**). Additional pans were installed, as roof conditions warranted.

[1] Bolt plates are 8"x 8" square steel plates. Their thickness at UBB was 3/16."
[2] The side where the continuous miner operator is typically stationed during remote control operation.

During our investigation two aspects of pan damage were studied: pan bending and pan rusting. While pan bending gives evidence to the direction and magnitude of wind forces, the pans also subsequently rusted in ways which the investigators believed are indicative of their relative exposure to heat and flame. The amount and direction of bending varied considerably, and the large amount of data and complicated patterns seemed at first to defy comprehension. However, when studied systematically, classified, and mapped in a consistent descriptive manner, useful patterns and relationships emerged. A methodology was developed for observing, categorizing, and recording roof pan damage, which is summarized below.

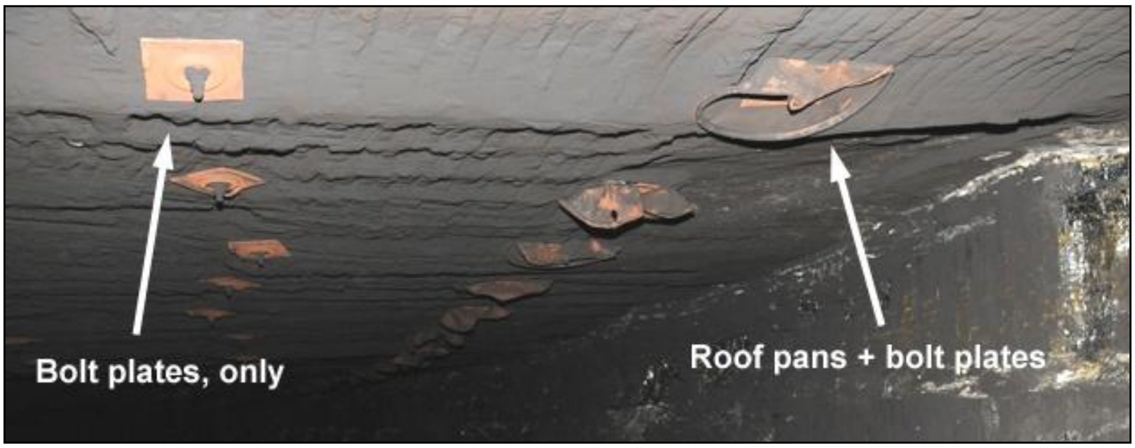


Figure 2. Example of roof pans (right) after explosion. Typically, four lines of bolts are installed on 4-ft. centers, but only one line incorporates roof pans at UBB. Additional roof pans are installed as roof conditions require. Round pans or "pizza pans" are used in this example.

Guidelines Developed for Classifying Roof Pan Bending

Below are four (4) basic rules which were developed to facilitate the classification of roof pans.

(1) Intersections. After an initial period of fieldwork underground, it was determined that for a meaningful characterization of pans to be possible, the intersections would have to be ignored. Where mine entries and crosscuts intersect each other, turbulence from reflected forces, cross-current forces, and multiple wind events often create random and contradicting patterns. The passageways *between* intersections, however, contain roof pan bending patterns that are more indicative of the actual wind direction and relative magnitude of force in that particular heading and location. With few exceptions, roof pans in all mine entries and crosscuts were systematically evaluated and counted according to direction of bending and as a group classified

for rusting, one by one, from the edge of one intersection to the next.[3] The region mapped in this fashion involved approximately 50 miles of entries and crosscuts.

(2) Recognizing previous bending. Some roof pan damage originated from impacts unrelated to the explosion. As a generally rule, a pan was not counted as explosion damage unless it satisfied three criteria:

(a) The roof pan has been bent 90-degrees or more (see **Figure 3)** in an example of a bending angle of approximately 180 degrees.

(b) The roof pan bending did not have markings or fine tears that might indicate pre-explosion impact from equipment, roof fall, or related cause

(c) The damage was consistent with other styles of observed explosion-related deformation

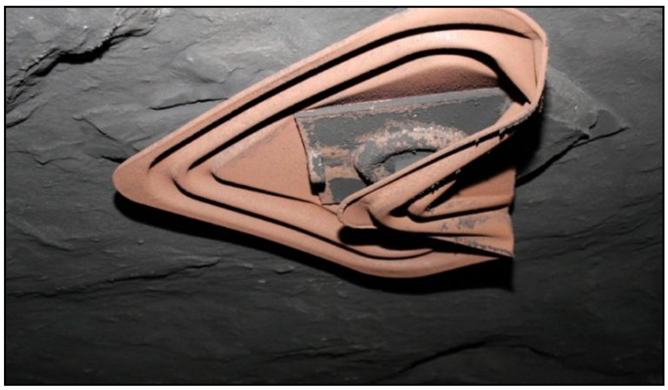


Figure 3. Example of simple roof pan bending in one direction—the most common mode of bending observed during the investigation.

Sometimes exceptions were made. For example, if pan bending was subtle (less than 90 degrees) but consistent and under a relatively even roof, it might be noted on our mapping (but usually was not counted).[4] Pans along the ribs near intersections were sometimes documented as examples of bending due to reflected pressure. Pans which could be rotated by hand around the roof bolt were not counted.

(3) Observe all areas. Early attempts at documenting pan bending by simply spot-checking certain areas proved to be inadequate. On September 13, 2010 WVOMHS&T began a supplemental mapping effort. By that time, a structured methodology had been developed that

[3] Mapping in #21 Tailgate west of BRK #81 was terminated prematurely due to deteriorating roof conditions that had blocked all routes in or out, except one.

[4] For example #21 Tailgate in parts of the regions SE and SW from the longwall. The WV Flames and Forces Map notes these few exceptions.

was suitable for the range of bending and rusting styles that were present in the study area. This work was undertaken to provide an objective and detailed compilation for future study and analysis, from which to base and test hypotheses. The emerging *West Virginia Flames and Forces Map* became a working blueprint for exploration and documentation of the explosion forces throughout the mine.

(4) Normalization of pan counts. Groups of pans were counted and recorded using arrows and numbers, according to their bending direction (see **Figure 4**). Because the actual numbers of installed pans varied, they were counted and noted in terms of "one equivalent line of pans," in order to normalize the counts. Pan counts were used to supplement directional information to organize the data in GIS for constructing summary contour maps of bending directions (see **Map 4A** and **Map 4B)**.

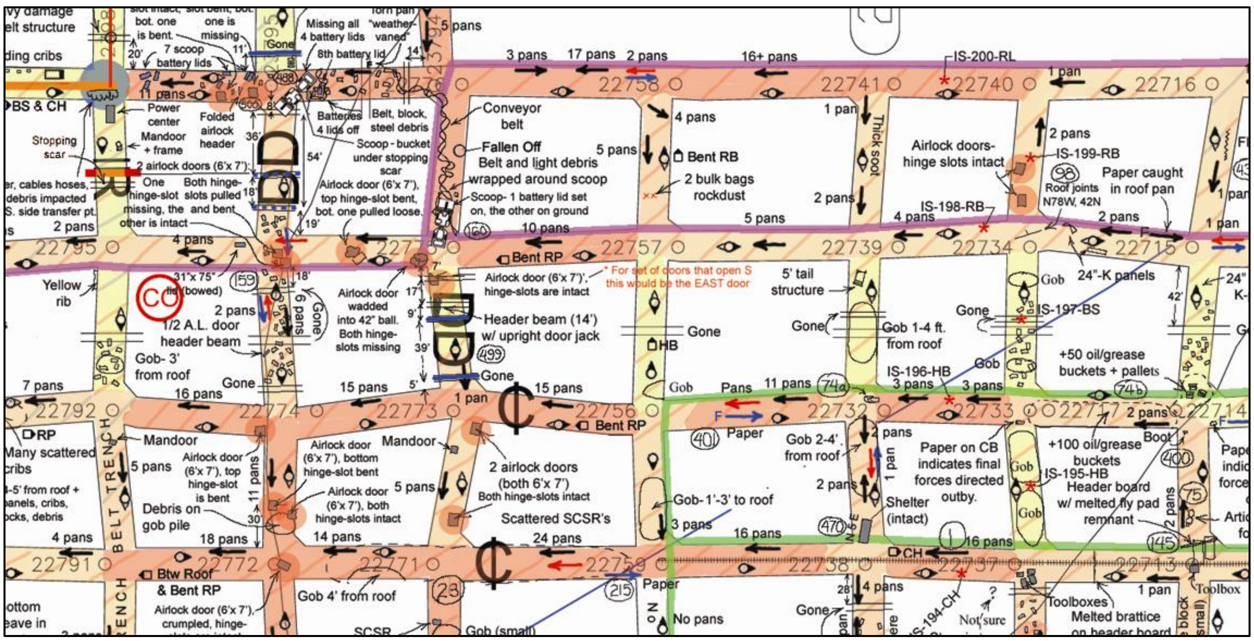


Figure 4. An excerpt of Sheet 4A of the *West Virginia Flames and Forces Map*. The full map is comprised of eight separate sheets.

Most of the passageways in the mine have a single line of roof pans, from which the pan counts are primarily based. If additional pans were present, they were typically not counted unless a pan in the primary line was missing. Only a few small areas did not have roof pans.

Procedure for Representing Pan Bending onto Work Maps

An operating procedure and instructions were developed to standardize the recording and depiction of data pertaining to pan type, damage, and degree of rusting. A copy of these instructions can be found in **Exhibit 1.** This short-hand expedited data recording in the mine and data transfer at night to the *West Virginia Flames and Forces Map*.

A 3-color classification was adopted for depicting the observed relative degrees of ***pan bending*** using a solid background fill pattern. A simplified version of the compiled map is shown in **Map 1**, and summarized as follows:

(a) **NO pan bending**: The GRAY regions shown in **Map 1** indicate where pan bending did not occur **(**see **Figure 5**).[5] These are relatively quiet areas of the mine, in which comparatively less damage occurred.

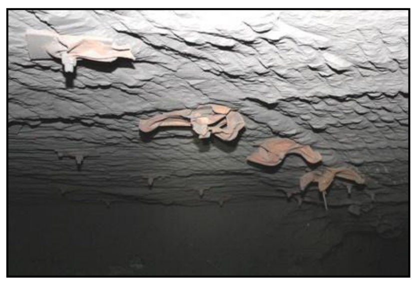
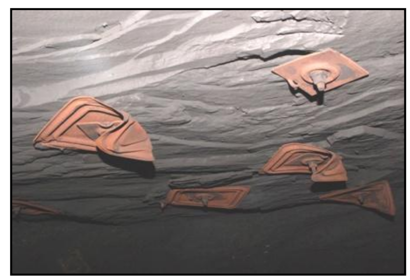




Figure 5. (Left) An example of "NO PAN BENDING." Pans bent < 90 degrees.

Figure 6. (Middle) An example of "SEVERE PAN BENDING." Generally,10 or more pans bent >90 degrees were in this category[6]. The mangled style was more diagnostic than the numbers.

Figure 7. (Right) An example of "MODERATE PAN BENDING." Pans bent > 90 degrees but not severely bent and mangled fell into this category.

(b) **SEVERE pan bending**: The RED regions in **Map 1** are used to indicate high numbers of bent pans and severe pan bending (**Figure 6**). Usually this involved 10 or more pans bent in one equivalent line of roof bolts, between the two adjacent intersections. Such severe pan bending was found in regions where severe damage to other structures was evident, and was where high flame speeds and/or high reflected pressures were involved. These occurred at physical obstructions, such as dead ends caused by roof falls or the farthest point of mining advancement. They also occurred at "T" intersections such as the junction of #21 Tailgate with #21 Cross-over, and also #22 Tailgate with #22 Cross-over. A third place they occurred was in the middle of #22 Headgate and #9 North, where the northern entries were playing catch-up and then overtaking

[5] The WV Flames and Forces Map used the color YELLOW to represent "no pan-bending."
[6] Pan counts were one-equivalent line of pans between adjacent intersections.

the southern entries as the leading edge of the propagating explosion. In case of the last two, the common denominator was their flame speeds were changing on one side of the headings, relative to the other. When the explosions leading edge finally switched sides, the direction of stopping breach in the crosscuts also changed (see **Appendix 7.9-4**). These examples are considered to be evidence of various modes of pressure reflections.

(c) **MINOR to MODERATE pan bending**: The ORANGE regions in **Map 1** are used to denote intermediate levels of pan bending damage (see **Figure 7**). This category includes everything in between categories (a) and (b), above. Their bending directions generally mirror the overall damage to other structures, although many variations and exceptions are possible and do occur.

The Effect of Physical Surroundings

Uneven and potted-out mine roof creates turbulent airflows which can result in significant damage to pans in their vicinity, while pans on flat mine roof in the same entry remain unaffected. Pans that are flat against the mine roof are more difficult for passing explosion wind forces to develop the leverage necessary to bend them.

Roof falls or gob piles that create obstructions resulting in opening heights of 2 feet or less tend to serve as "blast attenuators" which greatly reduce explosion wind pressures to structures on their leeward side. Damage to overlying roof pans tend to be magnified as wind energy increases at the constriction.

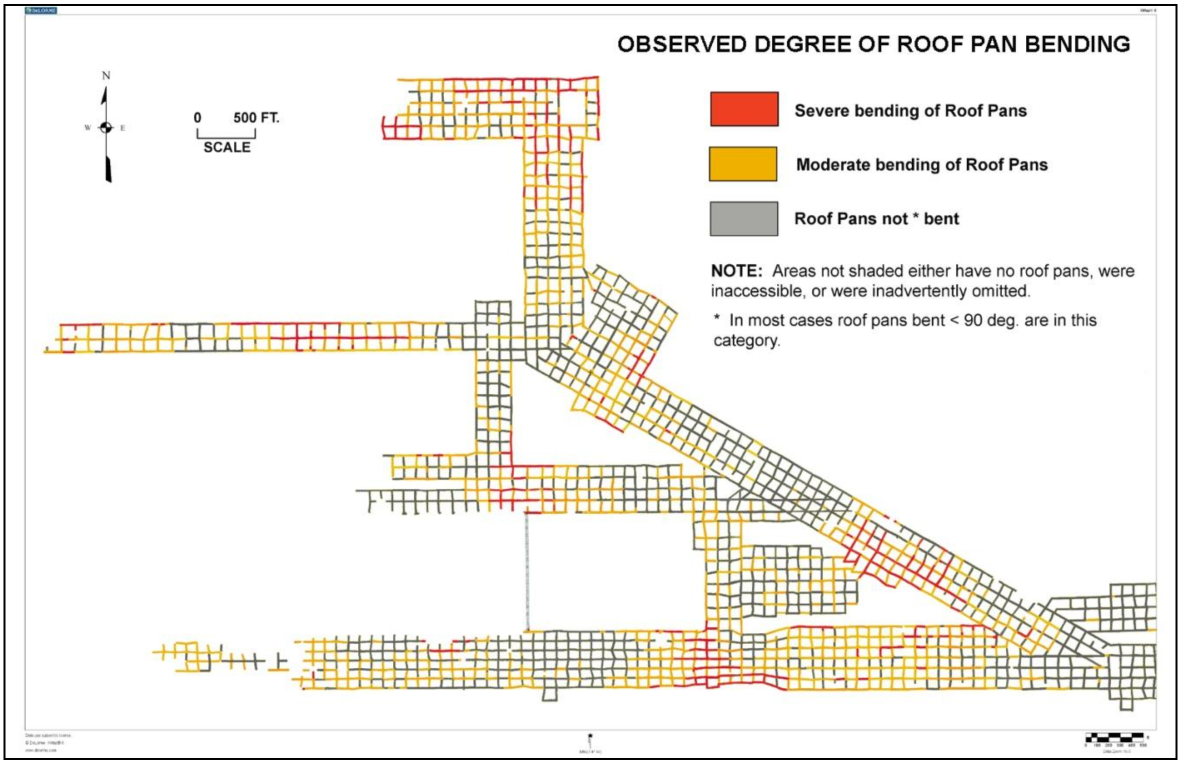
Locations in the mine with high cross-sectional areas, such as roof falls that have been cleaned up and re-bolted, typically have little or no pan damage, whereas nearby areas with typical roof heights[7] have more pan damage. These conditions result because the air velocity due to wind forces varies inversely with the area, and the forces associated with the air flow increase with the square of the velocity.

Guidelines Developed for Classifying Pan Rusting

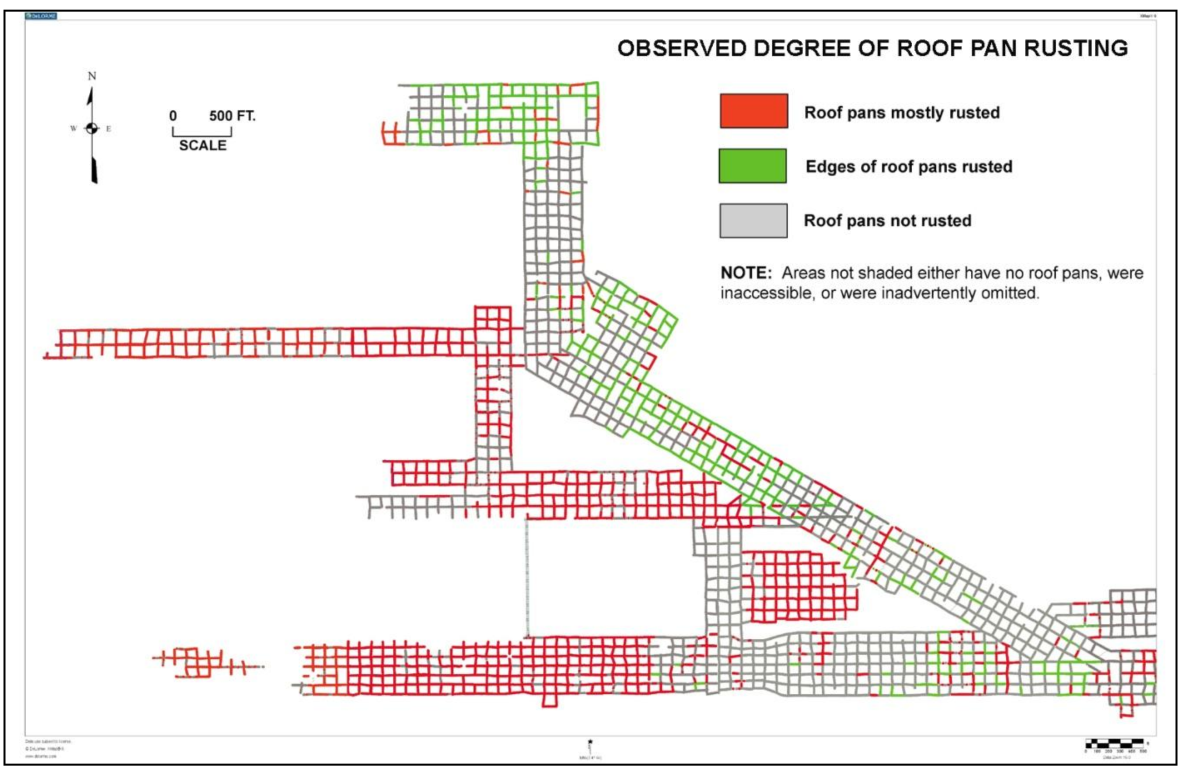
The classification short-hand that was developed also was descriptive of the relative amount of *pan rusting* that was observed (see **Exhibit 1)**, and facilitated transfer of this information to the *West Virginia Flames and Forces Map*.

The descriptions for pan rusting are simple and general, as the significance of this information was not known at the time they were mapped. The pans were either rusted, not rusted, or the edges, only were rusted.

[7] Normal mining height averages approximately 7.5'



Map 1. The relative degree of “Pan Bending,” summarized from the *WV Flames and Forces Map*.



Map 2. The relative degree of “Pan Rusting,” summarized from the *WV Flames and Forces Map*.

From the start of the investigation in July, 2010, many of the moderately to severely damaged pans already developed a reddish-brown patina due to erosion of their galvanized finish. As the investigation progressed, the pans in several areas which had been mapped originally a few months earlier as “no rusting” had begun to develop rusted edges.

Procedure for Representing Pan Rusting

Although the data may be subjective, the relative degrees of pan rusting were observed and represented, as described below. A 3-color hatch-pattern classification system was devised for representing the relative amount of ***pan rusting*** on the *West Virginia Flames and Forces Map.* [8]

(a) **NO** Rusting: Pans which are not rusted (**Figure 8**) are indicated in GRAY. In general, pans that were not rusted were not bent or were moderately bent. There were just a few examples where severely bent pans were not rusted.

(b) **MOSTLY** or entirely **RUSTED**: The color RED is used to indicate pans that are mostly or entirely rusted (**Figure 9**). Pans that were severely bent were usually rusted, although there are a few examples where this was not the case.

(c) **EDGES** of pans, only **RUSTED**: The color GREEN is used to indicate when most of the pan itself is not rusted, just the exposed edges (**Figure 10**). Over time, some of the areas that were originally mapped as “not rusted” began showing effects of edge rusting. This category represents a transition between (a) and (b), above.

Some pans outside the explosion area also exhibit rusting, but a distinctly different style of rusting. These outby pans have a pitted, corroded, appearance, which is likely due to the combination of age and gradual oxidation.

Figure 8. (Left) An example of a roof pan Not Rusted **Figure 9**. (Middle) An example a roof pan Mostly or Entirely Rusted. **Figure10**. (Right) An example of a roof pan with Edges, Only Rusted

[8] **Map 2** uses solid fills instead of hatch patterns, for clarity at this reduced scale.

Effects of Heating on Pan Rusting

General observations indicated that round pans were rusted less than square pans. Factors, such as the type of finish on the outside of the pans, whether enamel or galvanized, the thickness of that finish, and amount of weathering, (how long pans may have been subjected to moisture both during and after installation) also may have an influence on the degree of pan rusting. It is believed that at least a portion of their rusted appearance is due to exposure to heat, flame, and perhaps abrasion during the explosion.

A stack of unbound square pans found in a cross-cut near the mouth of #22 Headgate exhibits the reddish-brown patina rusting on exposed surfaces (see **Figure 11**). The surfaces that were exposed to heat, wind, and abrasion showed rusting, while the sheltered surfaces do not.

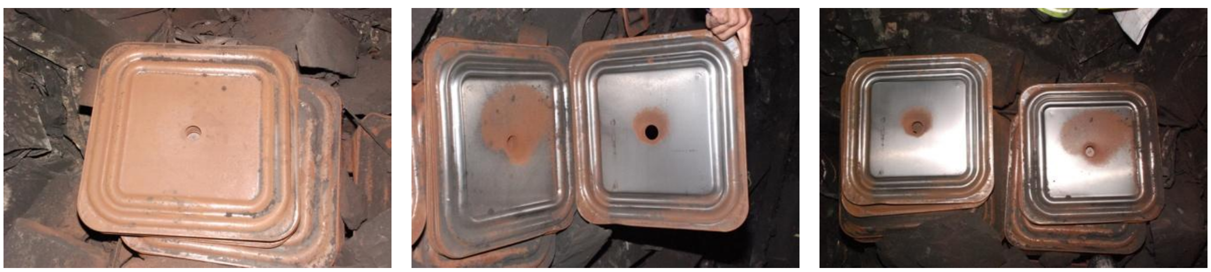


Figure 11. A stack of square pans found near the mouth of #22 Headgate survived the explosion and exhibited general rusting on their outside surfaces. Inside the stack, the only rusting was in the vicinity of the 1" roof bolt hole. It is believed that the "patina rusting" is due mainly to heat vaporizing some or all of the galvanized finish. Abrasion by wind-born particles may also play a role.

It is likely that the pans were affected by the explosion in a way that led to increased rates of oxidation. The pans are thin sheet metal, only about 0.08 cm thick, and both the steel of the pan and the zinc coating are good conductors of heat. An explosion can generate temperatures above the melting temperature of zinc, 692° K, and its vaporization temperature of about 1,180° K. Assuming the pans were exposed to a temperature of 1,627° K, investigators estimate the time required to reach the temperature necessary to destroy the rust-preventative coating on the pan. It was determined that such reactions were possible, but additional research is needed to validate this theory.

It is also believed that other factors such as the quality and type of protective finish used on the pans, the length of time that had elapsed since their installation, and possibly their exposure to the weather in the mine yard before installation may have had an effect. See **Figure 12** for the estimated plate temperature rise with time.

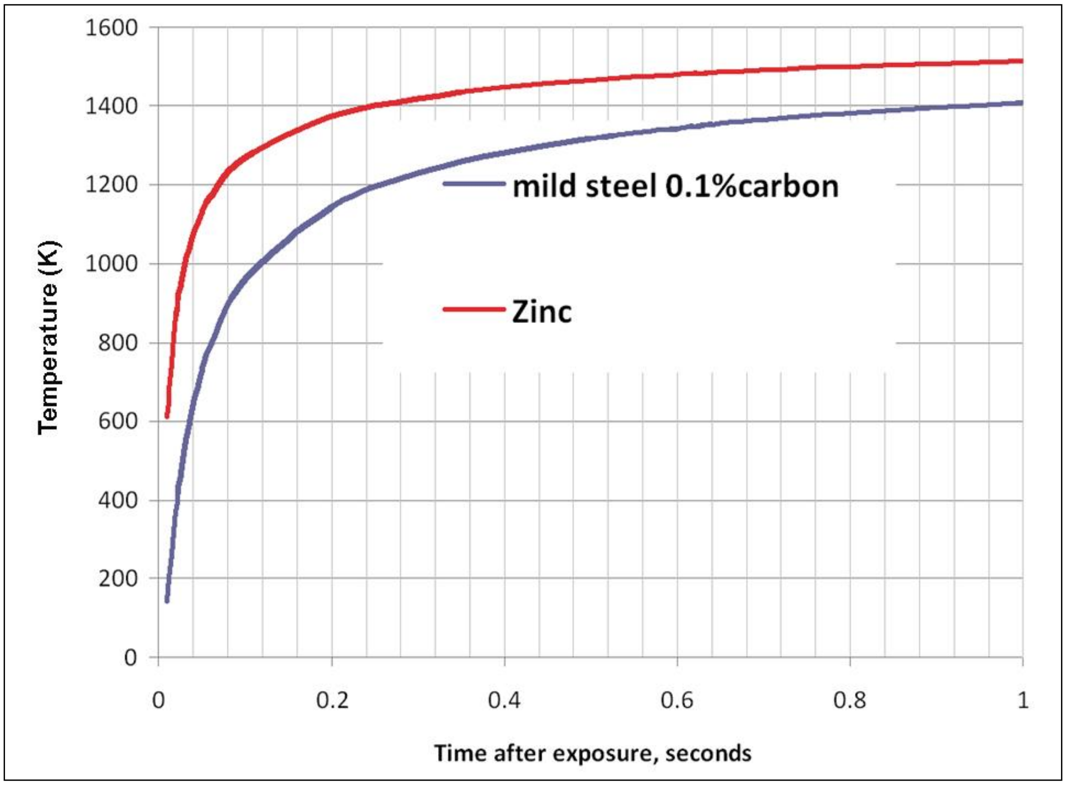
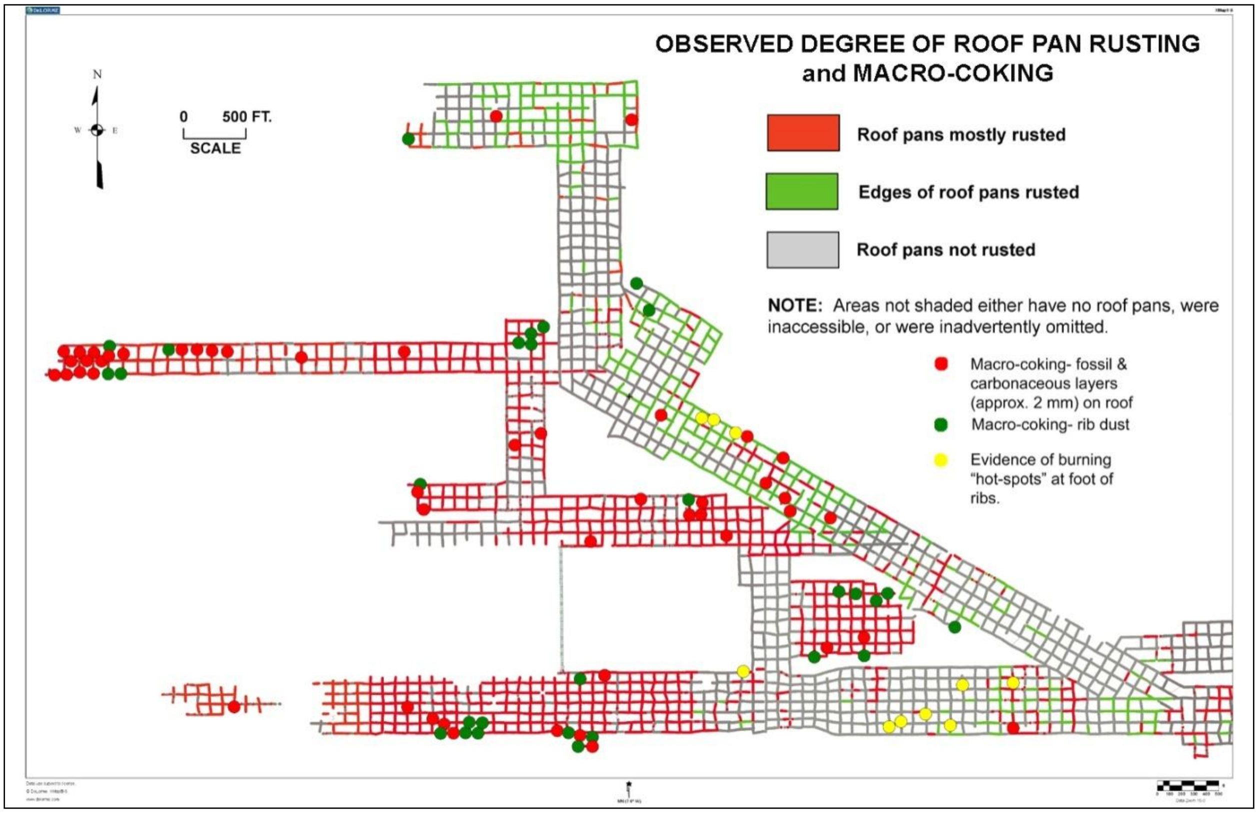


Figure 12. Temperature rise in a 0.08 cm thick plate with time. Plate is assumed heated by a constant temperature of 1627 K, and the curve represents temperature rise with time for zinc and steel.

Macro-coking and Pan Rusting

There is a possible correlation between macro-coking and pan rusting (see **Map 3**). Macro-coking is defined here as coked coal textures that are visible to the naked eye, occurring when particles and/or thin carbonaceous layers on the mine roof, ribs, or floor are exposed to flame of extended duration. Virtually all of the locations where macro-coking of the roof and ribs was observed the pans were either rusted or had edges rusted. Similarly, where the pans were not rusted, macro-coking evidence was not found (see **Map 3**). This could be indicative of either a stronger flame, slower flame, flame in proximity to the perimeter surfaces rather than down the middle of the mine opening, or a combination of the above.

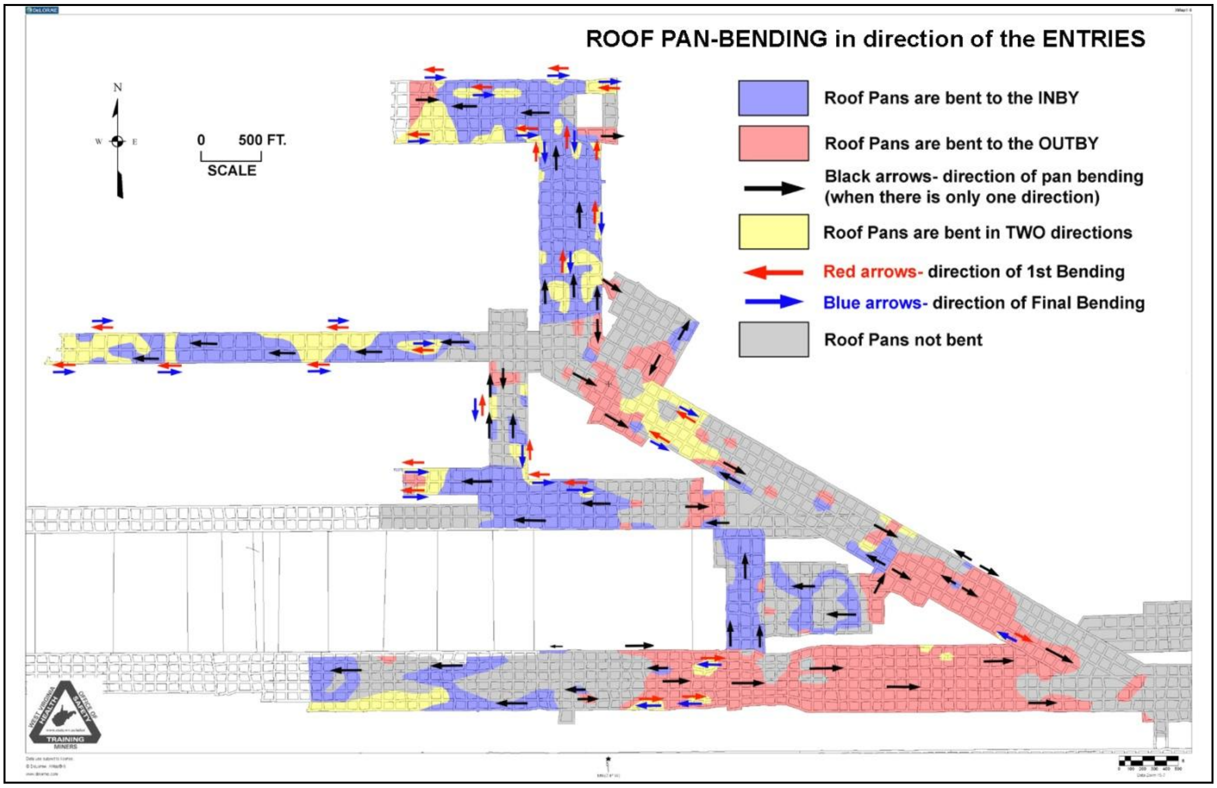


Map 3. Where macro-coking of roof and/or ribs was observed, pans were either rusted or had their edges only rusted. Areas where the pans were not rusted did not have macro-coking.

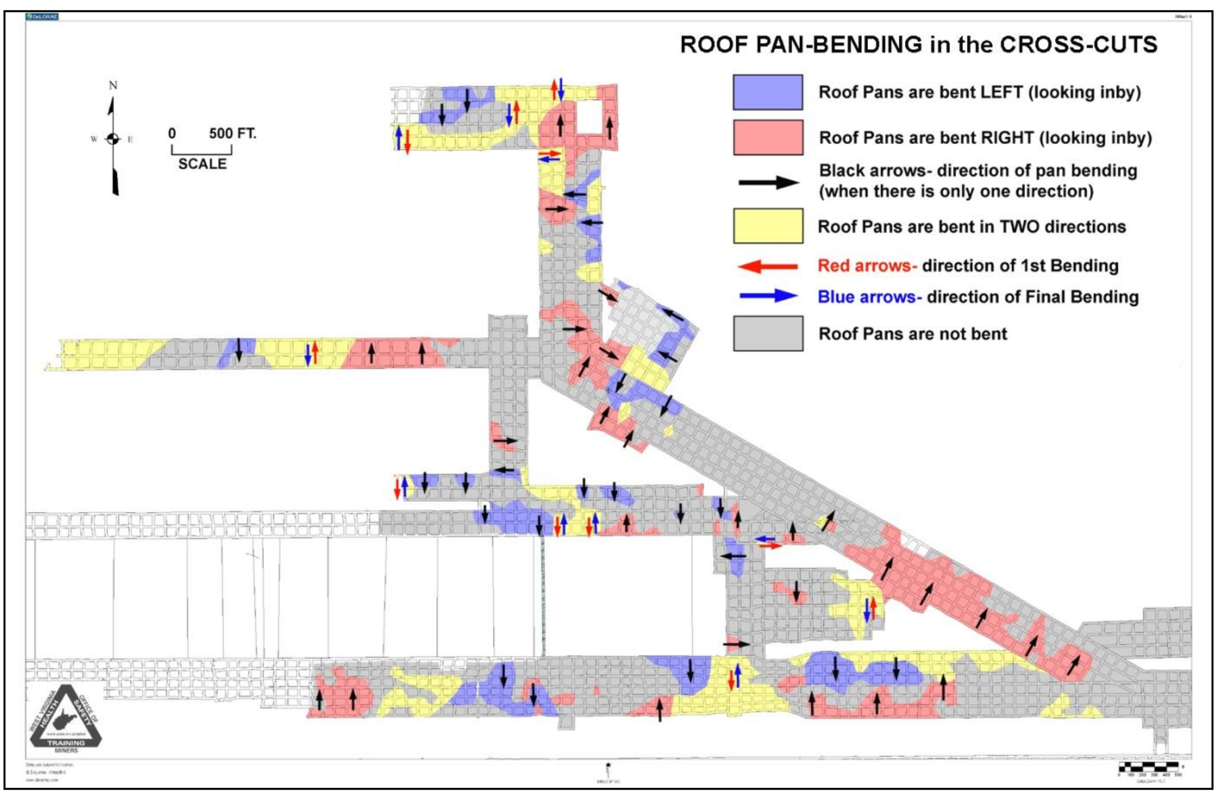
Determining Bending Direction and Sequence

The directions of pan bending have been summarized in **Map 4A** and **4B,** which are a first-iteration of data summarized from the *WV Flames and Forces Map.* For clarity it was necessary to express the data for *mine entries* separately from *mine crosscuts*. Similarly, "inby" and "outby" conventions are a necessary but imperfect description of direction. While this basic format might require a bit of concentration to follow, it is one of the more objective and useful ways to organize the data, and was a first step for analyzing bending direction, in order to separate propagation paths into First Forces and Return Forces. Once these paths have been worked out, the next generation of maps (e.g. **Map 5A** and **5B**) are organized according to the *First Forces* and *Return Forces* convention.

Areas shaded in blue and red in **Map 4A** and **4B** indicate where unidirectional bending occurred in the inby and outby directions, respectively. The black arrows are added to help clarify the indicated bending trends. The areas shaded in gray are regions where pans were not bent. The yellow shaded regions indicate where roof pans were observed to be bent in two directions—some one way, some the other way, some both ways.



Map 4A. "Pan Bending" in the "ENTRIES"; summarized data from the *WV Flames and Forces Map*



Map 4B. “Pan Bending ” in the “CROSSCUTS”; summarized data from the *WV Flames and Forces Map*

In certain cases it was possible to determine which direction of bending occurred first. Where an individual pan has been bent first one way, and then another—and if the sequential order of that bending could be resolved—the WV Flames and Forces Map shows a **red arrow** to indicate the direction of the "first bending" and next to it a **blue arrow**, indicating that there was subsequent and significant bending in the opposite direction (summarized in **Map 4A** and **Map 4B**).

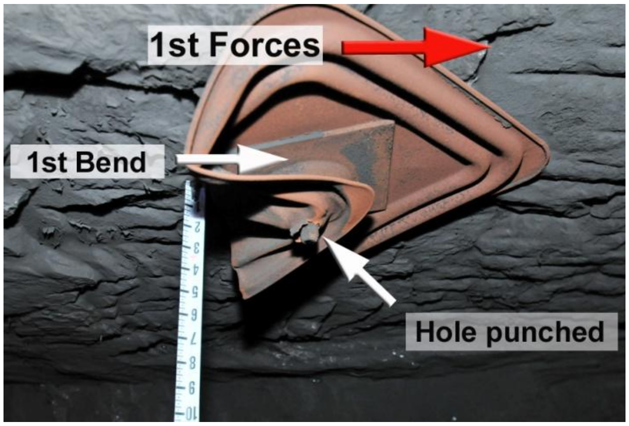


Figure 13. An example of pan bending from 1st Forces. Where threaded bolt heads protrude more than 1" below the bolt plate, a hole is often punched through pan on impact.

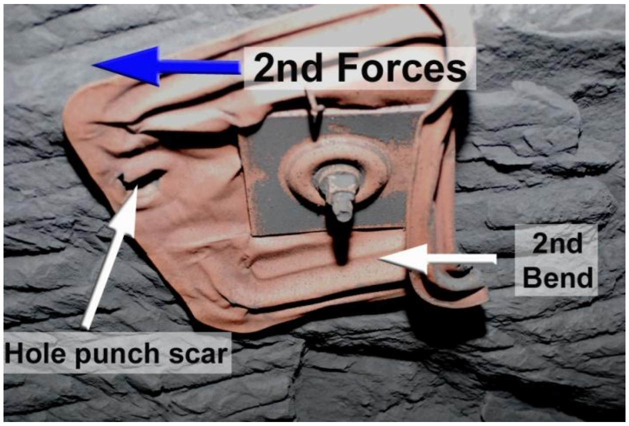


Figure 14. An example of pan bending by 2nd Forces. Hole-punched pan is straightened back.

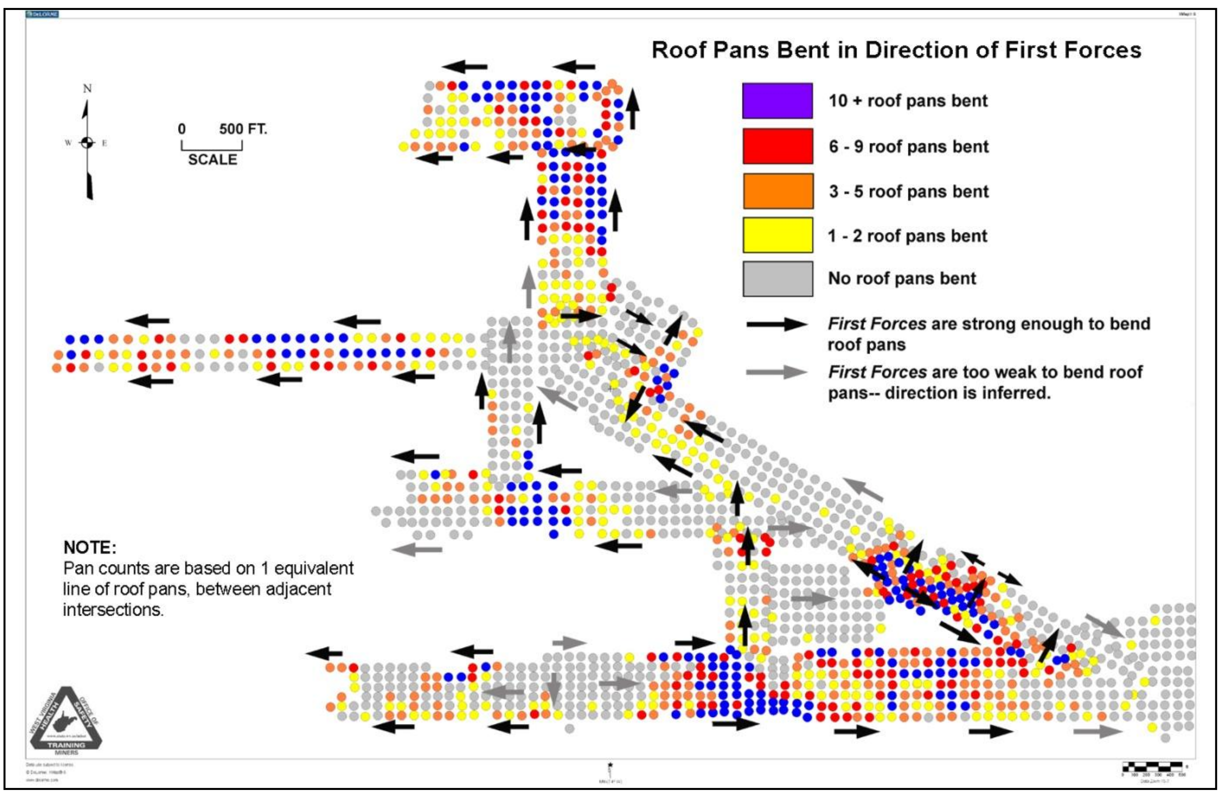
Examples are shown in **Figure 13** and **Figure 14**, where a hole is first punched through a square pan as it was bent initially over the end of a *torque tension roof bolt*. If subsequent wind forces were sufficient to remove the "hole-punch" from its impaled position, it might dislodge the "hole-punch" and return the roof pan always in regions where other pans were similarly bent, or alternately bent just one way or the other (the yellow regions in **Map 3A** and **3B**).

Their consistency and corroboration with other indicators reinforced the conclusion that this was valuable data. For example, this bending sequence was used to help determine the explosion origin in a process of elimination. When the First Forces in a dead-end heading point to the inby, the explosion is known to have not originated in the dead end.

Combining Pan Bending Direction with Pan Counts

After a determination was made about the direction of First Forces and Return Forces, **Map 5A** and **Map 5B** were constructed to summarize pan bending according to numbers bent in those directions. These are based on the "pan count" procedure described earlier, and timing of the pan bending (*First Forces* vs *Return Forces*).

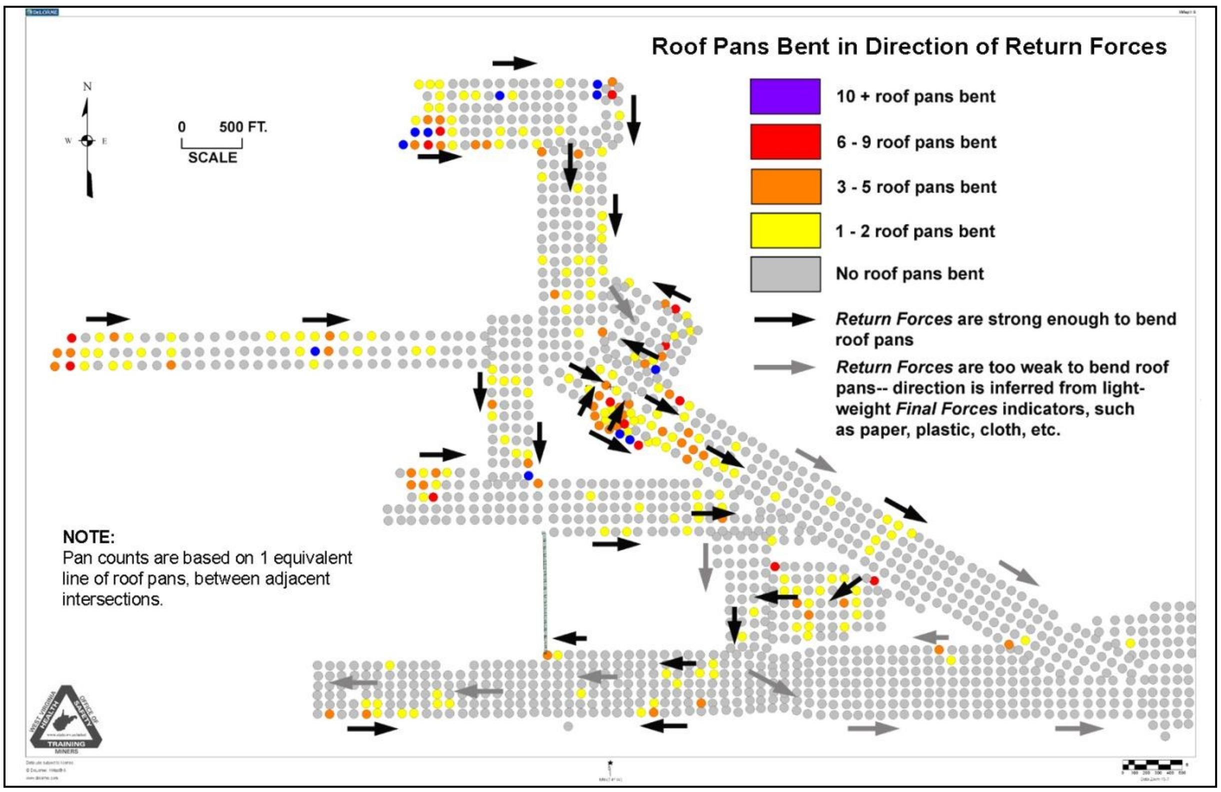
First Forces here refers to the first explosion forces to enter that part of the mine. Return Forces refers to a secondary set of forces that followed First Forces, but in a different direction (usually in the opposite direction).



Map 5A. Pan Bending by First Forces; summarized data from the *WV Flames and Forces Map*

The regions indicated in gray represent areas where roof pans were not bent. The colors yellow, orange, red, and violet are used to indicate where pans are bent and their frequency (pan counts), which gives a relative indication of explosion pressures across the mine.

Map 5A and **5B** are interpretive, based on the primary propagation paths, which are primarily in the direction of the *entries*. The primary path can also include the *crosscuts,* where forces enter from another part of the mine, such as at where the "Cut-across" and the "Glory Hole" panels intersect the North Glory Mains. In those instances the data from the crosscuts, were included to show these pressure trends, based on the interpreted explosion sequence. **Map 1** and **Map 2** of **Section 7.9** give a generalized view of the interpreted explosion sequence.



Map 5B. Bending by Return Forces; summarized data from the *WV Flames and Forces Map*

Summation

The detailed study of the damage to and rusting of the roof pans adds to the total body of evidence and has increased the investigators confidence in conclusions about the explosion.

APPENDIX 7.9-2 EXHIBIT 1

Format for describing CONDITION OF ROOF PANS:

The following format was developed to record description of pan type, pan bending style, and pan rusting. The WV Flames and Forces Map was developed in part from this data.

ABBREVIATIONS to USE:

N = NO pan bending	**SP** = "Spider Plate" + "**B**ending"--	**R** = Pans are RUSTED
M = Minor to moderate	**PP** = "Pizza Pan" + "**B**ending"--	**ER** = EDGES RUSTED, only
S = Severe		**NR** = Pans are NOT RUSTED

Examples:

(1) **NSPB –R** = "NO Spider Plate Bending—pans are RUSTED"

(2) **MSPB – ER** = "Minor to Moderate Spider Plate Bending – pan EDGES RUSTED, only"

(3) **SSPB – NR** = "Severe Spider Plate Bending – pans are NOT RUSTED"

Example 1. **NSPB –NR** = "NO Spider Plate Bending—pans are NOT RUSTED"

NSPB-NR	**NSPB-NR**	**NSPB-NR**	**NSPB-NR**
N = NO…	SP = …"Spider Plate"…	…"Bending"…	…NR = Pans are NOT RUSTED

Example 2. **MPPB – R** = "Minor to Moderate Spider Plate Bending – pans are RUSTED"

MPPB-R	**MPPB-R**	**MPPB-R**	**MPPB-R**
N = Minor or Mod.	…PP = "Pizza Pan"…	…"Bending"…	…R = Pans are RUSTED

Example 3. **SSPB – ER** = "Severe Spider Plate Bending – pans EDGES RUSTED, only"

SSPB-ER	**SSPB-ER**	**SSPB-ER**	**SSPB-ER**
S = Severe…	…SP = "Spider Plate"…	…"Bending"…	…ER = EDGES RUSTED, only

FURTHER INSTRUCTIONS:

The objective is to denote THREE classes of pan damage: (1) SEVERE bending, (2) NO BENDING, and. MINOR to MODERATE bending. The Minor to Moderate areas are noted on the map mainly for completeness-- to verify that every area has been looked at.

By definition:

SEVERE PAN BENDING means that a MAJORITY of pans are bent or torn (usually 10 or more for one equivalent line of roof bolts). A few pans may be moderately bent, but the majority of pans are STRONGLY bent—that is at angles > 90 degrees and/or mangled and torn.

NO PAN BENDING means NO pans have bending attributed to wind pressure forces alone. Occasionally a pan or two is bent during installation or by equipment impacts, rock drop-outs, or other means before the explosion-- these are usually easy to distinguish and do not count as damage. However, a pan bent before the explosion is more likely to be caught and bent further by the explosion wind forces. Pans that are bent at angles beyond 90 degrees can therefore be counted—unless there is reason to believe it was bent beyond 90 degrees by forces other than wind pressure. When in doubt, a pan should not be counted.

MINOR TO MODERATE BENDING is everything in between the two extremes, except areas where pans were not set at all, which are to be labeled **NO PANS**.

NOTE:

To normalize pan observations, count only the equivalent of one full line of pans down the particular entry or crosscut being examined. Use an arrow to denote the bending direction, putting the arrow(s) on the same side of the heading as where the pan(s) are. If the equivalent of one full row is unavailable, put a "+" after the number of pans. (EXAMPLE: "3+ pans") If there are no pans installed, write "No pans" on the map.

If some pans are bent one way and some another, count the number of pans for each and record with numbers and arrows assigned accordingly. Show the arrows on the same side of the heading as the majority of the observed pans that it summarizes, if possible.

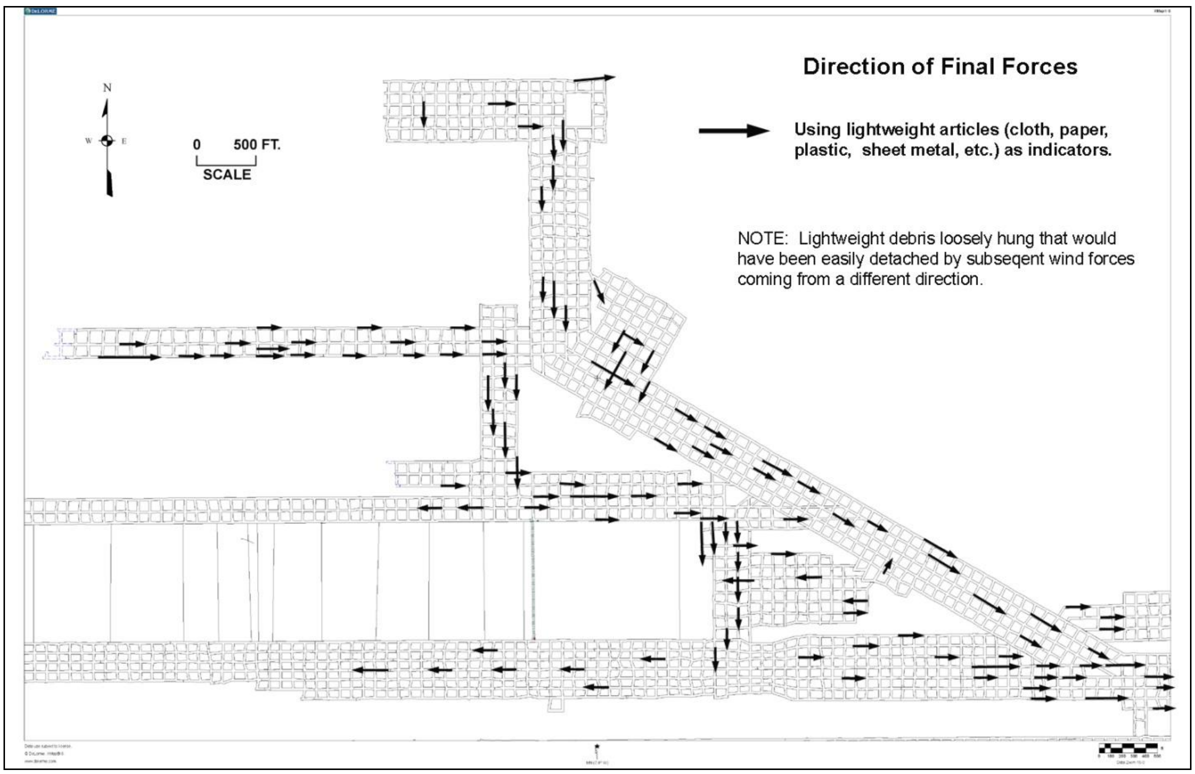
When first and second force directions can be resolved by fold sequence, bolt hole punching, bolt plate footprints, etc., show the **first force** direction with a **red arrow** and the **second force** direction with a **blue arrow**.

Impacted lightweight items that are loose and would have been dislodged by subsequent wind from the opposite direction are indicators of **final force** winds, and are denoted with a **capital "F" and an arrow** pointing in the direction of transport.

APPENDIX 7.9-3

IDENTIFYING FINAL FORCES

"Final Forces" as the term is used in this report, refers both to the *direction* of the final wind force to pass through a particular region as the oscillating of explosion forces stop, and it also refers to *indicators* that give evidence to the direction of those final air currents. Their value lies primarily in providing evidence of the sequence of explosion forces and also assists in understanding the movement and distribution of dust patterns observed.



Map 1. This map of "Final Forces" across the explosion region of the Upper Big Branch Mine was based mostly on the lightweight items caught loosely on a stationary structure, where subsequent wind from a different direction would have likely dislodged them. See **Map 3A, 3B** for details of the longwall.

The investigation determined the direction of "Final Forces" by observing the position of lightweight items like paper, plastic, and cloth that were loosely caught in a way that they identified the last direction of movement. During the latter stages of the investigation it was determined that other indicators were consistent with lightweight final force indicators, and could be used to verify and corroborate, and if needed could be used to infer a direction of the final forces when lightweight indicators are scarce (or in some instances, rearranged). The three most useful indicators are:

(1) Lightweight items, such as paper, plastic, cloth that was loosely caught by a stationary structure, and in a way that they would have been easily removed by a subsequent wind force.

(2) Impacted "V" dust cones on stationary cylindrical structures

(3) Outer insulation on suspended telephone and "Pyott-Boone" communications lines.

Lightweight Items

The Final Forces Map (see **Map 1**) is based primarily on paper and other lightweight items caught loosely on a stationary structure, such that they would have been easily removed by a subsequent wind force from a different direction. Examples of these items are shown in **Figures 1 to 6,** below.

It is important that the items are loose and can be easily removed, and that it was not likely they had been placed by the re-established ventilation air currents or by tampering. Their impact geometry should have one interpretation and the item cannot pivot, (such as being hooked on a single wire protruding from roof support wire mesh).

The most common Final Forces indicators are scraps of paper. Occasionally sheet metal remnants are caught so that they function as a "weathervane," such as parts of Kennedy panels around standing jacks or roof pans that were torn and shredded in-place. Plastic items were sometimes used, but only if they were loosely caught, and were not fused or melted in a way that secured them to the structure surface.

Figure 1. (LEFT) Paper shard, loosely caught on belt hanger; Outby end of #21 Tailgate, near spad 19641. View looking East.. Final Forces are to the EAST.

Figure 2. (RIGHT) Roof pan shredded and "weathervaned" to the EAST, indicating Final Forces were in that direction; East end of 9-North (West Jarrel's Mains), 1 ½ breaks outby spad 20659, looking South.


Figure 3. (LEFT) Paper shard on belt structure; North Glory Mains, at spad 19832. View looking NE. Final Forces are to the SE.

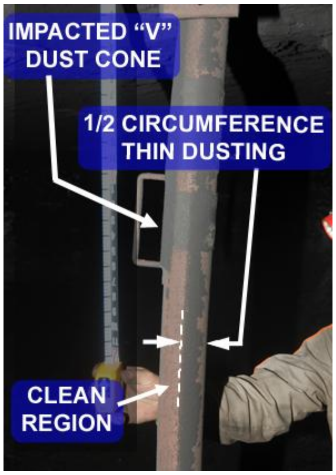
Figure 4. (RIGHT) Paper shard on chain link "belt guard"; Top end of North Glory Mains, near spad 24356. View looking SW. Final Forces are to the SE.


Figure 5. (LEFT) Paper shard caught in wire roof mesh: 8-North (North Jarrel's Mains), near spad 20473. View looking W-NW. Final Forces are to the SOUTH.

Figure 6. (RIGHT) Spray can, impacted loosely around belt chain; North Glory Mains, at spad 20045. View looking NW. Final Forces are to the SE.

Impacted "V" Dust Cones

Besides lightweight articles, investigators found certain styles of dust accumulations to be good indicators of the direction final wind force. One such style of impacted dust formed longitudinal accumulations along one side of stationary cylindrical structures, like belt rollers and standing supports such as steel jacks and wooden propsetters. These narrow bands formed impacted dust wedge or "V" deposits culminating in a peak. On timbers and propsetters they have basal widths of 1.5 inches to 2 inches. On 13 inch diameter cylinder jacks, on the longwall shields, they exhibited basal widths of 1.5 inches to 2.5 inches.



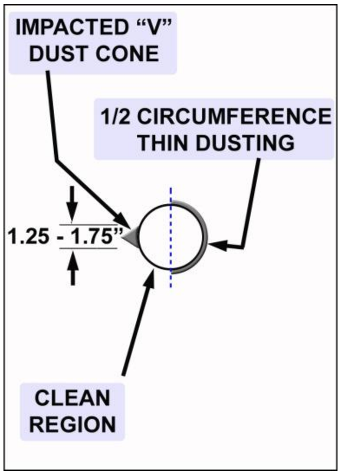


Figure 7. (LEFT) Standing sand jack on #21 Tailgate showing example of an *Impacted "V" Dust Cone* formed on the leading edge that pointed in the windward direction of the Final Forces. *Original photo courtesy of Performance Coal Co,*

Figure 8. (RIGHT) Generalized geometry of dust deposition observed *in plan-view* around cylindrical structures that have diameters of 2 inches to 13 inches.[1]

These *Impacted "V" Dust Cones* (sometimes referred to herein simply as "dust cones") occur on one side only of the cylinder. On the backside, almost exactly ½ of the cylinder circumference is coated in a uniform layer of thin dust.[2] Separating these dust configurations is a "clean region" that is mostly or entirely free of impacted dust. This is illustrated more fully in **Figures 7 and 8**.

Figure 9A. (LEFT) Dust cone on sand jack; #21 Tailgate; track entry, approx. 2 breaks EAST of the Longwall

Figure 9B. (RIGHT) Same as Figure 9A; different view.

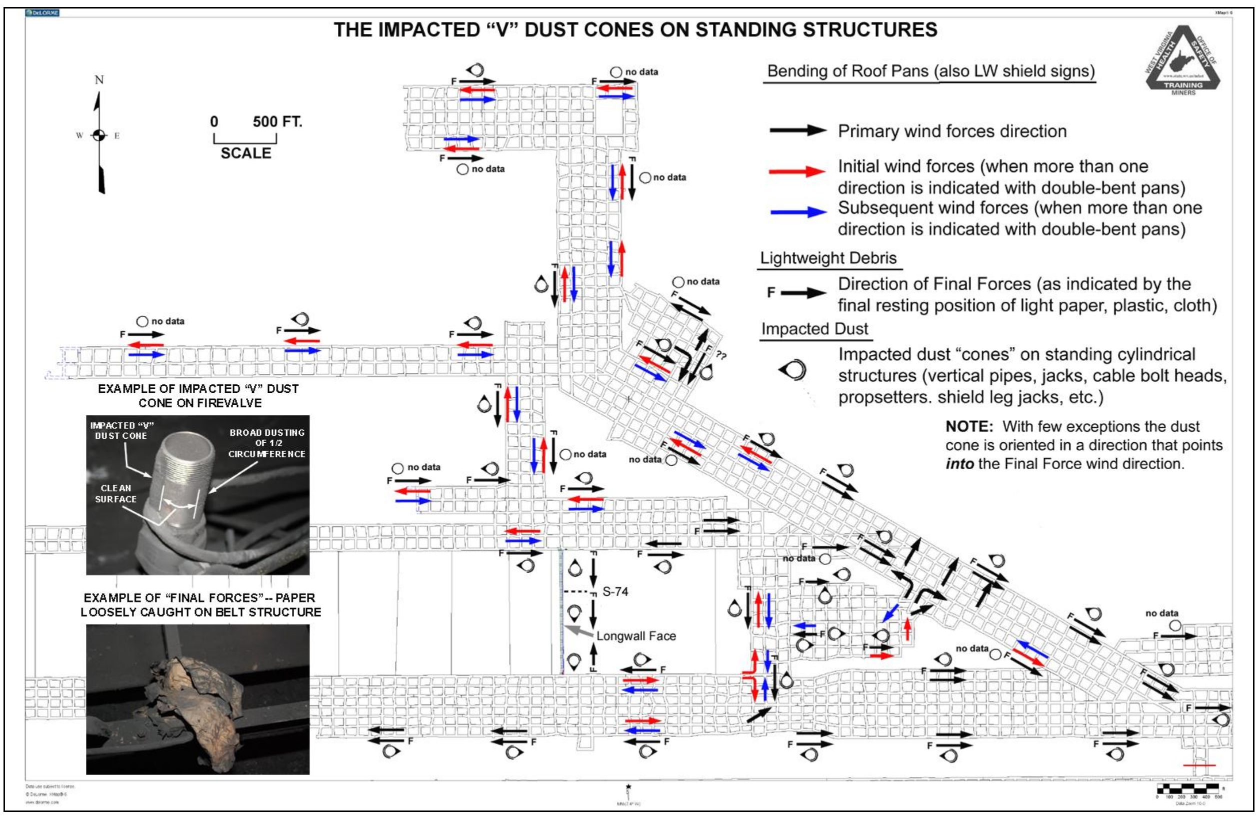
[1] Cylinders with diameters less than 3.5" and larger than 10" sometimes had narrower and wider dust cones, respectively, than the 1.25" -1.75" range indicated

[2] Proximity to obstructions resulting in wind blockage or turbulence interferes with development of these impacted dust structures.

The significance of these structures was not fully realized until late in the systematic mapping phase of the investigation, when the patterns and data relationships of the whole region began to emerge. It then became apparent that cylinders that are stationary and openly exposed to wind forces during the explosion developed dust cones that always point in the windward direction of the Final Forces. Research has indicated support for this observation.[3] Lightweight items caught on nearby structures were observed to be on the same side that acquired dust cones.

This important principle assisted our investigation effort by giving us a way to both corroborate independent pieces of evidence and as a surrogate for lightweight Final Forces indicators when these indicators were locally lacking or had been rearranged.

It is the exposed, cylindrical surfaces that make these geometries unique. Square surfaces show only that they received impacted dust at some time in the explosion process.



Map 2. The Impacted "V" Dust Cones observed on various cylindrical structures across the explosion region all point in the windward direction of the Final Forces. They are dust deposits that appear to have been placed during the last wind event carrying dust.

Although it is not certain, it appears that any dust placements on cylindrical surfaces from earlier wind events are scoured off by the Final Forces event, culminating with Impacted "V" Dust Cones being preserved only on the windward side of that final wind cycle.

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3 "Impingement of Particles on a Transverse Cylinder" by C. N. Davies and C. V. Peetz, Proceedings of the Royal Society of London, Vol. 234, No. 1197 Feb 7, 1956, pp 269-295.

There appears to be a critical cylinder size that starts at about 1.5 inches and goes up to at least 13 inches (see **Figure 8**) that is necessary before the full dust cone and scour zones are fully developed.[4]

As shown in **Map 2,** the regions such as the eastern ½ of #21 Tailgate, dust cones point in the direction of initial forces because the Initial Forces and Final Forces were in the same direction.

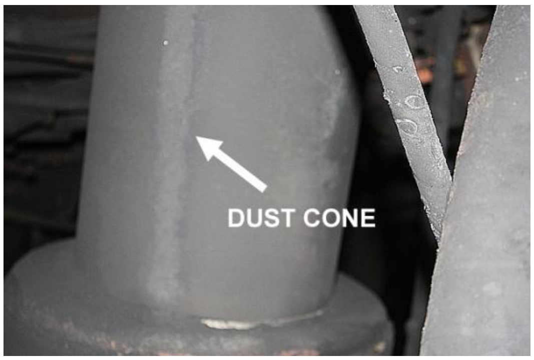


Figure 10. (LEFT) Cylinder leg on Longwall; South side of south jack, Shield 166. View looking NW. These are deposits are Final Forces features, originating from the Tailgate side of the longwall.

Figure 11. (RIGHT) Cylinder leg on Longwall; North side of north jack, Shield 10. View looking W. These are deposits are Final Forces features, originating from the Headgate side of the longwall.

Before our systematic mapping of these impacted dust features could begin, many dust cones had already dropped off (see example, **Figure 12**). In some cases this made the remainder more obvious, in other cases only a narrow rust shadow remained as evidence that a dust cone had once been there. Some of the more well-developed examples were found on "sand jacks" as they tended to be set away from obstructions and open to dust-carrying wind currents. They need not be vertical, as evidenced by belt rollers. But they did have to be exposed on all sides to develop impacted "V" cones. Cylinder legs on the longwall that were semi-obstructed by nearby hoses and cables were somewhat affected, but "V" cones still formed, just not as well-developed. The best-developed and thickest deposits, however, tended to be those that were most exposed and unobstructed to the direct wind path.

[4] Roof bolt heads and threaded ends accumulated impacted dust, but they do not display the dust geometry discussed. The dust geometries were found occasionally on cable bolt heads and fire valves (about 2") and were observed on cylinders as large as the bottom cylinder legs on the longwall shields (about 13").

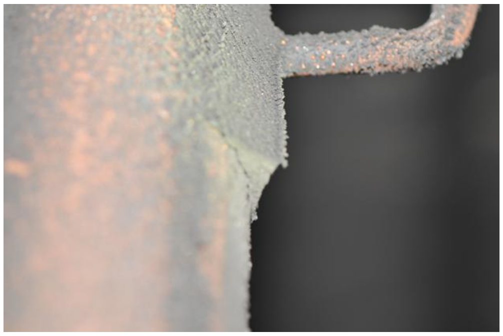
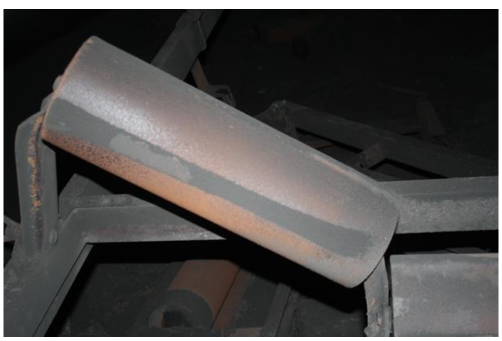


Figure 12. (LEFT) Sand jack with dust cone (lower part has fallen away); #21 Tailgate, approximately 2 breaks east of the Longwall, looking North. Final Forces were from the EAST

Figure 13. (RIGHT) A propsetter with impacted dust cone. In the #4 belt entry of North Glory Mains, outby spad 19835, BRK 95; looking outby. Final Forces were traveling to the S.E.. *Photograph courtesy of Performance Coal Co.*

Other standing supports like propsetters (**Figure 13**) developed dust cones, although not as well-developed and consistent as on the sand jacks. It is not clear if the dust cones were less conspicuous on the cylinder jack legs on the longwall was related to diameter size and more to do with wind-deflecting structures like cables and hoses that were in close proximity.



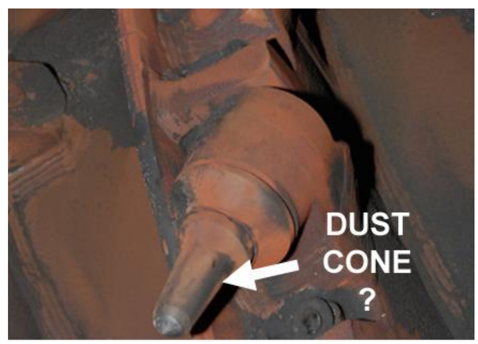


Figure 14. (LEFT) Roller on belt structure with impacted dust cone; #21 Cross-over, approximately 30 feet south of spad 23813, looking south. Final Forces were from the NORTH.

Figure 15. (RIGHT) Poorly-developed dust cone on bit of longwall shearer. In the #7 entry of #21 Tailgate, near spad 22544, looking W-NW. Final Forces were traveling to the WEST. *This photograph courtesy of Performance Coal Co.*

Other cylindrical structures, such as belt rollers (**Figure 14**), developed prominent dust cones--again, always on the windward side relative to the Final Forces direction, as indicated by the lightweight debris.

The bits on the tailgate shearer drum were exposed to wind forces in the #7 entry of #21 Tailgate. The cutting bits appear to have acquired dust cones, although most of the material had fallen off, and it was difficult to discern (**Figure 15**). These apparent cone shadows point east, which is the direction Final Forces were traveling from in this area.

Outer Insulation on Communications Lines

Several sets of communications lines were suspended from the roof, in the track and belt entries, and these were also useful Final Forces indicators. These include pager phone (phone line), the shielded Pyott-Boone cable, and the leaky feeder (radio line). The outer insulation jacket on the phone line and shielded cable were commonly peeled back and bunched-up in directions which were consistent with the wind direction of the Final Forces (see **Figures 16** and **17**).

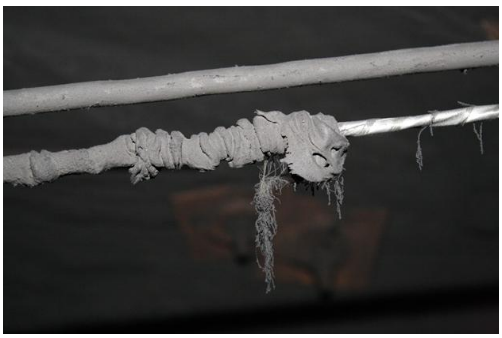


Figure 16. (LEFT) Shielded cable; North Glory Mains, 20-ft inby spad 20440, looking SW. Bunching is in the direction of Final Forces (to the SE).

Figure 17. (RIGHT) Shielded cable; North Glory Mains, 40-ft inby spad 20440, looking SE. Bunching is in the direction of Final Forces (to the SE).

Peeling and bunching of insulation was observed in areas where there was enough heat to melt plastic. It is believed that heating during the initial explosion propagation softened plastic sufficiently to allow the final wind forces to bunch the insulation of these cables as depicted.

Bunching was sometimes observed in the opposite direction when near hangers that suspended these wires, especially when perpendicular wind forces[5] had traveled across the area. In these cases, lateral deflection of the lines against the suspension hangers caused bunching, also. When observing these insulation indicators for Final Forces purposes, it is necessary to take this into account and examine all the features.

[5] In the direction of the crosscuts

Corroboration of Final Forces

Considering all evidence allows a more rapid and trustworthy determination of the forces that caused them. In this case, mapping of the explosion region was nearly completed before the significance of the various Final Forces indicators became apparent.

Below is an example of the three primary Final Forces indicators occurring together (**Figures 18** to **21**). The outby direction is to the southeast, which is to the left in these views. The first image was taken from the opposite vantage point, and was flipped to normalize its view with the others.

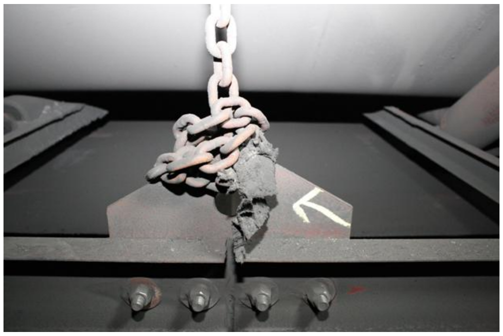


Figure 18. (LEFT) North Glory Mains: 50-ft SE of spad 20045 (SW view). The heated outer insulation of the phone line is bunched in the direction of Final Forces, which were directed SE. (Note: The original photograph was taken from the opposite side of the belt. It has been inverted here to a comparable SW view).

Figure 19. (RIGHT) North Glory Mains: 60-ft NW of spad 20048 (looking SW). This is an example of paper loosely caught on the windward side of the indicated Final Forces, which were directed SE.

Figure 20. (LEFT) North Glory Mains, 60-ft NW of spad 20048 (looking SE). This is an example of a belt roller with an Impacted "V" Dust Cone on the windward side of the indicated Final Forces, which were directed SE. The impacted "V" is well-developed, most likely because the belt is not tight to the roller.

Figure 21 (RIGHT) North Glory Mains, 60-ft NW of spad 20048 (looking NW). This is the other side of the same belt roller. This shows the broad dusting on the side opposite the impacted "V". Belt rollers that are in tight contact with the belt typically have less dust coating and poorly-developed dust cones.

Where multiple Final Forces indicators are found in a given location, they provide corroboration, reducing the chances of misinterpretation. Also, having performed the analysis to establish this correlation improved our understanding about the sequence of events on the longwall.

Final Wind Forces on the Longwall

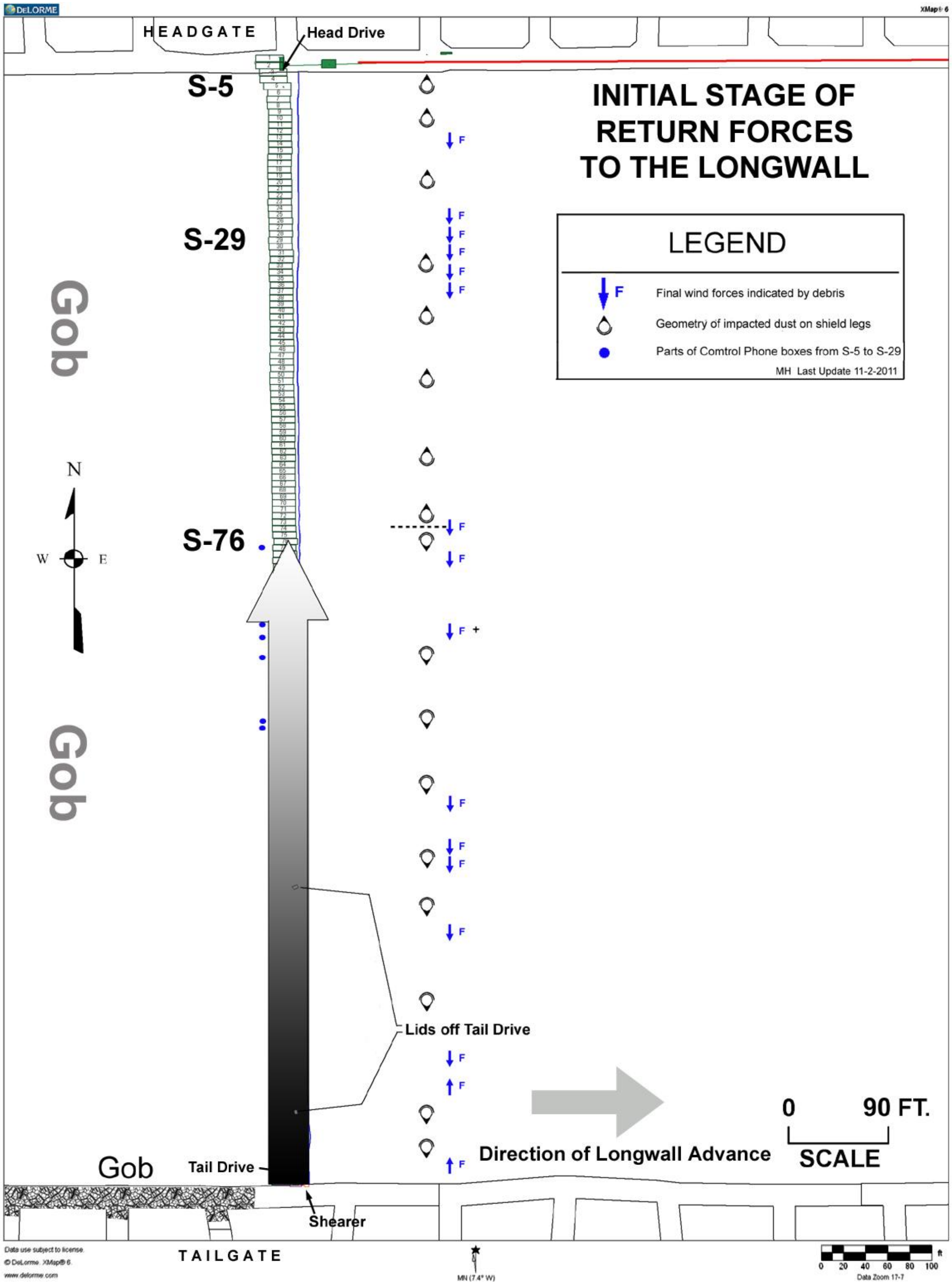
Two of the Final Force indicators were useful in our study and interpretation of the Longwall Final Forces.

There are 176 shields on the longwall. Each shield has two cylinder legs that are near the walkway, which accumulated Impacted “V” Dust Cones during the explosion. In the longwall region between the Headgate, and Shield 76, dust cones were deposited on the NORTH side of the cylinder legs. Conversely, in the region between the Tailgate, and Shield 72, they are on the SOUTH side of the cylinder legs. From our earlier work we knew this meant that there were Final Forces entering the longwall from both ends. A slight transition occurs at Shield 72-76 where cones were indistinctly noted on both sides of cylinder legs, due perhaps to their large diameters.

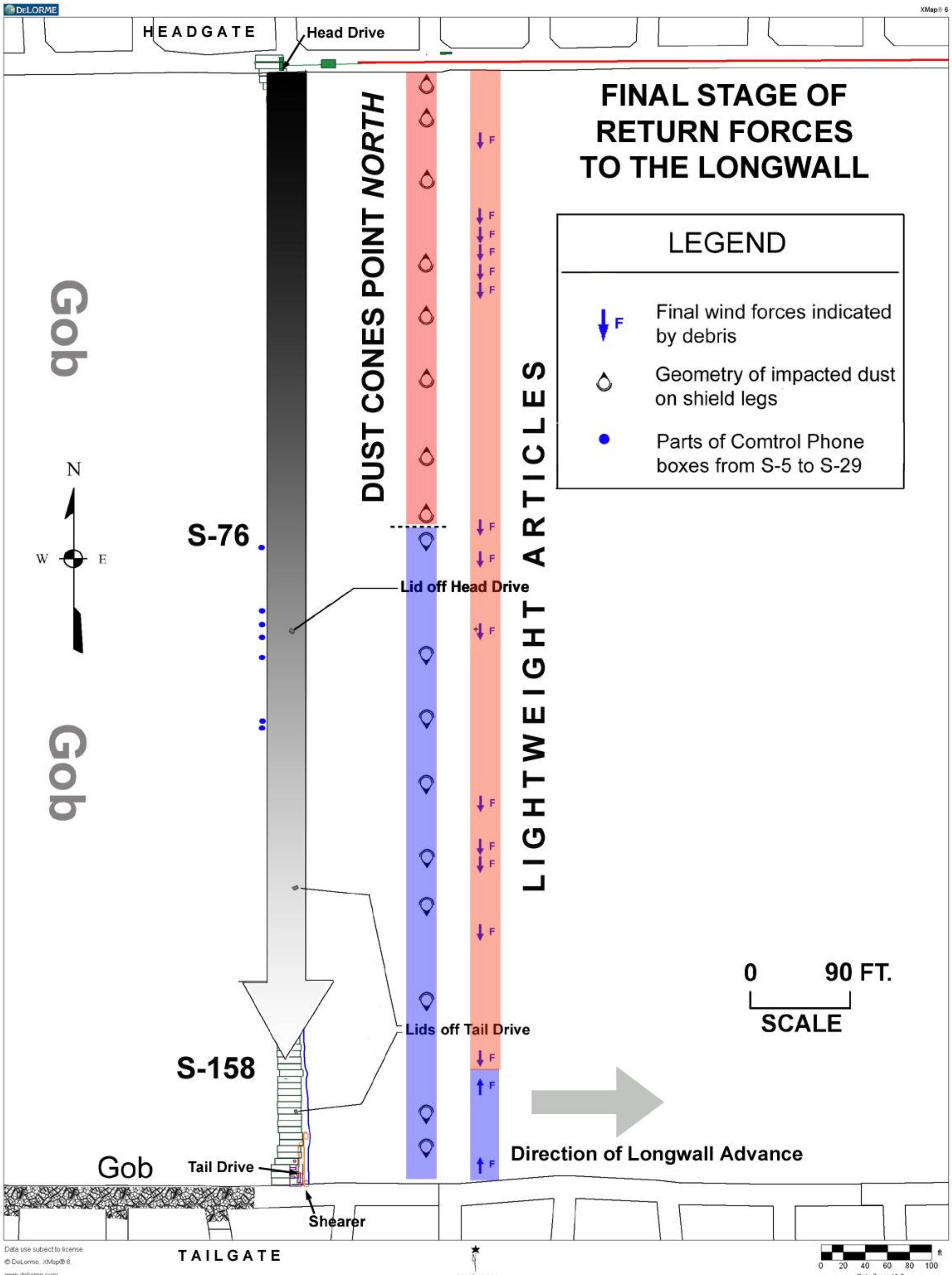
Whether these forces arrived at the same time or different times required other evidence. The placement of lightweight articles along the longwall face structures indicates that the final wind forces depositing them came from the north, and deposited these items as far south as Shield 158.

As illustrated in **Map 3A**, we know that dust-carrying final wind forces from the Tailgate deposited dust on the southern exposure of cylinder legs as far north as Shield 76, and lightweight debris should have traveled that far, or farther (both indicted in *blue*). However, if winds came subsequently from the north this debris would have been rearranged, and we might never know it.

As illustrated in **Map 3B** we find from the south-directed final wind forces, indicated between the Headgate and Shield 72, are consistent with the lightweight debris articles we observed. They came to rest in a manner consistent with these south-directed wind forces, at least as far south as Shield 159, where south of this point some of the former placement north-driven placement of lightweight articles survived.



Map 3A. <u>Final Forces</u> entered the longwall <u>first</u> from the *Tailgate region*, with enough energy to deposit Impacted "V" Dust Cones on the cylinder legs, at least as far as Shield 76.



Map 3B. Final Forces entered the longwall second from the *Headgate region*, with enough energy to deposit Impacted "V" Dust Cones on the north side of cylinder legs, at least as far as Shield 72, but rearranged lightweight structures as far south as Shield 158.

The middle area of the longwall (Shield 76-158) where there is apparently conflict between the Impacted "V" Dust Cone placement and the lightweight articles placement is believed to be due to the fact that the items between Shield 76 and Shield 158 were rearranged by winds coming last from the Headgate. Further, perhaps due to a combination of large cylinder leg diameters and because numerous obstructions from hydraulic hoses and electrical cables around the cylinder legs, there were found to be a few south-facing dust cones that had been placed south of Shield 75 survived re-deposition, but any that may have been deposited farther north were erased by the subsequent Headgate forces (as they normally are) and overprinted with dust cones which point the other way, as we found them.

Final wind forces that came into the Longwall, therefore appear to have come first from the south (Tailgate side), where they subsided to extinction as they traveled north up the longwall, then from the north (Headgate side), which likewise subsided to extinction as they traveled south down the longwall.

Summation

Because wind forces oscillate during a mine explosion, determining the direction of the initial forces is facilitated by determining the direction of the final wind forces, which can be deduced from the final placement of lightweight items and also by a special class of impacted "V" dust deposits that form on cylindrical structures whose surfaces are unobstructed to the wind path.

The Final Force indicators are easily observed, and detailed examination and diligent mapping helps to put other evidence of the explosion forces in perspective. Identifying the Final Forces allows one to extract definitive information from the conflicting evidence found after an explosion and more accurately determine the sequence of the explosion events.

APPENDIX 7.9-4

USING BREACHED AND DEFLECTED STRUCTURES to INTERPRET EXPLOSION FORCES

Documentation of structural damage to mine infrastructure has provided evidence of the sequence, direction, and magnitude of the explosion. A summary of roof pans (a related aspect) is given in **Appendix 7.9-2** and a summary on impacted dust is given in **Appendix 7.9-1** and **Appendix 7.9-3**. In this Appendix, the following are examined: (1) the deflection of belt conveyors, (2) breaching of ventilation stoppings, and (3) the deflection of plastic water discharge lines. This information was compiled into the *West Virginia Flames and Forces Map*, and further summarized into separate maps by topic, of which **Maps 1, 2, 3A,** and **3B** are examples.

Explosion Dynamics

The hot combustion products, of the explosion expand and exert a force equally in all directions. This is the static pressure. In a mine, the hot gases expand and flow through the mine passageways pushing air ahead. This flow of gas at high speed generates a wind or dynamic pressure, which is directional. Both the static and dynamic pressure can cause damage during a mine explosion. The static pressure rise can destroy stoppings in side entries perpendicular to the direction of gas flow. The dynamic pressure gives rise to wind forces that can disperse coal dust and that can move objects. This force increases with the square of the velocity.

Deflection of Belt Conveyors

Coal is transported from the working faces, through the mine, and to the outside via a system of conveyor belts. The belt structure at the Upper Big Branch Mine is constructed of C-channel steel beams which are bolted together to form two continuous, parallel structural rails onto which the roller frames and conveyor belts are attached. This structure is usually suspended from the mine roof, although in a few place floor stands are used.

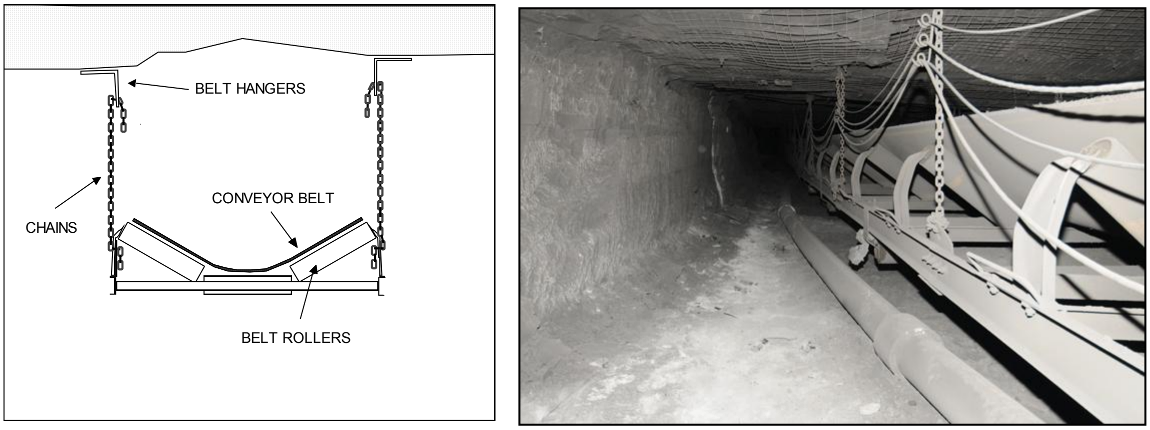


Figure 1A. Between crosscuts the belt structures are relatively intact. This is an example view of a suspended belt structure near spad 19819, North Glory Mains (NGM), looking inby.

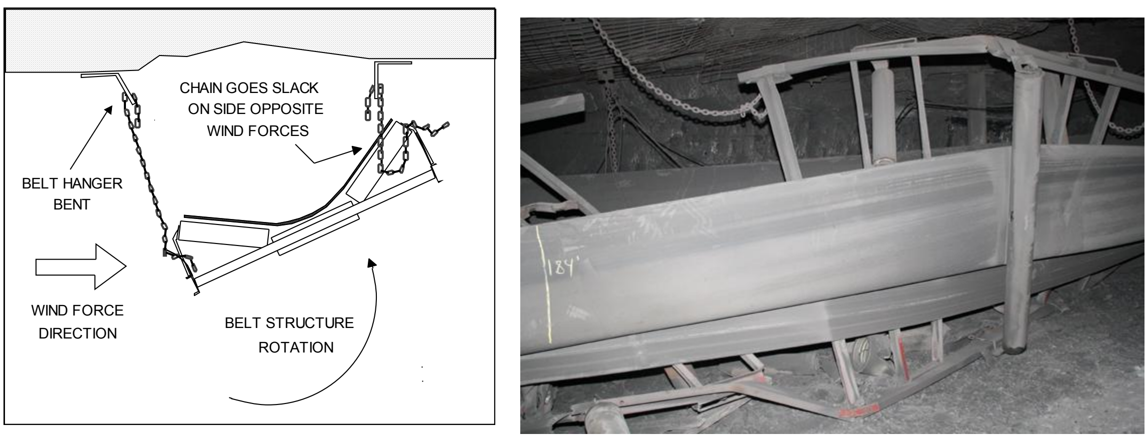


Figure 1B. In crosscuts, explosion forces entering perpendicular to the belt and from the SW side cause a CCW rotation of the belt structure, which would be from the LEFT side, looking inby (left lateral). This example view is near spad 19835 in NGM, looking to the SW from the edge of the crosscut.

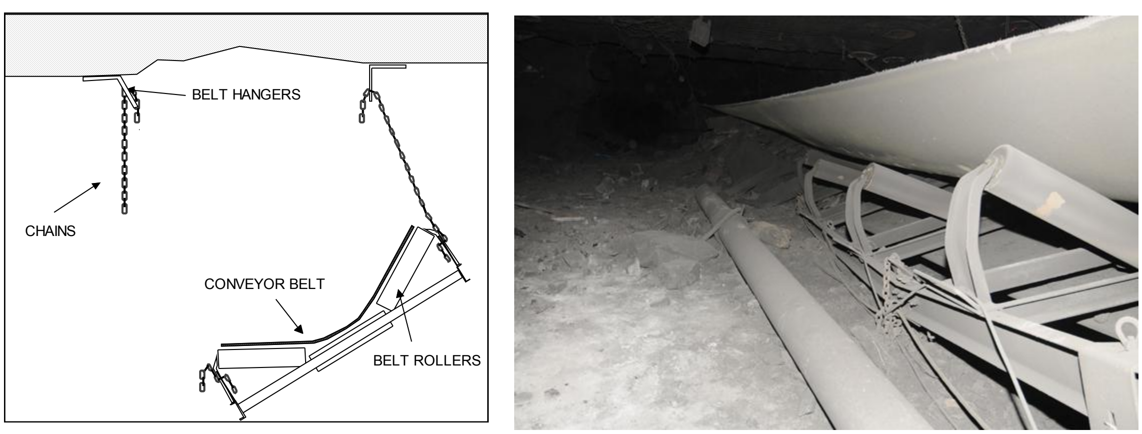
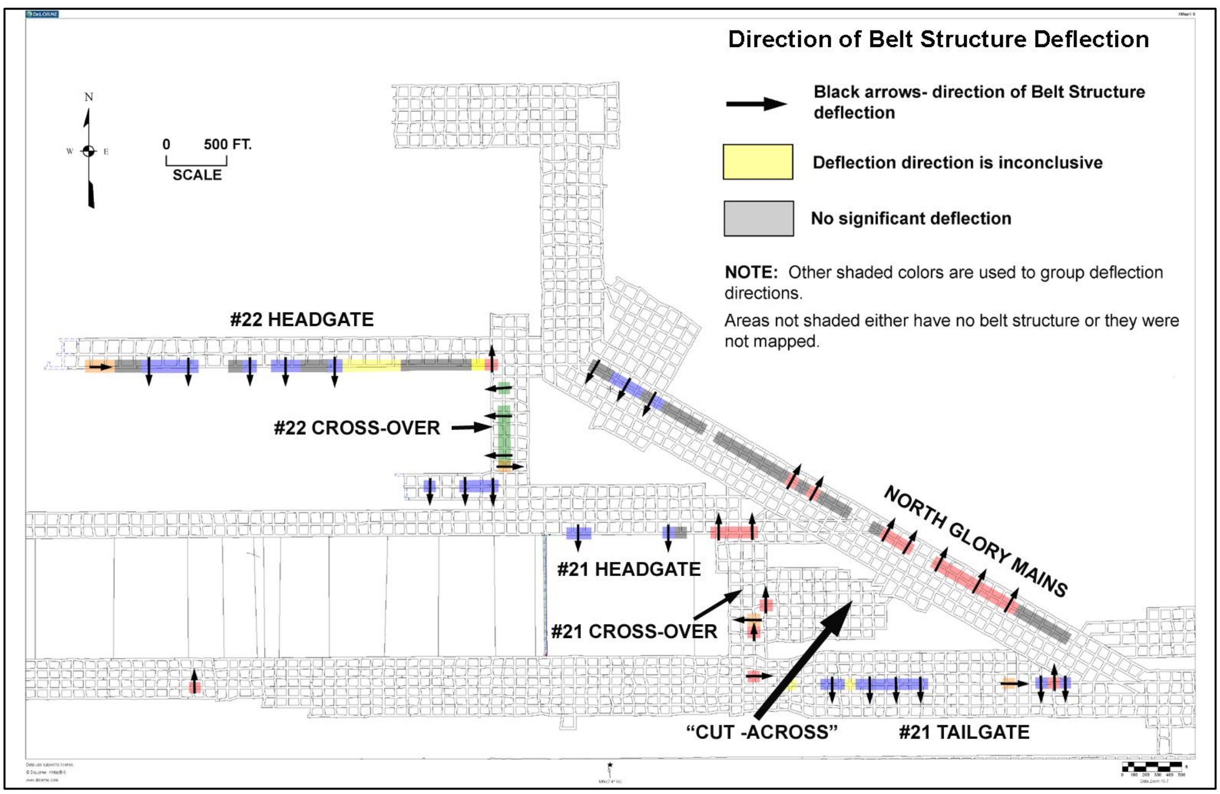


Figure 1C. After the CCW rotation the chain on the windward side may be broken, or the chain on the leeward side may become unhooked, dropping one side of the belt structure. This example view is in the North Glory Mains near spad 19852, looking inby.

It was noted by investigators that belt structures which were hit by left-lateral explosion forces tended to rotate counter-clockwise. The photos in the following example views are intended to illustrate the before, during, and after views of this reaction. Foot traffic in these photos shows visible rock dust on the floor under the soot layer.

Chains attached to belt hangers on the roof are attached to fins bolted to the belt structure (see **Figure 1**). The conveyor belts are typically 60 to 72 inches wide and travel over a series of 6-inch diameter roller cradles spaced 5-feet apart on top of the C-channel support structure. A series of straight rollers underneath are spaced about 10-feet apart, which carry the belt on its return loop (not shown in illustrations). Dimensions of the C-channel vary from 4"x 1-1/2" to 6"x 1-7/8", and in general structures using the smaller dimension C-channel sustained much heavier damage.

Explosion propagation directions which were parallel to the belt structure caused less damage than forces which were perpendicular, for example forces propagating from the Cut-Across and into North Glory Main crosscuts caused significant structural damage in these intersections, resulting in significant deflection or twisting of the belt structure.



Map 1. Areas where the explosion damage was noted to the Belt Structure, and the direction of forces involved.

The ***counter-clockwise*** rotation produced when left-lateral explosion forces intercept the suspended belt structure is illustrated in **Figures 1A, 1B** and **1C**. In this example the chains on the windward side are subjected to tensional stresses, often bending the belt hangers and ultimately pulling the chains apart. The chains on the leeward side of the wind forces, while not typically pulled apart, had frequently been popped out of their keyhole attachments as the belt structure rotation caused slack in the chains. The direction of belt structure deflection of the various belt lines is shown in **Map 1,** which covers most but not all sections of belt structure.

Summary of belt structure damage, by area

Explosion forces entering the crosscuts of the North Glory Mains from the Cut-Across resulted in significant structural damage to the belt structure at the confluence, and southeast of the confluence, but to the northwest only a few crosscuts between the mother-drive and Glory Hole showed damage. All deflections in the North Glory Mains were to the northeast, except at the entrance of the Glory Hole, where the belt structure was blown to the southwest.

The belt structure in #22 Headgate was damaged and deflected mainly to the south, but in parts of the eastern half the damage and deflection was both north and south. The belt tailpiece at the western terminus of the belt structure was pulled from its floor anchors and moved east, approximately 33 feet, and just east of the tailpiece there was approximately 130 feet of the belt structure compressed, accordion-fashion, into two debris piles, by east-directed forces. Where this belt crosses the #1 entry of #22 Cross-over, the belt structure is deflected north.

The belt structure in #22 Cross-over itself was deflected west at crosscut intersections, although subsequent forces from the #3 entry of #22 Tailgate bent the structure to the east at one location.

The belt structure in #22 Tailgate was deflected to the south.

The belt structure in #21 Headgate was deflected to the south in places, but deflected north where this belt crossed the #21 Cross-over.

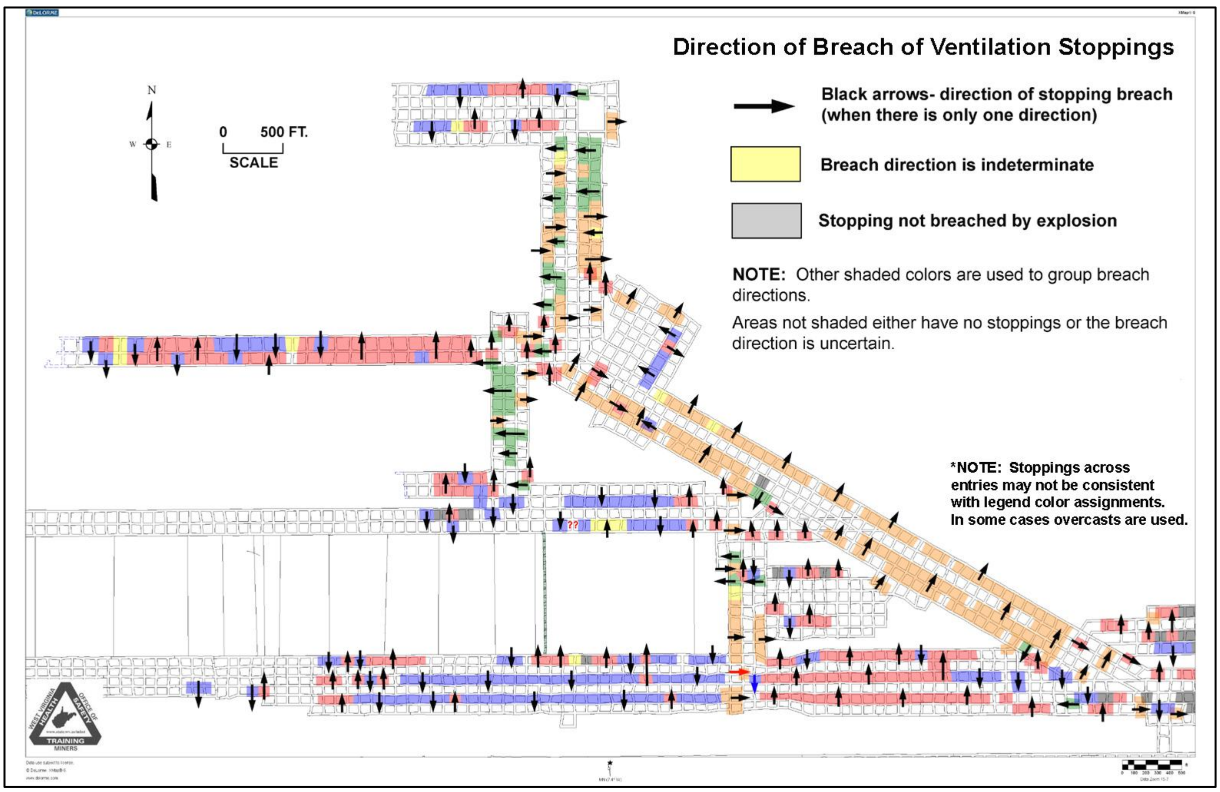
Where the Cut-across belt crosses the #4 entry of the #21 Cross-over, the belt structure is deflected north, while the belt itself was later caught as a sail and laid to the south. One break to the south in the #3 entry of this same crosscut the #21 Cross-over belt was deflected to the west by return forces traveling west out of the Cut-across. One break further yet to the south, the belt structure was severed and piled in accordion-fashion to the north.

The belt structure in the #21 Tailgate was not in use at the time of the explosion, and was partially or fully dismantled and not everywhere useful for determining deflections.

Breached Ventilation Stoppings

Ventilation stoppings provide useful information about the direction of explosion forces, and also as an indicator of the leading edge of the explosion, but much depends upon properly distinguishing original stopping material from other debris. Essential elements of this information are recorded in the *West Virginia Flames and Forces Map*. A map summarizing the directions of stopping breach is presented in **Map 2**.

Ventilation stoppings are used in underground mines to isolate air currents from one another. A few Kennedy[1] stoppings were used at the UBB Mine, but the vast majority of stoppings were of concrete block construction. Prior research shows that dry-stacked plastered solid concrete block stoppings can withstand static explosion overpressures of approximately 2 psi.[2] Ventilation stoppings are useful indicators of the direction of the first arrival of explosion forces.



Map 2. Direction of breach of ventilation stoppings due to explosion forces.

Most stoppings were constructed of 6 inch x 8 inch x 16 inch solid concrete blocks which were dry-stacked, with a coating of block plaster applied to one side. A few of the stoppings were of

[1] Constructed of sheet metal panels

[2] Nagy, J., Mitchell, D. W. Experimental Coal-Dust and Gas Explosions, Bureau of Mines Report of Investigations 6344

hollow 6 inch x 8 inch x 24 inch cinder block construction. Urethane foam was applied as needed to control leakage. Empty canisters of foam were found near stoppings at many locations, only a few of which showed signs of collapse from pressure, but some showed impact damage resulting from being transported by explosion forces or hit by debris.

Stopping scars[3] were identified, and then measured to a nearby rib corner, wherever possible. Block debris was often distributed on both sides of the stopping scar, which complicated determinations of the direction of actual stopping breach. The solution to this was to examine the debris on both sides to distinguish blocks used in the construction of the stopping from left-over block or other debris that were not part of the stopping. Investigators noted block bands, "partial pallets"[4] of block, remnants of man doors, and evidence of mortar or plaster on block debris to assist in this determination. Other clues were also used to distinguish stopping debris from extraneous debris in order to best determine the direction the stopping was blown.

Figure 4. (LEFT) Concrete block stopping, with a remainder pallet of unused block.

Figure 5. (RIGHT) Concrete block stopping, breached during explosion, with block debris in foreground.

Lines of stoppings are constructed to separate ventilating air currents (see **Figure 6**). Typically, two or more lines of stoppings are constructed for any given set of headings, for this purpose.

Usually, stoppings are built in crosscuts to separate the air currents in the entries. In a mine dust explosion, the heat of combustion within the confinement of the mine openings causes a rise in pressure and the propagating blast wave travels in all directions, and the available fuel in suspension, oxygen, and confinement influences the direction and extent of the explosion. The

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[3] Evidence of foam, wedges, mortar, etc. at the mine roof or ribs which might indicate that a stopping had once been there.

[4] Remnants of stacked block were found on one side of many of the stoppings, left over block from construction. These were referred to on the WV Flames and Forces map as "partial pallets."

static pressure acts in all directions as the explosion propagates and acts upon stoppings in crosscuts where they are encountered. If these forces are sufficiently strong, stoppings in these crosscuts will fail and remnants will be moved in the direction of the wind forces and dynamic pressure as the air rushes through the ruptured stopping. By carefully mapping the breach direction of the stoppings, it is possible to infer which entry (or entries) carried the leading edge of the explosion.

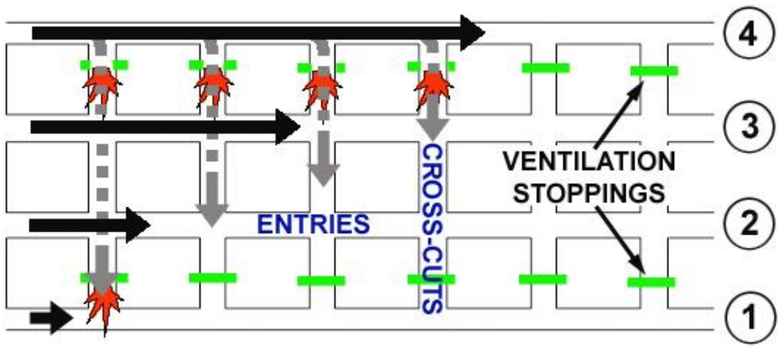

Figure 6. For a propagating explosion traveling in the direction of the entries (black arrows), the leading edge entry can be inferred by the direction in which the ventilation stoppings (green) are breached in the crosscuts (gray arrows), as determined by their debris fields (red).

An example is given in **Figure 6,** showing an explosion propagating through four parallel entries and branching into successive crosscuts as they are encountered. If the leading edge favors the outside entry (in this case, entry #4), the stoppings will tend to fail in the direction of entry #1. In making such turns wind forces are reflected off solid surfaces at intersections, resulting in confusing and potentially misleading damage patterns. This is part of the reason intersections are excluded when mapping and counting bent roof pans (see **Appendix 7.9-2**).

In the #21 Tailgate (a seven-entry system) between the #21 Cross-over and the Longwall, the majority of the crosscut stoppings are blown to the SOUTH (see **Map 3A**). The #7 entry[5] is believed to be the leading edge of the explosion as it propagated eastward, with forces in the other entries following behind. This entry had a head start coming out of the "T-split" at the Longwall, and it may also have had more combustible fuel.

When the explosion forces in the northern-most entries of #21 Tailgate encountered the #21 Cross-over they slowed or flame speeds in the southern entries increased, or both. The explosion forces in the #21 Tailgate impacted the stoppings, doors, and regulators at the junction with the #21 Cross-over, causing some increase in pressure. High reflected pressure and/or high flame speed is indicated by the large amount of roof pan damage in this region (see **Figure 7** and **Map 3B**).

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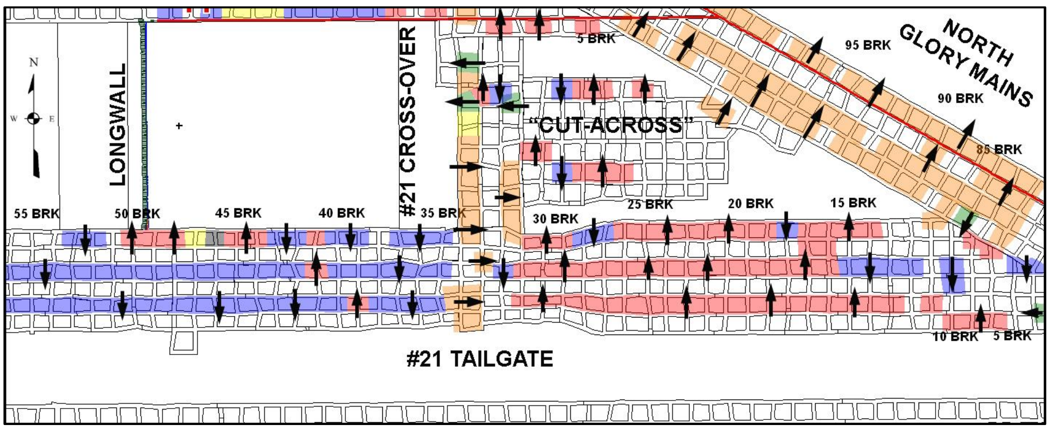
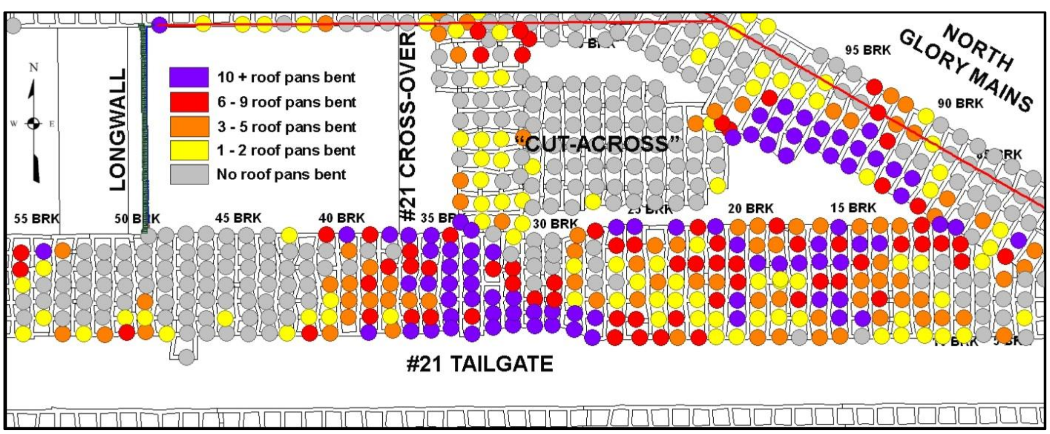
[5] This is the farthest north entry in this part of #21 Tailgate .

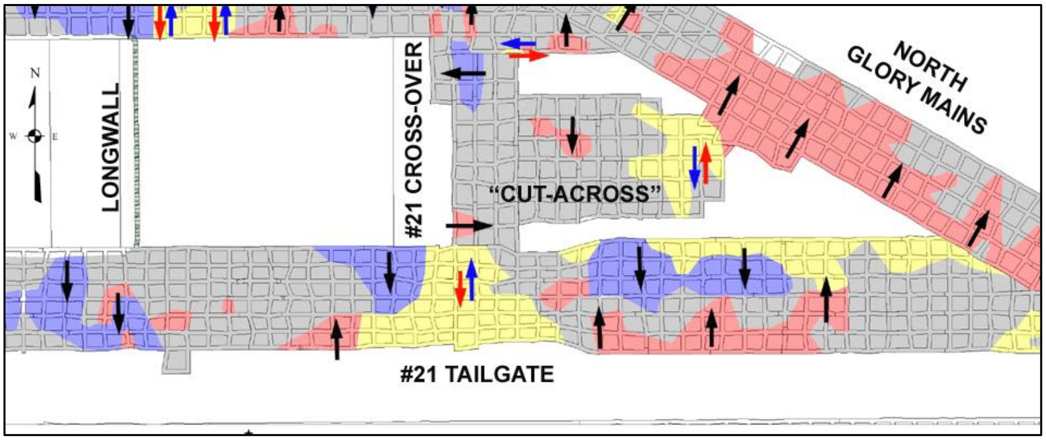
Figure 7. Examples of severe roof pan damage in the region of #21 Tailgate south of the the #21 Cross-over.



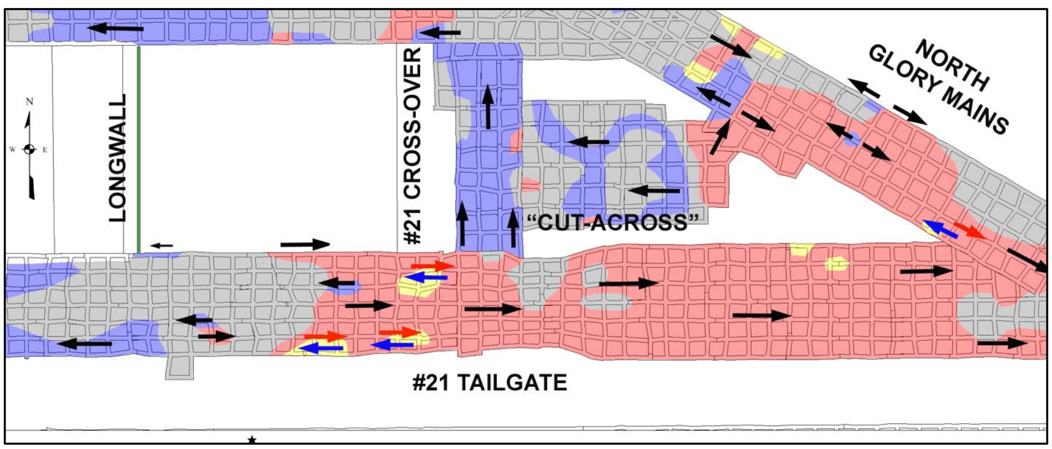
Map 3A. This map summarizes the <u>direction of stopping failure</u>, due to Initial Forces of the explosion. Note that the breach directions west and east of the #21 Cross-over are opposite each other.



Map 3B. This map summarizes the <u>numbers of roof pans</u> bent in the direction of the Initial Forces.



Map 3C. This map summarizes the direction of roof pan bending in the mine CROSSCUTS.



Map 3D. This map summarizes the direction of roof pan bending in the mine ENTRIES.

As a result of these factors, the leading edge of the explosion in #21 Tailgate transitioned from the north side (#7 entry) to the south side (#1 entry), as it passed by the #21 Cross-over, as evidenced by the corresponding change in the direction of stopping failures in the crosscuts--from a southward to a northward direction (see **Map 3A**). The leading edge of the First Forces through #21 Tailgate remained on the south side for the remainder of their travel outby, until extinction.

Wind forces in #21 Tailgate, east of the #21 Cross-over are for the most part always directed outby (eastward, see **Map 3D**), including the direction of final forces. The roof pans in the crosscuts (**Map 3C**) gives the same sense of direction as the stopping breaches. However, the belt structure is blown to the south (**Map 1**) which suggests a subsequent event with a leading edge along the northern entries of #21 Tailgate. This is corroborated by roof pans bent in a southerly direction.[6] As shown in **Map 3C** these multiple wind directions resulted in roof pans bent toward the middle entries on both sides. The direction of stopping failure gives us the direction of the first forces, the position of damage to belt structure and waterlines gives the direction of the subsequent return forces. By taking into account the information from roof pans, deflected waterlines, and deflected belt structure, a subsequent set of east-driving forces in this section of #21 Tailgate emerges, indicated in part by the final resting position of belt structure and the waterlines. Two separate episodes of east-directed propagating[7] events are suggested, as evidenced by roof pan bending in both instances.

Deflection of Waterlines

Where explosion forces intercept waterlines laterally they tended to deflect or break them, but parallel forces directed parallel to waterlines did not. The waterline and beltline deflections in #21 Tailgate were in opposite directions. It is believed that stoppings were knocked down by First Forces, and the final resting position of belt structure and waterlines is the result of Return Forces traveling inby the #22 Cross-over junction.

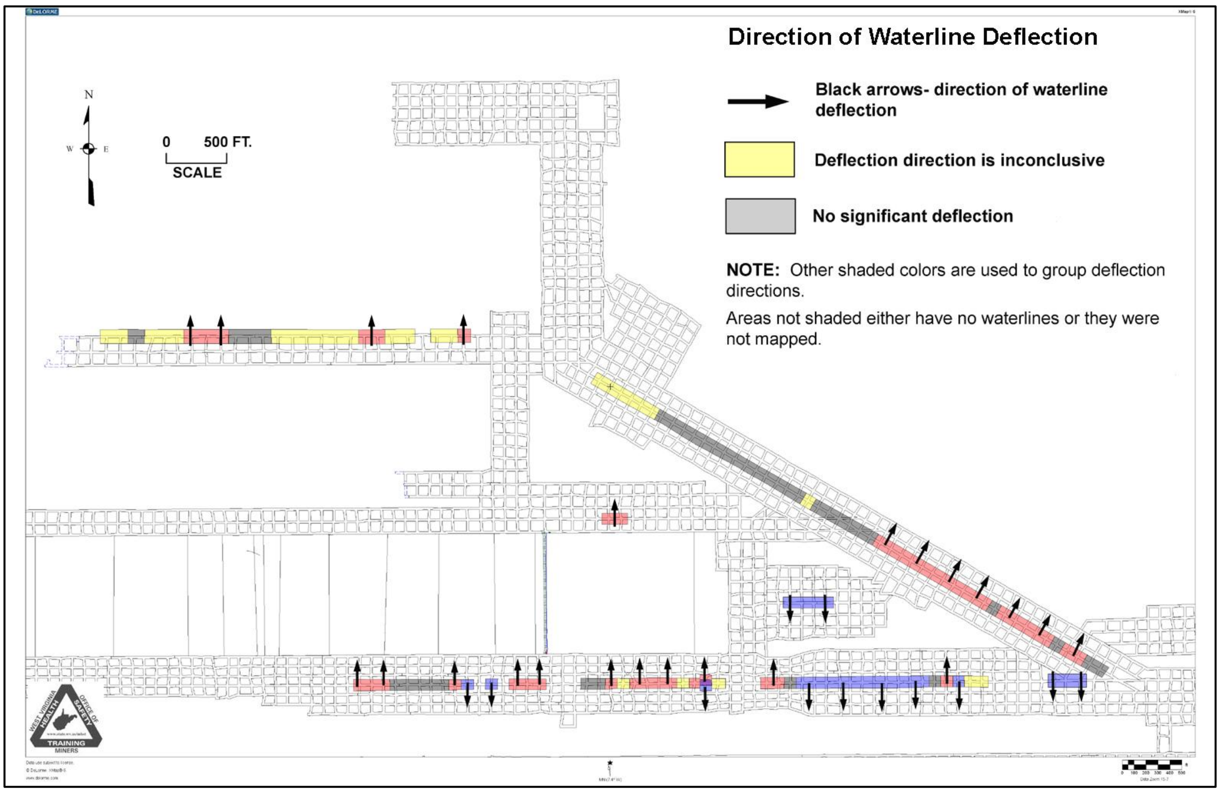
Waterline diameters are approximately 4.5, 6.5 and 8.5 inches (O.D.) and when in service they were generally laid parallel to the track, and/or the belt structure.[8] Although they were laid on the mine floor they were sometimes chained to the mine roof at equipment crossings. Waterlines were documented in the North Glory Mains, #22 Headgate, and #21 Headgate.

Figure 8. (LEFT) Example of a waterline moved by explosion forces. (RIGHT) An example of a small waterline broken (perhaps by explosion forces).

[6] The very northern region of #21 Tailgate has roof pans bent both directions.
[7] Propagation involves fuel consumption
[8] Sometimes a waterline existed in other entries, such as the #3 entry return in #22 Headgate.,

Laboratory testing and computational analysis were performed by Steve Sawyer, Sr., et.al. for MSHA, for at least one bowed and displaced waterline. The results have not yet been officially released, but they found the northeasterly displacements to a 6.5" HDPE waterline into a crosscut northeast of the track entry of North Glory Mains at break 85 indicate minimum, total explosion pressures of 5.7 to 6.3 psi.[9] Using the overpressure one can calculate the air velocity, then the force exerted by the velocity can be calculated.

The observed deflections to the waterlines, are noted on the *West Virginia Flames and Forces Map*, and are summarized in **Map 4.** Most, but not all waterlines were documented.



Map 4. Lateral displacement of discharge water lines, attributed to explosion wind forces.

Summary of explosion damage to waterlines, by area

Explosion forces entering the crosscuts of the North Glory Mains from the Cut-Across resulted in deflection and bending of the plastic waterlines at the confluence, and southeast of the confluence, but not to the northwest, except at the mouth of the Glory Hole, and at one crosscut located about 5 breaks inby the "mother drive." At these latter locations, the waterlines were distorted deflected in two directions or the direction was unclear. Otherwise, all deflections to

[9] Personal communication with Steve Sawyer, Sr.

waterlines in the North Glory Mains were to the northeast, same as the belt structure and stopping deflections.

Waterlines in the #4 entry of the Cut-across were deflected to the south.

Waterlines in the #3 entry of #22 Headgate were broken and bent in both directions, but a few were deflected in only a northerly direction.

Waterlines in #21 Tailgate are deflected to the south, in the region that is east of the #21 Cross-over. West of the #21 Cross-over, the final resting positions of the waterlines indicate mostly north-directed forces, although there are a few exceptions. This effect is opposite of the breach directions exhibited by the ventilation stoppings. The waterline deflections here appear to be the result of Return Forces entering the #21 Tailgate from the #21 Cross-over, branching outby and inby and carrying sufficient energy to bend pans, and to deflect waterlines and belt structure.

Debris Transport (an example)

Other mine structures were also used to determine direction and sequence of explosion forces. Two examples are given below, (1) transport of airlock doors, and (2) transport of power boxes, which are in the same general vicinity of the North Glory Mains (see **Figure 11**).

In the first example two sets of double doors,[10] near spad 19682 that were known to be in service in a crosscut between the #2 and #3 entries at the time of the explosion, were blown and transported during the explosion. Four (4) doors were found nearby, and since no other doors besides these were found in the area it is believed these are the same 4 doors. As shown in **Figure 12**, explosion forces coming from the Cut-across to the southwest apparently pulled the doors from their mounts and transported them to the NE, followed by subsequent forces coming out of the NW and passing through North Glory Mains, re-depositing two of these doors to the SE.

The same two-step transport sequence is also indicated in the second example, a nearby capacitor box found at location “C” (see **Figure 13**). The capacitor box is believed to have been stationed one break inby, at location “A,” prior to the explosion. Both its front and back end panels are bowed in the same direction and it is missing two top lids and two side panels.

This capacitor box, which is approximately 8 feet x 4 feet x 3.5 feet high was transported to the NE from its original location at “A” to location “B” where it appears to have impacted the track and waterline (**Figure 9**), deflecting both slightly, to the north (see **Figure 10**). Dynamic wind forces moved the box.

[10] Total of four doors (6’x 7’)

Figure 9). (LEFT) Bent track and punctured waterline, at location "B" (see the figures below).

Figure 10). (RIGHT) The capacitor box in its final resting position at location "C" (see the figures below).

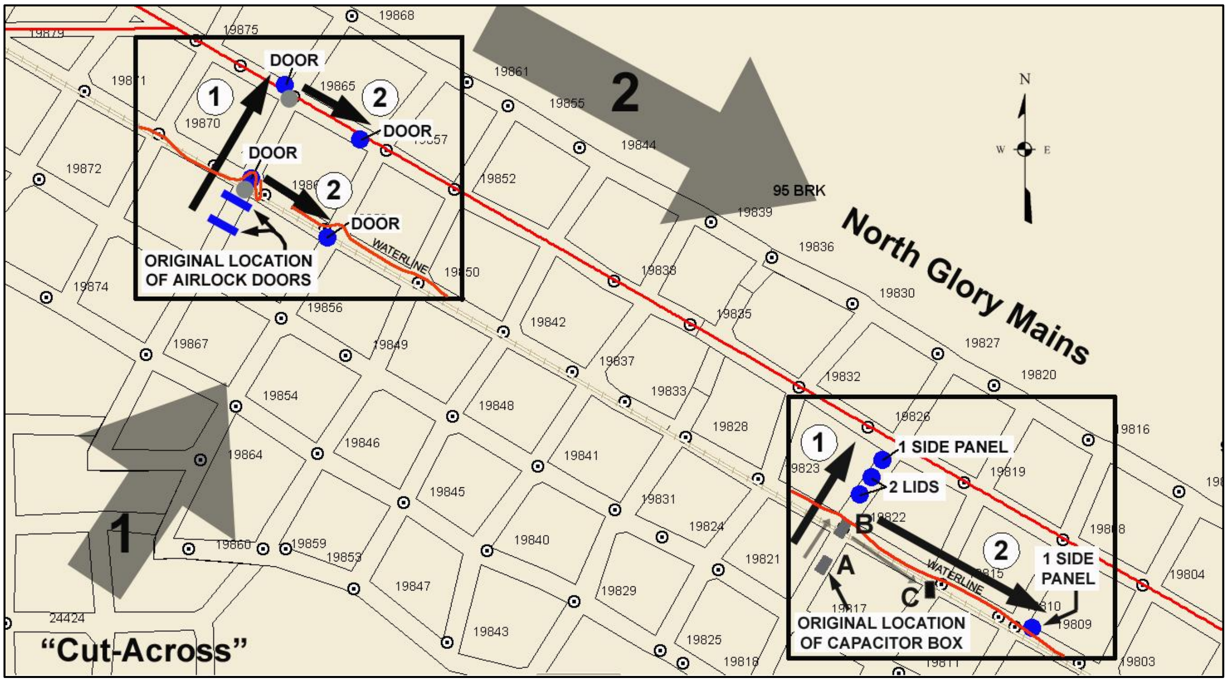
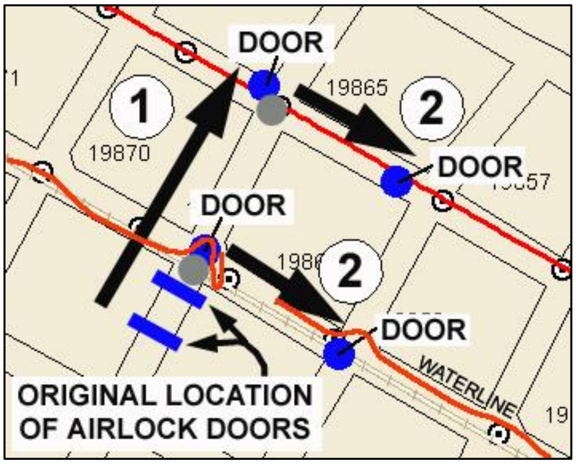


Figure 11. Forces traveling NE (1) out of the Cut-Across Panel entered the North Glory Mains, followed later by return forces (from the NW) through the North Glory Mains, traveling to the SE (2).

The two missing lids and one of the side panels traveled slightly farther, coming to rest on the other side of the track, approximately 30-50 ft. to the NE. Later, the capacitor box was transported one break SE to its final resting place at location "C," near spad 19815. Its remaining side panel was found one break further to the SE, at spad 19809.



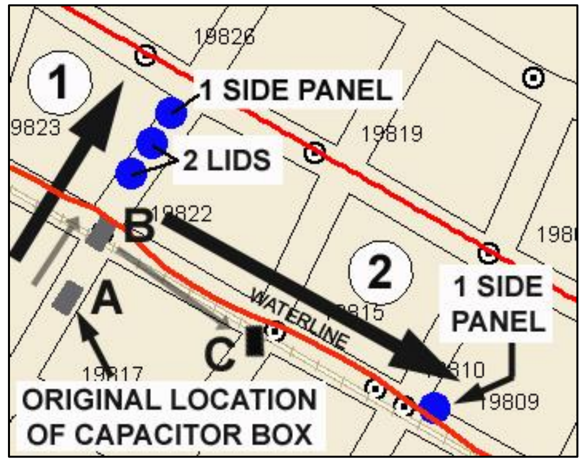


Figure 12. (LEFT) Four airlock doors that were found crumpled on the mine floor, appear to have originally been the doors that were hanging just SW of spad 19862 prior to the explosion. They were transported first NE. Two became tangled in debris, and the other two were subsequently transported SE.

Figure 13. (RIGHT) A capacitor box found at location "C" is believed to have been at location "A" prior to the explosion. It is missing 2 lids and 2 side panels. It is believed to have first been transported NE where it impacted the track and waterline at location "B," losing 2 lids and one of the side panels which traveled an additional 50-ft NE. The capacitor box was subsequently transported one break SE to its final resting spot, location "C," and its remaining side panel was found 1 break further SE at spad 19809.

In these two examples we have corroboration with independent items in the same relative vicinity of a two-step transport sequence: (1) NE direction up the crosscuts of North Glory Mains, then (2) SE, and outby in the entries of North Glory Mains. This movement direction and sequence of wind forces in North Glory Mains was further corroborated with detailed mapping of the roof pans.

Summation

These examples of deflected and breached structures illustrate the different types of information and methods that were used to analyze the UBB explosion and interpret the direction, sequence, and strength of explosion forces involved. Careful documentation facilitates effective conceptualization and corroboration of multiple lines of evidence permits complex processes like the UBB explosion to be better understood.

APPENDIX 7.9-5

FORCES AND HEAT ON THE LONGWALL

The explosion appears to have originated behind the Longwall shields in the gob, somewhere between Shield 173 and Shield 117. From there, it appears to have entered the Longwall, passing over the shearer and exiting the Longwall at the #7 entry of the #21 Tailgate (the "T-split"), where it then appears to have transitioned to a dust explosion in the #21 Tailgate entries. It also appears to have propagated north along the gob fringe behind the shields, directing wind pressures toward the face of the Longwall until approximately Shield 65 where forces became funneled into the Longwall, where they apparently subsided to extinction. There is also evidence that explosion forces exited the gob approximately 300 - 400 feet west of the Longwall shearer at the #6 entry of #21 Tailgate, spreading then into the other entries. The explosion propagated east and west in #21 Tailgate.

The two likely possibilities for the cause of the ignition are falling rock igniting methane, or hot streaks from the shearer cutting into sandstone and igniting methane. Once ignited, methane flame can travel some distance along a thin, flammable boundary between methane and air until the flame contacts a body of gas mixed with sufficient air to explode. The ignition origin and explosion origin therefore can be in different locations.

There is little evidence of flame and coking on the longwall, except between Shield 72 and Shield 41 where coke was found on shield cylinder legs and shield surfaces facing the gob. The highest pressures appear to have developed in the Headgate and Tailgate regions, and probably ranged from 6-15 psi,[1] when explosion forces returned to the Longwall, first at the Tailgate, then at the Headgate.

Evidence of Heat

The Longwall is oriented north-south, and is supported by 176 shields that are approximately 20 feet long and 6 feet wide, and arranged shoulder-to-shoulder down the length of the Longwall, starting with Shield 1 at the Headgate (north end of Longwall) and ending with Shield 176 at the Tailgate (south end of Longwall). The distance between the Headgate and Tailgate is approximately 1,000 feet. Shields 1, 2 and part of Shield 3 actually extend out past the Longwall face, into the first entry (the belt entry) of the headgate.

[1] From MSHA summary of Expert Report Findings, November 22, 2011, by Steve Sawyer, Sr., et. al. These reports have not been officially released.

Evidence of heating exists on most of the shields north of Shield 72, but there is little evidence of heat between Shield 72 and Shield 160. Items that display evidence of heating (blistering, discoloration, melting) include zip ties (used to secure and hang cables and hoses), plastic speaker and lens covers on CIU boxes, and fluorescent light covers (see examples, **Figure 1, 2**). There is little evidence of coked dust on the Longwall, except between Shield 41 and Shield 72, (see **Appendix 7.9-1, Map 4**) where small and medium amounts of coke are present on the south side of shield cylinder legs and on surfaces which face the gob (west). Coke is evidence of flame.[2]

Figure 1. (LEFT): Melted zip ties; Shield 38; (MIDDLE): Melted speaker cover; Shield 39; (RIGHT): Melted plastic lens cover on Shield 62 control box (CIU). Note the clean white area behind the melted red lens.

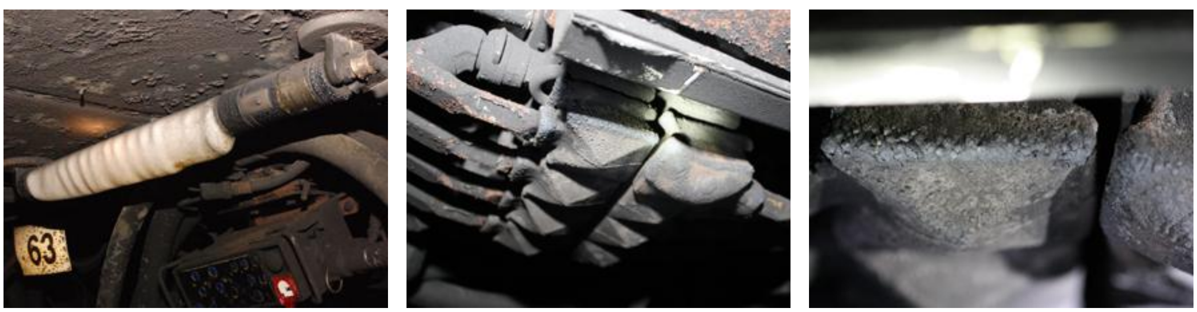


Figure 2. (LEFT): Melted fluorescent light cover at Shield 62; (MIDDLE): Evidence of heat on the rubber cover for manual shield control box; Shield 62; (RIGHT): Close-up of cover for manual shield control box; Shield 62.

Small aluminum signs (6 inch x 6 inch, used to identify each shield by a number) were found attached to the underside of the shield canopies. These signs are covered with a thin film of reflective mylar that becomes blistered and discolored when heated (**Figure 3B)**. About half of the signs that existed between Shield 1 and Shield 65 were destroyed and are missing. Of the surviving signs, those having the most conspicuous evidence of heating include: 14, 15, 18, 19,

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[2] Man, C.K., Harris, M.L., Weiss, E.S., Determining Flame Travel Measurements from Experimental Coal Dust Explosion, Pittsburgh Research center, NIOSH

34, 56, 57, and 61-64. Most items showing visual evidence of heating tend to be located within 1-2 feet beneath the shield canopies.[3]

Between Shield 72 and Shield 160 there is almost no apparent heat damage, but from Shield 160-176 there is evidence of heating on the plastic shield components, primarily cable couplers. Because there is little coke found on the Longwall, the burning that produced the evidence of longwall heat is believed to come principally from the gob.

Some of the heating between Shield 12 and Shield 72 is believed to be related to continued gas combustion in the gob for a brief time after the explosion. The evidence for this includes a melted plastic lens cover on the Shield 62 control box (CIU) which has the appearance of being melted after dust from the explosion had settled (see **Figure 1**).

Initial wind forces on the Longwall

<u>Wind forces from the Gob, propagating north</u>

The small aluminum signs under the shield canopies typically were attached by a simple “S” hook or sometimes a plastic zip tie. The shield signs or “tags” that survived the explosion are indicators of relative heat and wind forces. They developed two styles of bending damage that were used to help reconstruct the sequence of events during the early stages of the explosion.

Signs on the north side of the Longwall were mostly destroyed. Between Shield 1 and Shield 44 only 11 remained hanging after the explosion. Between Shield 45 and Shield 62 all signs remained hanging, except for three. Between Shield 63 and Shield 158 all but nine remained hanging, and between Shield 159 and Shield 176 (the last shield) all but eight signs remained hanging. Of the hanging signs, some were bent, some not.

The surviving bent signs were folded in one of two characteristic styles, and were generally confined to their own region of the Longwall. Signs bent along a *horizontal fold axis* are located south of Shield 56 (and encompass the Shield 56-64 “hotspot”). Signs bent along a vertical fold axis appear north of about Shield 49. There is a transition of these styles between Shield 49 and Shield 64. These geometries are illustrated with examples in **Figure 3A** and **Figure 3B**.

Shield signs were generally hung from a steel hanger strip oriented north-south (N-S bead), attached to the underside of the shield canopy near the west edge of the longwall walkway (the three examples in **Figure 3B** are hung from this strip). Signs hung from this location would originally have faced the gob, and were free to swivel on the “S” hook. Sometimes signs were hung from one of two “U” hook attachments further back under the shield canopy, and signs hung from these locations would have generally faced the axis of the longwall. Many of these

[3] The reflective mylar covering the aluminum signs is considered a plastic

signs were not bent by explosion forces, for reasons believed to be related to sheltering. Signs hung from the mounting strips, however, were more exposed and close to the canopy surface, resulting in the largest numbers of bent signs.

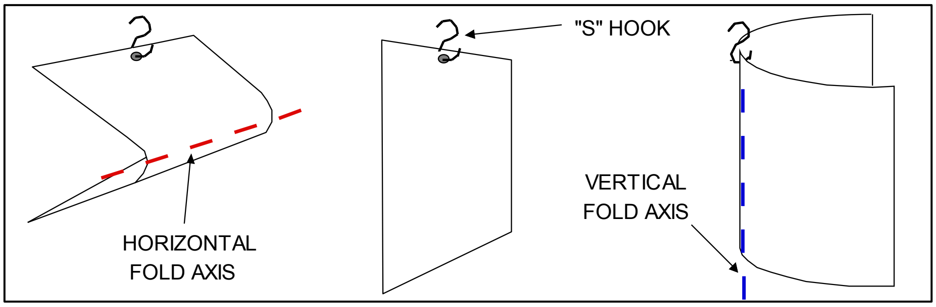

Figure 3A. (LEFT): Shield sign bent along horizontal fold axis, (MIDDLE): Shield sign unbent, (RIGHT): Shield sign bent along vertical fold axis.

Figure 3B. (LEFT): Typical bending of shield sign south of Shield 56 is to the SOUTH, along a horizontal fold axis, (MIDDLE): Shield 62 sign is generally unbent, but heat damaged, (RIGHT): Typical bending of shield sign north of Shield 56 to the NORTH, along a vertical fold axis. There are exceptions.

It is believed that the change in bending styles is related to an obstruction in the gob, just north of the “hotspot” that terminated propagation behind the shields. Earlier in the day a delay to mining occurred while repairs were made to the B-lock on the shearer between the Headgate and approximately Shield 65. In this same region, many of the shields were not pulled up, and the delay involved at least 2.5 hours. When mining did resume, the shields south to the Tailgate were pulled up as the shearer advanced. It is unknown why the Headgate shields were not advanced, but because of the time the shields were stationary it is believed the gob would have been tight against those shields (see **Section 4.1**). In contrast, mining from Shield 65 to the Tailgate was completed in approximately 30 minutes, and those shields were moved up as the shearer advanced, creating some space behind the shields that had not caved or was in the process of caving. It is believed that the explosion began in the gob near the Tailgate, and as one branch expanded north behind the shields it traveled in this space, and expanding gas forced it’s way from the back of the shield openings into the longwall. The signs hanging along the walkway record this event by being horizontally bent as pressure forces from the gob impacted them against the bottom of the shield canopy.

A study of the styles of bending of the shield signs just described was performed for WVOMHS&T by Mallett Technology,[4] using computational fluid dynamics (CFD). The analysis concludes that the characteristic *horizontally-bent signs* were not the result of wind forces traveling through the Longwall, but were more likely the result of wind forces coming from the gob. The bent signs between Shield 56 and Shield 108 exhibited this mode of bending. South of Shield 108 a mix of bending styles are present, and in two regions there is no bending at all. From Shield 146 to Shield 164, the majority of the horizontal folds point to the gob.

North of the "hotspot" between shields 64 and 56 the horizontal bending style transitions to the vertical bending style (from Shield 56 to Shield 42). The surviving signs north of Shield 42 (inclusive) are bent along their vertical axes. The CFD analysis demonstrates that signs folded along their vertical axes are caused by wind forces traveling in the direction of the axis of the longwall, not from the direction of the gob. It is believed the explosion forces behind the shield encountered gob rocks closer to shields that had not been pulled up, which denied it space and/or fuel to propagate into. These forces became funneled into the Longwall, where it appears they subsided to extinction. Just north of this jump is a region where reflected pressure appears to have been created between Shield 50 and Shield 36, causing the majority of the E-Stop buttons on the shield control boxes (CIU 's) to be pushed in. The minimum normally-incident pressure to do this is approximately 6-7 psi.[5] It is speculated that the diverted forces of this pressure event reflecting off the Longwall coal face or cable trough next to the chain conveyor pushed these buttons. The CIU buttons are described below in more detail. North of Shield 47 not many signs survived, but those which remained were folded along their vertical axes, indicating that wind forces through this region were directed either north-to-south or vice versa, but not from the gob.

Wind forces from the Gob, propagating west

There is evidence that early forces west of the Longwall entered the #6 entry of the #21 Tailgate from the edge of the caved area (gob). Force directions from various mapped indicators are illustrated in **Figures 4A** to **4D**. In the #6 and #7 entries west of the Longwall the 3rd and 4th stoppings west of the Longwall were blown south (1), accompanied by bending of roof pans southward through the crosscuts (2) and westward in the entries (3). A roof fall across the #6 entry obstructed westward propagation in this entry, causing reflected pressures and severe bending of roof pans there and in the #5 entry (4). These forces continued west and south.

4 Explicit Dynamics and CFD Analysis of a Mining Accident; Mallett Technology Inc, Columbia MD, 2012 (see executive summary, **Exhibit 2**).
5 Ibid

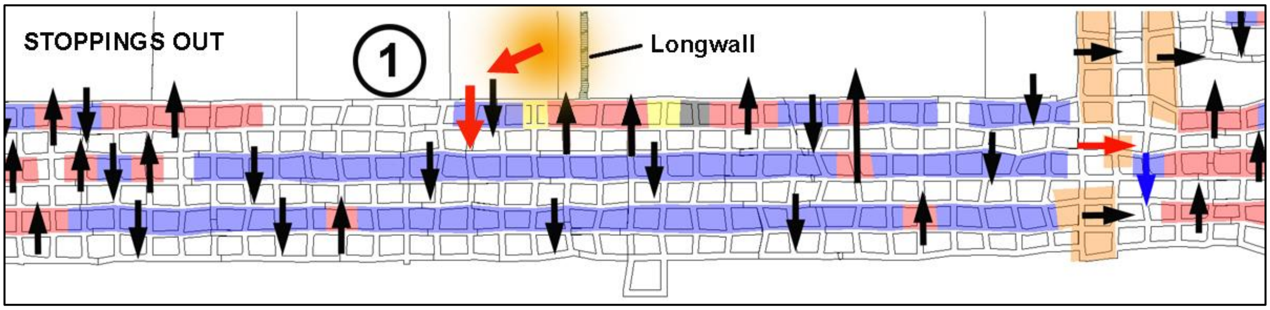

Figure 4A. #21 Tailgate: Directions which ventilation stopping were blown by explosion forces.

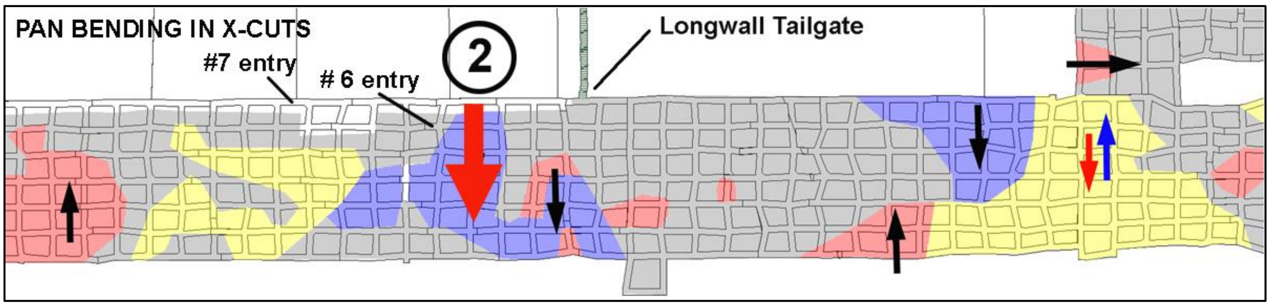

Figure 4B. #21 Tailgate: Direction roof pans in CROSS-CUTS are bent by explosion forces. YELLOW areas are where there is bending of pans both ways.

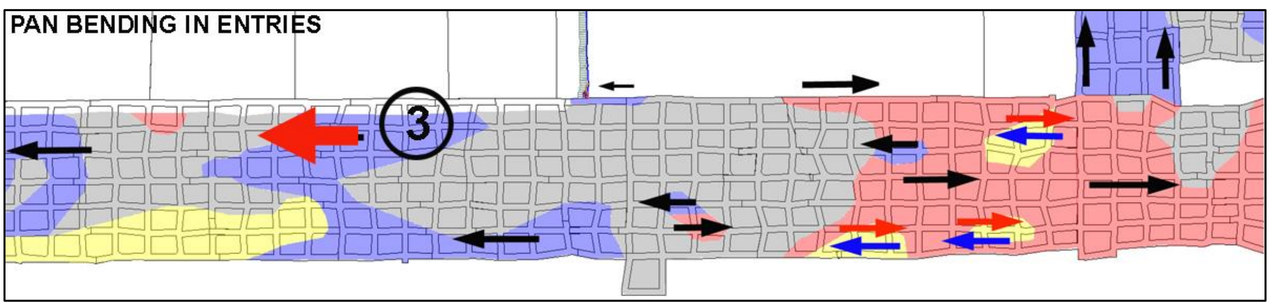

Figure 4C. #21 Tailgate: Direction roof pans in ENTRIES are bent by explosion forces. YELLOW areas are where there is bending of pans both ways

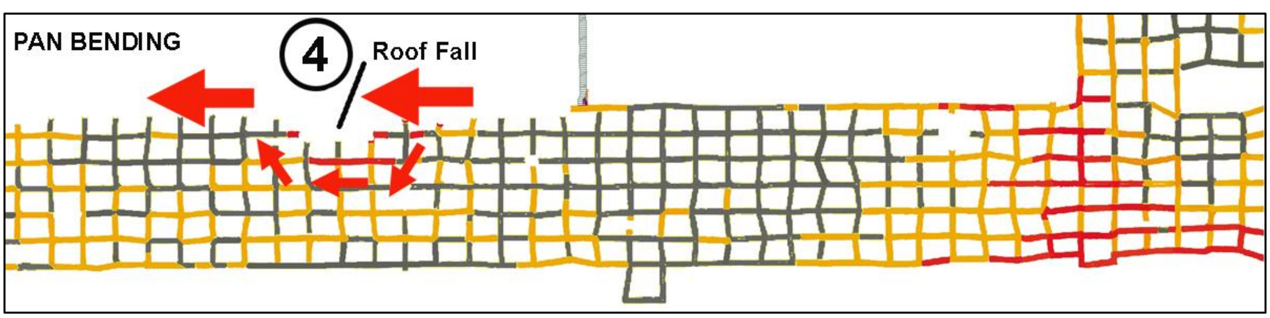

Figure 4D. #21 Tailgate: GRAY: Roof pans are unbent.. ORANGE: Roof pans bent >90 degrees. RED: Roof pans are severely bent.

Wind forces from the Gob, propagating east

The part of the explosion that propagated east from the Longwall in the #21 Tailgate began initially with forces from the gob entering the southern region of the Longwall, then exiting the Longwall at the tailgate “T-split”, traveling across the shearer and entering the #7 entry of #21 Tailgate. The leading edge of continued propagation eastward appears to have remained in this entry for approximately 1,500 feet, until reaching the #21 Cross-over.

Figure 5A. (LEFT): Two pieces of the same Comtrol box believed to have originated at Shield 173 (RIGHT): Impacted coal and dust along the north face of shearer bit, next to the solid coal face.

Figure 5B. (LEFT): Impacted wet coal and dust along the bottom half of the first propsetter outby the shearer. This points toward the back (west) side of the shearer cutting head; (MIDDLE): Close-up view. (RIGHT): The coal “windrow” (coal berm) that normally develops here is missing.

Impacted wet dust (mud) on the north side of the Tailgate shearer drum suggests initial explosion forces passed over the shearer and exited the Tailgate. Deposits of impacted mud were found on the tail-drive cowl,[6] shearer bits (**Figure 5A**, right) and on the first several wood props (propsetters) standing just outby the shearer in the #7 entry of the tailgate (**Figure 5B**, left). The

[6] The tail-drive cowl had not yet been flipped to begin a longwall pass north.

impacted muddy deposits at the base of the propsetters outby the shearer are oriented in the direction of the opening between the shearer and the tail drive (see **Figure 6**). The coal berm or "windrow" that typically forms where the shearer completes its pass into the Tailgate had been scoured away from around the Tailgate shearer drum (**Figures 5B** (right), and **Figure 6**). The mud which formed on the propsetters (see P1 to P4, **Figure 6**) is believed to have originated from the Longwall and perhaps some came from the windrow, but none was not found on the propsetters west.

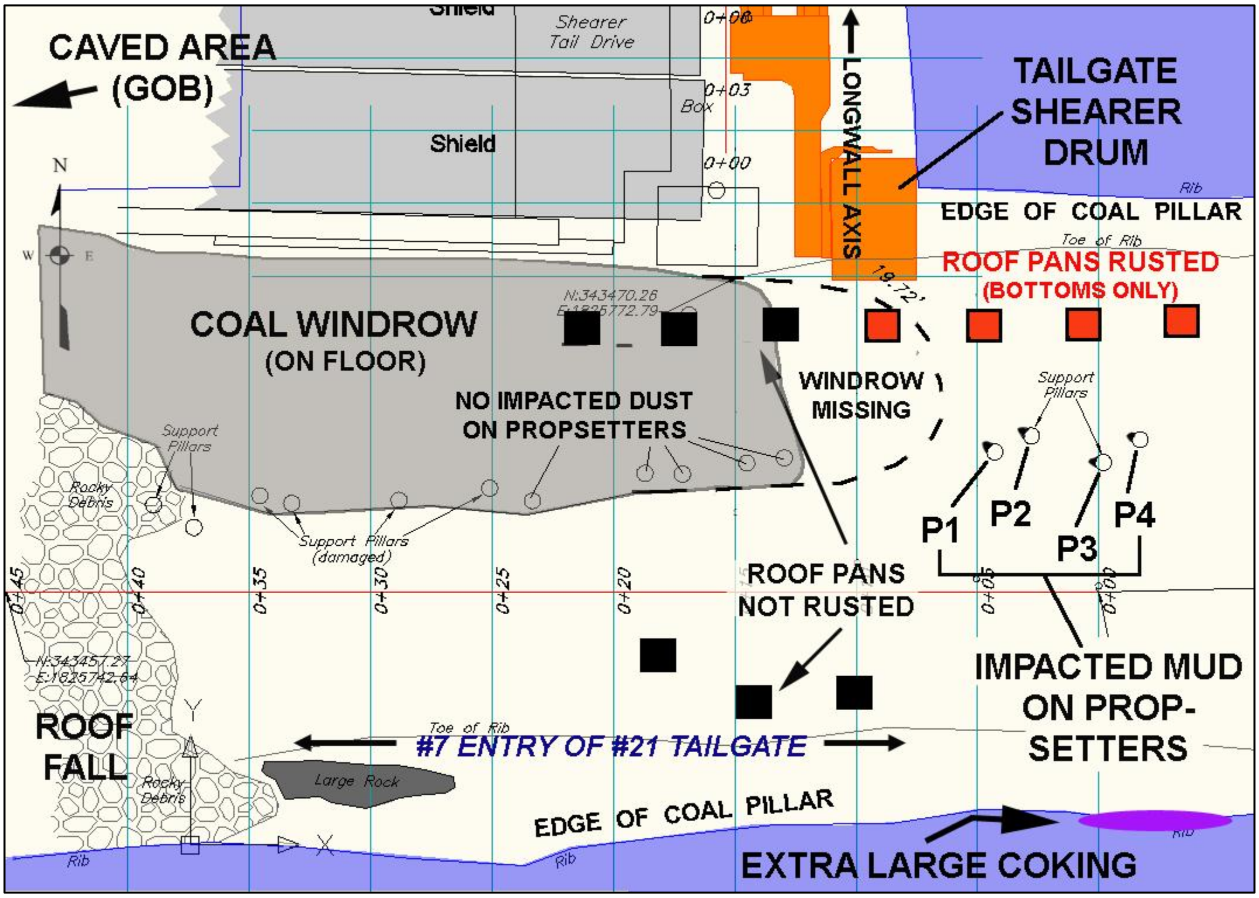

Figure 6. Illustration of some of the features of the "T-split" where the Longwall and the #7 entry of #21 Tailgate intersect. Note roof fall blockage of just inby (west) of the longwall.

Two Comtrol phones in the southern half of the Longwall were missing from their shield mounts after the explosion. The unit at Shield 117 was missing, but its pieces appear to have traveled north as far as Shield 106. The other unit was at Shield 173, and pieces (see **Figure 5A**, left) were found as far north as Shield 166 and at least one piece was found outby, east of the shearer in the #7 entry. Examination showed that an aluminum bottom (MSHA evidence PE-0281) found near Shield 171 and an aluminum side (State evidence CMTL-02.22.11-S171) found approximately 140 feet outby the shearer were a close match.[7] These items and others from the Longwall found outby the shearer[8] indicate forces exited the Tailgate during the methane explosion in the gob.

After entering the #7 entry of #21 Tailgate explosion forces traveled east toward the #21 Cross-over. As it traveled east its strength increased as fuel was consumed and pressures increased. This progression of increasing force corresponds to increasing to levels of damage to standing supports, stoppings, and roof pans (see **Figures 7A-7E**).

The 1st ventilation stopping (see **Figure 7A**) located east of the Longwall is approximately 20 feet wide and has an opening of approximately 8 feet. It would be normal for this stopping to have been manually breached as part of normal Longwall ventilation. The initial explosion forces from the Longwall did not cause conspicuous damage to this stopping, although some blocks were blown northward by subsequent forces. Tests performed on an empty, undamaged spray can indicate static pressure here did not exceed 13.2 psi.[9]

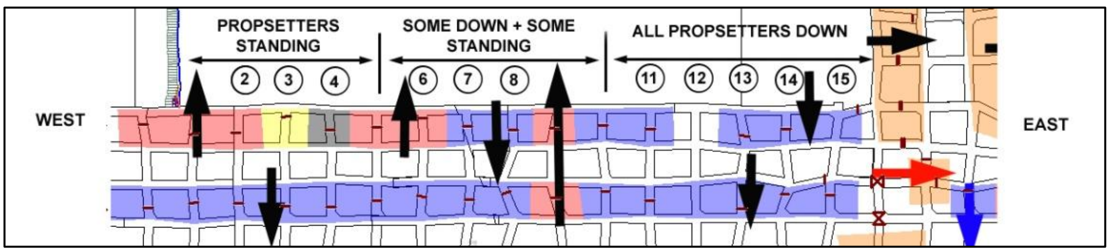

Figure 7A. Direction of Stopping Deflection. RED: Stopping failed to the N.; BLUE: Stopping failed to the SOUTH.; YELLOW: Stopping debris went N. and S.; GRAY: Stopping is still intact

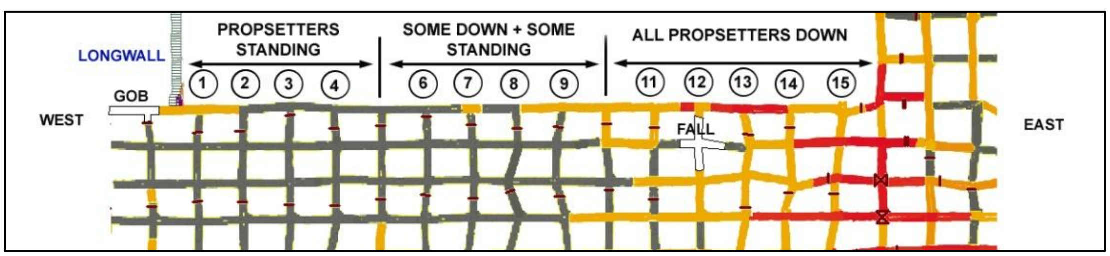

Figure 7B. Degree of Pan Bending. GRAY: Pans are not bent. ORANGE: Pans are moderately bent; RED: Pans are severely bent.

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7 Close examination of the broken wires from the two pieces confirmed they went together. This examination was performed at the MSHA Approval and Certification Center, Triadelphia, WV.
8 Includes circuit boards and an airstream helmet
9 Implosion pressure testing on identical spray cans was performed by NIOSH (see **Appendix 7.9-6**).

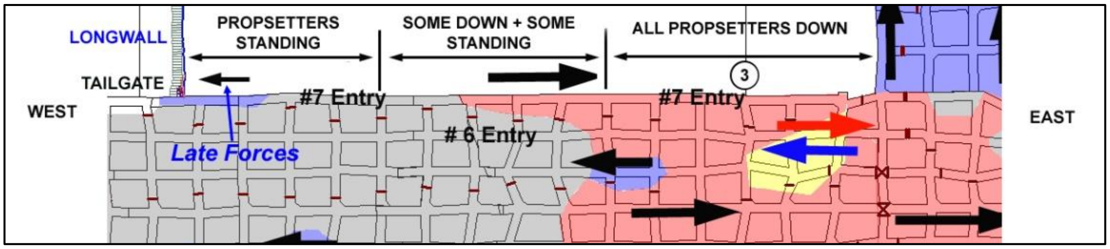

Figure 7C. Roof Pan Bending in the direction of the ENTRIES. RED: Pans are bent to the OUTBY; BLUE: Pans are bent to the INBY(left); YELLOW: Pans are bent both directions; GRAY: Pans are unbent.

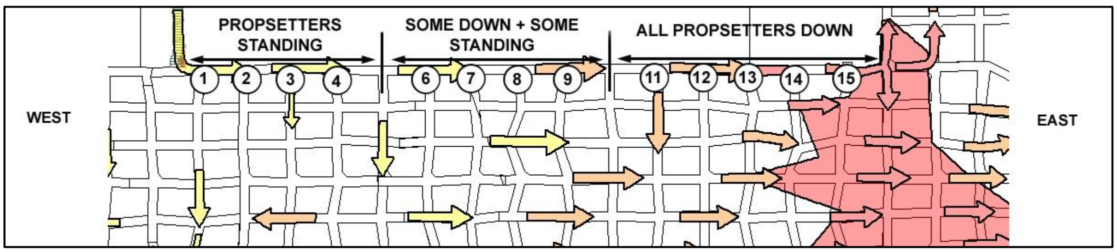

Figure 7D. Generalized Explosion Path- YELLOW ARROWS: Inferred wind direction, but pans are not bent.; ORANGE- RED ARROWS: Pans are moderately and severely bent, respectively. The red shaded region is severe pan-bending.

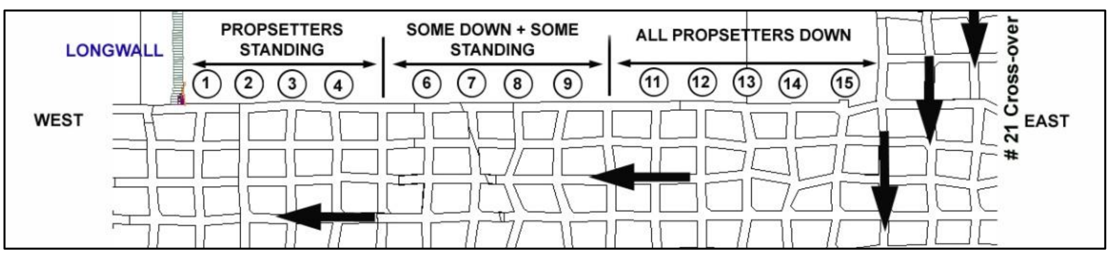

Figure 7E. Final Forces. Based on light-weight items (paper, plastic, cloth) caught loosely on stationary structures, and which would have been easily dislodged by subsequent wind forces.

The 2nd stopping outby failed by subsequent explosion forces directed to the north. It is appears to have survived the initial pressures of the explosion in #7 entry.

The 3rd stopping failed, leaving debris both north and south. This stopping is believed to have been partially opened as a regulator[10], but repaired shortly before April 5, 2010. As a result, it appears to have partially failed on the initial outby propagation in #7 entry, scattering debris to the south, then failed more completely as return forces scattered more of it later to the north.

[10] As indicated by testimony. This particular stopping has foam and other evidence of repair.

The 4th stopping is fully intact. It is shown on the mine map as a regulator, but there is no evidence it ever was one.[11] There is heavy macro-coking of the mine roof on the north side of this stopping, as well coking of the NW-facing rib corner---evidence of extended flame duration.

The 5th and 6th stoppings, failed in a northward direction, and are believed to have survived the initial explosion, only to fail from subsequent forces. Propsetters (round timbers) had been erected in the #7 entry ahead of the Longwall for supplemental support. Between the Longwall and this location they remained standing. For the next 5 breaks some propsetters remained standing, some are down.

In approximately the middle of this transition, we lose the 7th and 8th stoppings in a breach directed south, indicating pressures in #7 entry had gained sufficient strength to breach them. Simultaneously, pans begin being bent moderately to the east (see **Figures 7B, 7C**).

The 9th stopping survived the initial explosion (but failed later to the north). Moderate pan bending pointing east is observed in #7 entry, in response to the escalating pressure wave.

Beginning with the 10th stopping outby the shearer, explosion pressures reached a point at which no more propsetters were left standing outby and all stoppings from there outby to the #21 Cross-over had failed in breaches directed southward. Moderate pan bending (see **Figure 7C**) pointing east was observed in entries #4, 5 and 6 confirming the explosion has reached those entries.

At the 12th break a roof fall in #6 entry denied forces in #7 entry the expansion volume in the south crosscut, and for the next 2 breaks in #7 entry there is evidence of increasing pressure, accompanied by severe pan bending (see **Figure 7D**).

At the 16th break, the forces arrived at the #21 Cross-over first in the #7 entry, where initial forces branched left (north) and right (south) at the #1 entry of this cross-over. At this confluence the region south developed high reflected pressure, as indicated by severe pan bending (see **Figure 7D).** Final wind forces in this region of #21 Tailgate are directed west (see **Figure 7E**). These forces or others from the same direction returned to the longwall tailgate, creating impacted "V" dust deposits on the east surfaces of propsetters and bending roof pans along the north side of the "T-split" near the shearer. Because these pans were not bent to the east by the initial propagation, the forces returning appear to stronger.[12]

Return Wind Forces enter the Longwall Tailgate

After the initial explosion wind forces returned to the Tailgate from the south. Two aluminum covers (59"x 22"x ¾") were stripped off the top of the tail drive (see **Figure 9**), located between

[11] It is believed stopping #3 was the regulator.
[12] However, bottom rusting on these roof pans is indicative of heating, that could have softened them.

Shield 174 and 175 and transported northward up the longwall (see **Figure 8** and **Map 1**). The first cover became wedged in an upright position at Shield 157 (a distance of about 100 feet), and the second cover traveled farther, coming to rest in the pan-line at Shield 130 (a distance of about 256 feet). Calculations suggest the probable pressure-range which this aluminum cover experienced is between 6.86 and 14.43 psi.[13]

Figure 8. (LEFT): Aluminum cover off the tail-drive motor that came to rest in an upright position, wedged under the canopy at Shield 157 (view looking north). Because it was stopped this way the pressures responsible for its transport could not be calculated. (MIDDLE): South view, showing debris piled against north side. (RIGHT): South view, close-up of paper fragment caught in a grip hole.

Figure 9. (LEFT): A view of the tail-drive; where two aluminum covers were removed by wind forces which came from the south. (RIGHT): One of the covers was found in the panline at Shield 130, having traveled approximately 256 feet.

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13 From MSHA summary of Expert Report Findings, November 22, 2011, by Steve Sawyer, Sr., et.al. These reports have not been officially released.

Wind forces from the south deposited impacted “V” dust cones on the south-facing surfaces of the cylinder legs between Shield 176 and Shield 76 (see **Appendix 7.9-3** for a discussion of these dust deposits and their significance), indicating the final dust-carrying air currents here were directed northward.

The observed horizontal fold geometries of the bent 6-inch x 6-inch aluminum shield signs could not be reproduced by winds traveling the axis of the Longwall,[14] but rather are indicative of wind forces from the gob. However, it is possible these signs in the southern part of the Longwall were subsequently re-bent when return wind forces entered the Tailgate.

Short sections of sawed-off support posts were found impacted between the roof and the top of Shield 176, at the Tailgate (see **Figure 10**). Like the covers from the tail drive they were transported by winds coming into the Longwall from the outby. The last wind forces on the Longwall are believed to have come from the north (Headgate), but were insufficient to dislodge the sawed posts. It may be their location sheltered them from these forces or the winds subsided to extinction before reaching the Tailgate.

Figure 10. (LEFT): Short lengths of support posts were carried by winds entering the tailgate, traveling north, and impacted between the roof and top of Shield 176. This is a view from the tailgate, looking NW. (RIGHT): Any subsequent winds from the north were not sufficient to blow these back down.

Final Wind Forces enter the Longwall Headgate

The last wind forces to enter the Longwall entered at the Headgate. Some of the shield signs near the Headgate were likely bent or re-bent by these winds and some that were torn down and

[14] Explicit Dynamics and CFD Analysis of a Mining Accident; Mallett Technology Inc, Columbia MD, 2012 (see executive summary, **Exhibit 2**).

transported south exhibit the vertical fold axis[15] that is characteristic of first-bending due to wind forces traveling the Longwall axis.

Similar to the Tailgate return forces the final winds from the Headgate were of sufficient strength to dislodge an aluminum cover[16] from the head drive near Shield 4, transporting it south approximately 490 feet to its final resting place in the pan-line at Shield 89 (see **Map 1**). The most probable pressure-range of forces acting on the aluminum cover is between 6.56 to 13.82 psi, although the theoretical range is broader (5.95 to 95.95 psi).[17]

Final Force indicators appear to confirm that the final wave of winds through the Longwall came from the Headgate, and they decreased to extinction toward the Tailgate (see **Appendix 7.9-3**). "Final Forces" (as the term is used here) refers to the last wind direction, as determined from the resting position of lightweight items like paper, cans and plastic. Impacted "V" dust cones (see **Appendix 7.9-3)** can be used as a Final Forces indicator, and are deposited on the north faces of the shield cylinder legs, starting at the headgate, and as far south as Shield 72. These indicators provide agreement that wind forces from the Headgate were the final forces across the Longwall.

Comtrol Phone System

Comtrol phones on the Longwall were originally mounted with large magnets under every 8th shield canopy. The first four units on the Headgate side are missing. No parts of these were found to the north, but rather their component pieces came to rest in the region between Shield 77 and Shield 105 (near the middle of the Longwall). However the Comtrol box at Shield 117 appears to be scattered northward, as far as Shield 106. Parts of the Comtrol unit at Shield 173 appear to have been blown north as far as Shield 166 and at least one part was blown south, coming to rest outby the Longwall approximately 200 feet east of the shearer in the #7 entry of Tailgate #21. All other units south of Shield 77 (inclusive) are mounted in position and basically intact. The explosion in the gob most likely occurred somewhere between Shields 173 and 117.

Chain Pre-tensioner

A chain pre-tensioner that was kept near the floor on the Longwall face close to the Headgate (at Shield 4 or 5) was transported south by the explosion, leaving parts of it at Shield 65, 67 and 75. This was likely transported at the same time and direction the affected Comtrol Phone boxes were scattered.

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[15] Tags 11 and 30 were found folded along the vertical axis, just south of the shields where they were mounted.
[16] Dimension are approximately 22"x 41"x 5/8"
[17] From MSHA summary of Expert Report Findings, November 22, 2011, by Steve Sawyer, Sr., et.al. These reports have not been officially released.

Other indicators of pressure and wind forces

<u>Shield Control Boxes (CIU)</u>

A shield control box (CIU) was mounted at each shield, approximately 12 inches below the shield canopy and facing in the direction of the solid coal face. An emergency stop (E-stop) button is mounted in the upper right corner of each box (see **Figure 11**). The E-stop button is 1.5 inches in diameter and has a slightly curved face.

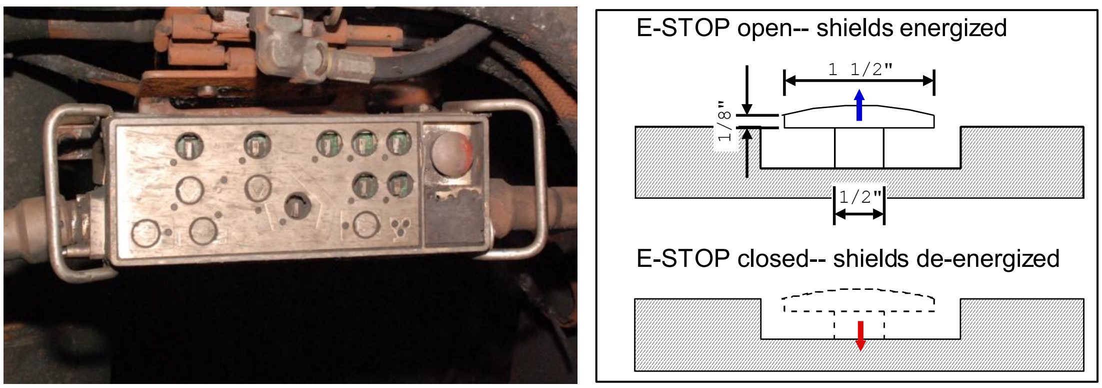


Figure 11. (LEFT): Shield control box (CIU). The E-stop button is in the upper-right corner. (RIGHT): The E-stop button has a slight curvature and 1/8 inch activation distance to engage. A force of 9-10 lb applied perpendicular engages the button.

Clusters of shield control boxes had their E-stop buttons engaged.[18] Red dots (see **Map 1**) signify where the E-stop buttons were noted to have been "engaged". To deactivate all of the shields on the Longwall it is necessary to engage only one button. Because numerous buttons were found engaged, especially at the Tailgate and Headgate, where longwall pressures and damage appear greatest, it is believed the buttons were pushed in by wind pressures from the explosion, not activated by the section crew.

A normal pressure force of approximately 9-10 lb. is needed to engage (push in) this button, which in terms of a minimum static pressure is approximately 6-7 psi.[19] The button could also be engaged by a transverse pressure wave passing over the button, due to the curvature of the button, but at pressures that are unrealistic for the purely transverse incident pressure, and not currently known for intermediate cases. Therefore, it is only known that the minimum pressure acting on CIU buttons that were found depressed is approximately 6-7 psi and the most logical

[18] Details of E-stop position were taken from data tabulated by MSHA during the investigation.
[19] Explicit Dynamics and CFD Analysis of a Mining Accident; Mallett Technology Inc, Columbia MD, 2012 (see executive summary, **Exhibit 2**).

source of such force is a reflected pressure wave normal, or near normal, to the face of the button.

Fluorescent Lights

Rubber light holders attached to large magnet mounts secured fluorescent light fixtures under the shield canopies. Prior to the explosion, these were mounted at every 2nd shield (see **Figure 12**). These lights were damaged by heat and explosion forces, to varying degrees.[20] **Map 1** illustrates the location of the fluorescent lights that survived the explosion, either fully or partially.

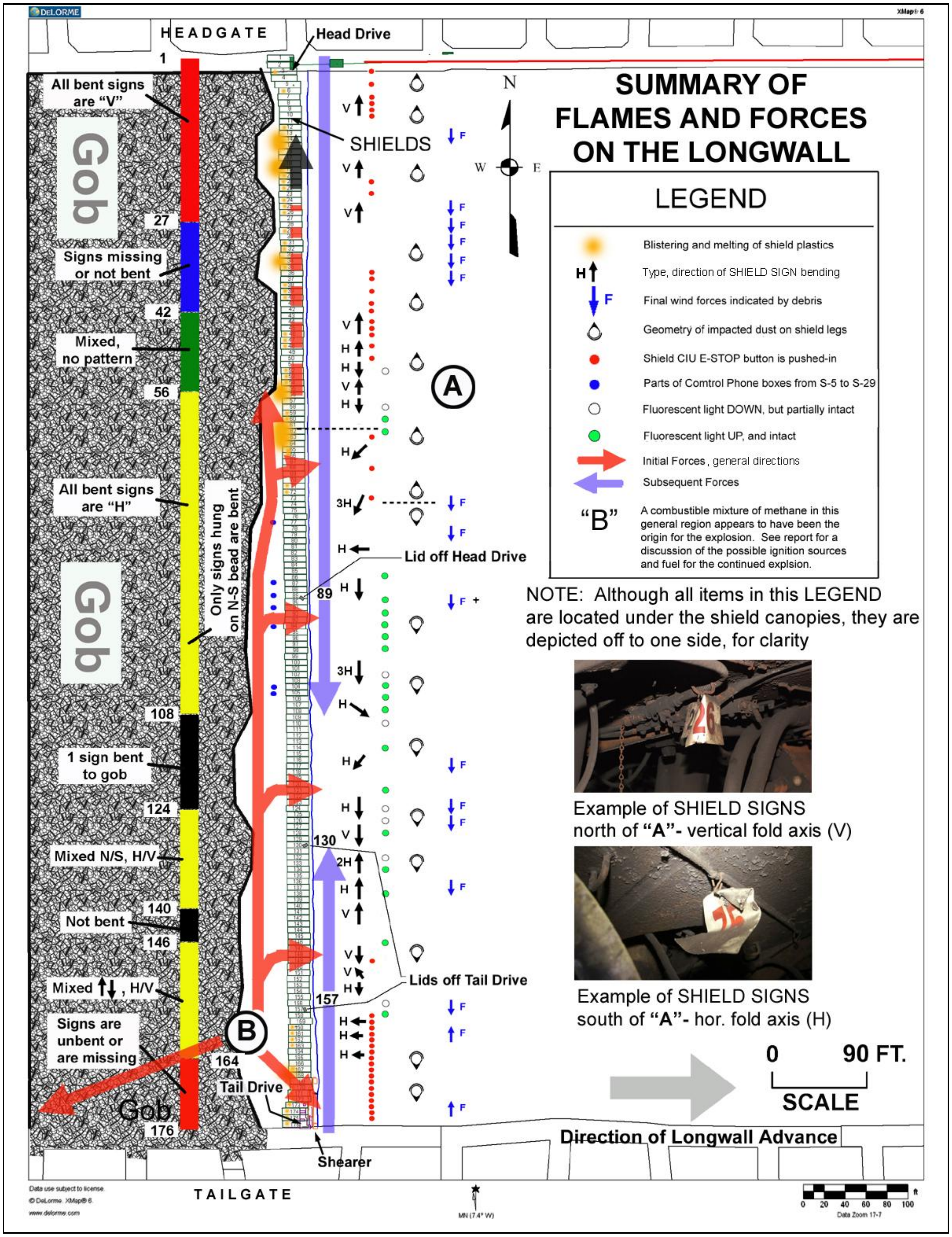
Figure 12. (LEFT) Fluorescent light hanging intact at Shield 138. (RIGHT) Fluorescent light, partially intact, but pulled off its mounts and down at Shield 74

The lights appear to generally have remained hanging and intact where the shield control box (CIU) E-stop buttons were not pushed in. Conversely, where the fluorescent lights had been knocked down, the E-stop buttons were engaged, suggesting that the two in combination may be useful indicators of relative explosion force strength.

Summary Flames and Forces Map of the Longwall

Some of the information used to determine the sequence of events, direction, relative heat and relative pressure on the Longwall is summarized in **Map 1**. The large red arrows show a generalized view of the initial explosion. Subsequent forces (large blue arrows) re-entered the Longwall, first from the south, then from the north. The symbols shown are described in the legend. Further information about the longwall region can be found in **Appendices 7.9-1, 7.9-3** and **8.2-4.**

[20] Details of the condition and position of the fluorescent light tubes were tabulated from data documented by MSHA during the investigation (see **Exhibit 1**).



Map 1. Initial Forces on the Longwall (red arrows) appear to have been influenced by amount of closure between the gob and back of shields. Subsequent Forces (blue arrows) entered the TG, then the HG.

Status of Longwall Shield Components-MSHA

Shield	CIU	Cables - Head End of CIU	Cables - Tail End of CIU	E-Stop Position	Phone/PS	Lights	Comments
1	Destroyed	Missing	Socket torn out	N/A			
2	Destroyed	OK	OK	Out			Heat Damage CIU Cable- inby side
3	Heat Damage	OK	Heat Damage	In	I.S. Wire pulled from plug. Permissibility OK		
4	Destroyed	OK	Damage	Out		1 mount - plug - no light	
5	Heat Damage	Heat Damage	OK	In			
6	Destroyed	See notes	OK	N/A			Light & Phone cable severed here. CIU Cable intact but pinched in two
7	Damaged	OK	OK	In			
8	OK	OK	Heat Damage	In		1 mount - plug - no light	* Crushed - 'Y' Cable - no ends
9	OK	Destroyed	OK	In		No light - plug present	
10	Heat Damage	OK	OK	In		1 mount - plug - no light	
11	OK	OK	OK	Out		No light - plug present	IS Cable damaged
12	OK	Damaged	OK	Out	Mount for phone present - No phone	No light - No mount	No cables for phone or light
13	OK	OK	OK	Out			
14	OK	Damaged	OK	Out		Mounts - no lights - no plugs	
15	Heat Damage	OK	OK	Out		light plug- possibly for 14	
16	OK	OK	OK	Out		1 mount - plug - no light	IS cable damage @ 'Y' connector.
17	Heat Damage	OK	OK	Out			
18	OK	OK	OK	Out		1 mount - no plug - no light	
19	OK	OK	Heat Damage	Out			

20	OK	OK	OK	Out	One piece of phone cable	1 mount - no plug - no light	damaged phone cable here
21	OK	OK	OK	In			Light cable found here.(possibly for shield 20) - cable pulled out of light.
22	OK	OK	OK	Out			
23	OK	OK	OK	In	P.S. OK - See notes		light plug on this shield.
24	Heat Damage	Heat Damage	OK	Out		no mount - no plug - no light	
25	OK	OK	OK	Out			light cable here
26	OK	* Damage	OK	Out			* Crushed @ connector - crushed going to shield 28
27	OK	OK	Damage	Out			
28	OK	*Damage	Damage	Out		1 mount - no light - no plug	*Crushed @ connector
29	OK	*Damage	OK	Out			*Socket pulled out of CIU (shield 28 to 29)
30	OK	OK	OK	Out		mounts - no light - no plug	
31	OK	OK	OK	Out			
32	OK	OK	OK	Out		1 mount - no light	
33	OK	OK	OK	Out			
34	OK	OK	OK	Out		1 mount - no plugs - no light	
35	OK	OK	OK	Out			IS cable - male end
36	OK	OK	OK	In		1 mount plug no light	
37	OK	OK	OK	In			
38	Heat Damage	OK	OK	Out		plug - no light - mounts	Light cable - damaged splice
39	Damage	OK	OK	In			Audible Alarm melted
40	Heat Damage	OK	OK	In-operable	Phone cable severed	plug - mounts - no light	
41	OK	OK	OK	In			light plug here
42	OK	OK	OK	In		1 mount plug - no light	

43	OK	OK	OK	Out	P.S. - See notes		damaged phone lying under pan here
44	OK	OK	OK	In		mounts - plug - no light	severed phoneline
45	OK	OK	OK	In	Phone intact - some damage		plug of phone unplugged and damaged
46	OK	OK	OK	In		no mounts - no lights - plug	
47	OK	OK	OK	Out			
48	OK	OK	OK	In		light intact - no plug	
49	OK	OK	OK	Out			
50	OK	OK	OK	In		*1 mount - no light	* 'Y' connector damaged.
51	OK	OK	OK	Out			
52	OK	OK	OK	Out	Phone cord severed here	Bulb intact - cable pulled from plug - housing busted	
53	OK	OK	OK	Out			
54	Heat Damage	OK	OK	Out		1 mount - cable but no plug - no light	
55	Heat Damage - Infrared Lens	OK	OK	Out	Phone damaged - lying on this shield - still strain relief to phone cord		
56	OK	OK	OK	Out		1 mount - plug present - light still connected but destroyed	
57	- Infrared Lens	OK	OK	Out			
58	OK	OK	OK	Out		1 mount - plug present - no light	
59	OK	OK	OK	Out			
60	OK	OK	OK	Out		plug & light intact - is cable splice	

61	OK	OK	OK	Out	Phone intact - heat damage to excterior plastic parts. - cable from outby has jacket damage. 2" to conductors		
62	Melting on face plate	OK	OK	Out		light present - severely melted - unplugged from supply	
63	OK	OK	OK	In	P.S. - See notes		
64	heat on face plate	OK	OK	Out		light not in hangers - laying on shield - intact	
65	OK	OK	OK	Out			
66	OK	OK	OK	Out			
67	OK	OK	OK	Out		light mount - light laying on shield 66 - damage @ both ends	
68	OK	OK	OK	In		light plug - no light - no mount	
69	OK	OK	OK	Out			
70	Intact - But bent down	OK	OK	Out	Phone not mounted. - Intact & laying on shield	light laying between shields	
71	OK	OK	OK	Out			
72	OK	OK	OK	Out		no light - plug has both male/female ends intact - cable pulled out	Lighting cable repair
73	OK	OK	OK	In			
74	OK	OK	Damage to Jacket @ 75 Connection	Out		light damaged - not in mounts	

75	OK	OK	OK	In-operable			Several Damaged Disconnected cables in this area
76	OK - Shield being towed	OK	OK	Out		no light - mounts - damaged IS cable	Phone Intact.
77	OK - But bent on mount	OK	OK	Out			
78	OK	OK	OK	Out		light present - cable pulled out of plug	
79	OK	OK	OK	Out		damaged lights in area - no mounts - no plug	
80	OK	OK	OK	Out		light & cables intact	
81	OK	OK	OK	Out			Location of victim #7
82	OK	OK	OK	Out		no mounts present - no plug	110V receptacle with about 15' of cord located here
83	OK	OK	OK	Out	P.S. - See Notes		Power Supply flame path fit - OK - Plug from outby - <1/8 gland clearance - X/P-4046-0, Model ISSXP2
84	OK	OK	OK	Out		no light - mountspresent & plug	Location on victim #8
85	OK	OK	OK	Out	Phone present - head side cable spliced - tail side unplugged	light laying on shield but no mounts	Location of Victim #8's notepad
86	OK	OK	OK	Out		light & cables intact	
87	OK	OK	OK	Out			Mid Face Splice- visual inspection - no defects present
88	OK	OK	OK	Out		one mount - light back in shields	
89	OK	OK	OK	Out			Cover off of head drive motor
90	OK	OK	OK	Out		light intact - another light on ground	Loop in bretby - flopped toward headgate
91	OK	OK	OK	Out			Loop in incoming shearer power cable here.
92	OK	OK	OK	Out		light intact	

93	OK	OK	OK	Out	Phone intact but unplugged		
94	OK	OK	OK	Out		light intact - not plugged in	There is an SCSR deployed with hard hat liner at this location
95	OK	OK	OK	Out			
96	OK	OK	OK	Out		light intact	Other end of of IS lighting pigtail has plug in it with cable missing
97	OK	OK	OK	Out			
98	OK	OK	OK	Out		light intact	Face of a CIU and an intact light at this location on floor
99	OK	OK	OK	Out			
100	OK	OK	OK	Out		no mounts - plug with cable pulled out	
101	OK	OK	OK	Out	Phone intact		One unused/unplugged phone plug at this location - appears to be going outby
102	OK	OK	OK	Out		mounts - light intact & laying on shield	
103	OK	OK	OK	Out	P.S. - See notes		X/P-4046-0, Model ISSXP2, C10407, 13.0/8.10 Amp, S/N 1669, S/N 1354 - X/P connector gland <1/8 Clearance on inby end
104	OK	OK	OK	Out		Intact	Location of victim 9 & 10
105	OK	OK	OK	Out			Location of Victim #11
106	OK	OK	OK	Out		Intact	Location of Victim #12 - Damaged light housing on shield
107	OK	OK	OK	Out			
108	OK	OK	OK	Out	Phone Intact	Intact	
109	OK	OK	OK	Out			Pieces of another phone at this location
110	OK - Bent Down	OK	OK	Out		intact but laying on shields	Cable "pig-tailed" coming out of a light. About 12"
111	Bent	OK	OK	Out			
112	Bent	OK	OK	Out		mounts - plug - no light	

113	OK	OK	OK	Out			
114	OK	OK	OK	Out		intact	
115	OK	OK	OK	Out			
116	OK	OK	OK	In-operable	plugs present & intact - no phone	mounts- plug - no light	
117	OK	OK	OK	Out			
118	OK	OK	OK	Out		mounts - no light	IS Lighting cord pulled out of plug receptacle at this location
119	OK	OK	OK	Out			
120	OK	OK	OK	Out		mount & plug - no light - receptacle for light has cable missing	
121	OK	OK	OK	Out			
122	OK	OK	OK	Out		Intact	Damaged 10/5 cable in cable tray at this location. Marked with ribbon
123	OK	OK	OK	Out	P.S. - See Notes		X/P-4046-0, Model ISSXP2, C10407, 13.0/8.10 Amp, S/N 1669, S/N 1354 - MSHA - IA13827-0, S/N 4203, S/N 4204
124	OK	OK	OK	Out		light intact but not in mounts	Light housing does appear to be completely seated on base(rubber o-ring is loose) there is tape around where light housing meets base
125	OK	OK	OK	Out	Phone Intact - not plugged in		
126	OK	OK	OK	Out		light intact but not mounted and not plugged in	
127	OK	OK	OK	Out			
128	OK	OK	OK	Out		intact - not plugged in	
129	OK	OK	OK	Out			
130	OK	OK	OK	Out		mount and plug - no light	
131	OK	OK	OK	Out			

132	OK	OK	OK	Out		intact	IS cable going to light is spliced 8" below plug
133	OK	OK	OK	Out	Phone intact		One plug is not connected and phone lead(which is the one that is unplugged) is damaged exposing conductors
134	OK	OK	OK	Out		intact	
135	OK	OK	OK	Out			
136	OK	OK	OK	Out		mounts & plug - no light	IS lighting pig-tail damaged one end missing - receptacle showing bare conductors
137	OK	OK	OK	Out			
138	OK	OK	OK	Out		intact	
139	OK	OK	OK	Out			
140	OK	OK	OK	Out		mounts & plug - no light	IS & lighting cables spliced at this location
141	OK	OK	OK	Out	Phone intact		
142	OK	OK	OK	Out		mounts & plug - no light	
143	OK	OK	OK	Out	P.S. - See Notes		X/P-4046-0, Model ISSXP2, C10407 - PS S/N 1050, S/N 1049 - X/P Connector - .9" both
144	OK	OK	OK	Out		mounts - no light- cable pulled out of plug	
145	OK	OK	OK	Out			Damaged light lying on shield
146	OK	OK	OK	Out		Intact - unplugged	
147	OK	OK	OK	Out			
148	OK	OK	OK	Out		mounts & plug - no light	
149	OK	OK	OK	In	Lockout mechanism damaged. - plugs damaged		IS lighting cable spliced
150	OK	OK	OK	Out		mounts & plug - no light	IS lighting cable unplugged from inby here

151	OK	OK	OK	Out			
152	OK	OK	OK	Out		mounts & plug - no light	End of IS cable from PS at shield 143
153	OK - See notes	OK	OK	Out			Handle bent towards E-stop but not touching
154	OK	OK	OK	Out		mounts - no light	
155	OK	OK	OK	Out			Light laying on shield - taped IS cable
156	OK	OK	OK	Out		mounts - light intact & laying on shield - buld busted	End of entratance gland & cable damaged
157	OK	OK	OK	Out	Phone connected outby - damage to case on inby side		Actuated page and heard it at shield 149. Tail drive motor cover panel located here
158	OK	OK	OK	In		intact - unplugged	
159	OK	OK	OK	In			
160	OK	OK	OK	In		mount - light damaged - unplugged & lying back in shield	IS cable damage by 'Y' connector.
161	Heat Damage	OK	OK	In			IS cable damage
162	OK	OK	OK	In		mount & plug - no light - damage at 'Y' connector	
163	OK	OK	OK	In	P.S. - See Notes		IS cable from PS pulled out of plug - other IS cable is ripped out of receptacle on PS
164	OK	OK	OK	In		mount - no light	IS cable damage - both ends of Y connector
165	Slight Heat Damage	OK	OK	In - slight heat damged	Phone, inby, & outby cables damaged		IS cable outer jacket damage - damage to phone toward tail side.
166	OK	OK	OK	In		no mounts, or plug - globe lying on shield	IS lighting cable outer jacket damage
167	OK	OK	OK	In			IS lighting cable - splice, leads just twisted together - was taped but leads apart

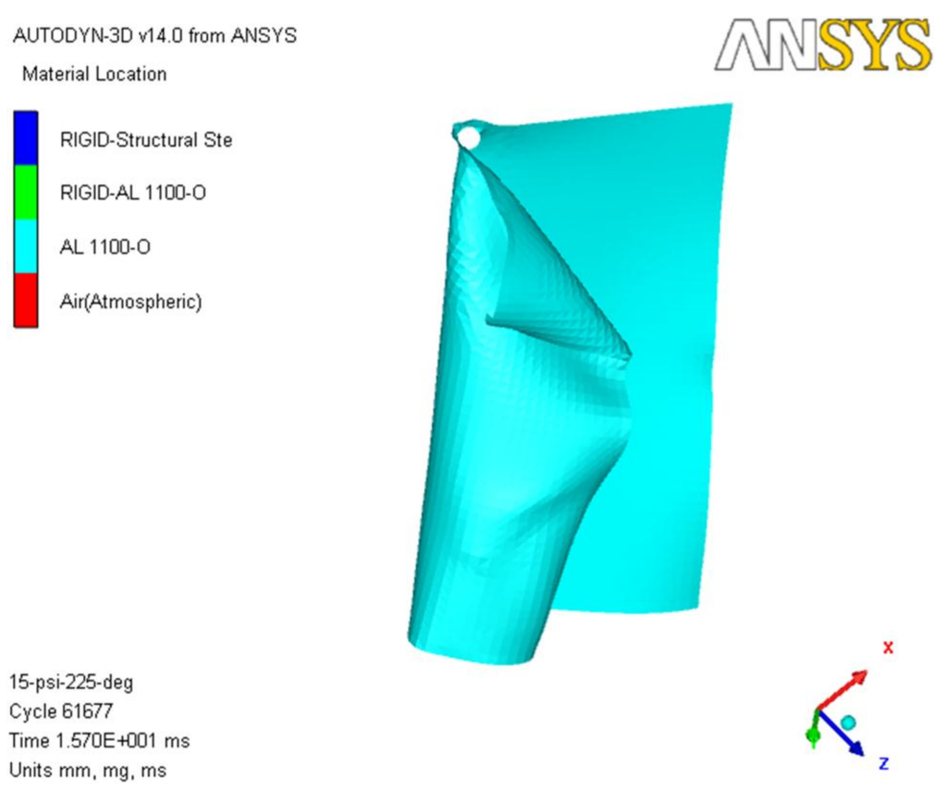
168	Slight Heat Damage	OK	OK	In		no mounts, plugs, or light	IS lighting cable damage - 2 of 3 conducotrs severed - bare conductor on 3rd wire
169	OK	OK	OK	In			
170	See Notes	OK	Heat Damage	In		mounts & plug - no light	Outby cable receptacle unplugged - CIU damaged . Infrared cover is smiked - audible is blowed out
171	See Notes	Heat Damage	{Nothing noted in notes}	In	P.S. See Other Notes		IS Light cable 10' damaged - CIU damaged - infrared lens smoked - audible alarm pushed into case - intershield cable burnt
172	See Notes	Heat Damage	Heat Damage	In		mounts - light destroyed	CIU - Severe heat damage
173	See Notes	Heat Damage	Heat Damage	In			CIU - audible alarm damage
174	See Notes	Heat Damage	See Notes	In		mounts - no light - no cables	CIU- Audible gone - infrared lens smoked, heat damage - heat damge to inter-CIU cable - metal bucket wrapped around cable
175	See Notes	Heat Damage	Heat Damage	In			CIU - heat damage - cables intact but with heat damage
176	Heat Damage	Heat Damage	Heat Damage	Out		mounts - nop light - no cable	

Notes:

Shield 61 Loud Mouth Phone, Approval 9B-71-2, Model LM115
IS Lighting cable spliced

Shield 63 LightingPower Supply - X/P-4046-0, Model ISSXP2, C10407 - Opening of .008", all bolts - 1.5'
Continuity reading back outby - all leads open
Enclosure has gob in flame path & 1/8" water ponding in back left corner inside enclosure

EXPLICIT DYNAMICS AND CFD ANALYSIS OF A MINING ACCIDENT



Explicit Dynamics and CFD Analysis of a Mining Accident

By

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Scott A. Marinus

Executive Summary

The West Virginia Office of Miners' Health, Safety, and Training is investigating conditions in a recent mine explosion on a longwall in West Virginia. The damaged items we were asked to evaluate included 6" square aluminum placards hung at regular intervals beneath the canopies of the longwall shields. Signs to the north of a particular location (in the vicinity of shield 62) were bent to the north along a vertical fold line while signs to the south of this location were bent to the south along a horizontal fold line. We investigate what directions and pressures are consistent with these styles of damage to these signs.

The first purpose of the work presented here was to investigate whether a traveling pressure disturbance emanating from the vicinity of shield 62 and propagating up and down the axis can cause these types of damage, and if so, what overpressures might be required. We find that vertically folded signs similar to those observed can be produced by either a north-to-south or a south to north traveling disturbance of 10-20 psi. However, we find it unlikely that the southern, horizontally folded signs were damaged by a north to south traveling disturbance. They may have been damaged by a <u>south to north</u> traveling disturbance of 10-15 psi, but we find it is more likely that they were damaged by forces emanating from the gob area behind the shields.

In addition to the damage to the aluminum placards, there are locations along the longwall axis where the emergency stop buttons on shield control boxes have been depressed. Our second purpose was to model a traveling pressure disturbance incident on a button, under both transverse and normal incidence, to determine the forces the buttons would be subject to under various overpressure conditions. The client has specified that a static force of approximately 9 to 10 lbf is required to depress the buttons. We find the steady state normal forces sustained by the button for transverse incidence to be less than 1 lbf for all incident overpressures up to 20 psi, while the steady state normal forces for normal incidence must be zero on physical grounds. We find that the maximum normal forces in the transverse incidence case can exceed 9 to10 lbf at approximately 14 to 15 psi total overpressure, but only very briefly (approximately 0.05 ms). We find that the maximum normal forces in the normal incidence case are approximately twice as high and twice the duration as those found in the transverse incidence cases, with the maximum normal force exceeding 9 to 10 lbf at approximately 6 to 7 psi total overpressure. Because the response of the button assembly to dynamic loading is itself dynamic, we cannot say under what conditions the button would be pushed in the absence of a transient dynamic model of the assembly to the loads calculated herein. What we can say is that, if the button is to be pushed at all, it appears much more likely that it would be pushed for the normal incidence rather than transverse incidence for any given overpressure.

Appendix 7.9-6

Explosion Pressures

Calculations of explosion pressures based on displaced or deformed materials and equipment involve assumptions which are subjective, and WVOMHS&T investigators have not directly attempted to estimate the pressures developed by the explosion by these methods. For example, ventilation stoppings have been determined experimentally to fail at about 2 to 3 psi but concrete block stoppings under heavy vertical load, such as that caused by roof pressures or floor heaving in mines can make the stopping significantly stronger.[1] In addition, explosive forces traveling along parallel entries can experience pressure rise slightly faster in one entry creating a pressure differential across a stopping that has no relation to the pressure of the explosion.[2] Calculating the force necessary to deflect steel structures or propel an object along an entry requires a knowledge of the time the pressure pulse existed and its exact direction at the time of impact, which at best must be estimated.

Investigators have found some worthwhile information about pressure ranges that may have existed during the explosion. Light bulbs located at various locations within the explosion area were not broken by the static pressure of the explosion. The authors of the Massey report[3] attached significant findings stating that the explosion pressures were so low that they did not break the light bulbs. WVOMHS&T investigators asked NIOSH to conduct experiments to determine the pressure necessary to break the bulbs. They found that the light bulbs would resist over 100 psi without breaking, even when powered. See **Tables 1** and **2** below.

Table 1. Results of Philips Frost Incandescent Lamps tests

Philips Frost Incandescent Lamps		
Non-powered		
Test #	Pressure, psig	Result
1	161	Did not implode
2	141.7	Did not implode
Powered		
3	119.7	Imploded
4	185.8	Imploded

Table 2. Results of Phillips Energy Saver tests

Philips Energy Saver		
Non-powered		
Test #	Pressure, psig	Result
5	165.7	Did not implode
6	185.8	Did not implode
Powered		
7	183	Did not implode
8	183	Did not implode

[1] Weiss, E. Evaluation of Explosion-Resistant Seals, stopping, and Overcasts for Ventilation Control in Underground Coal Mining, National Institute for Occupational Safety and Health, RI 9659

[2] Richmond, J. K. A Physical Description of Coal Mine Explosions, Part II, Bureau of Mines, U.S. Department of the Interior, Pittsburgh Pa

[3] Preliminary Report of Investigation, Upper Big Branch Mine Explosion, April 5, 2010

Some photographs of the lamps underground in areas covered by the explosion are shown in **Figures 1 and 2.**

Figure 1. Undamaged lamp in the vicinity of the longwall mother drive unit

Figure 2. Undamaged lamp showing heat melting plastic cover on undamaged fluorescent lamp near longwall mother drive unit.

Description of NIOSH evaluation**:**

20-Liter Chamber Tests to Determine the Approximate Pressures to Implode Lamps

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested assistance from the National Institute for Occupational Safety and Health's Office of Mine Safety and Health Research (OMSHR) to determine the approximate external static over pressure to implode two types of lamps provided by Monte Hieb of WVOMHS&T; Philips Frost Incandescent Lamp shown in **Figure 3** and Philips Energy Saver shown in **Figure 4**.

The OMSHR 20-L test chamber (**Figure 5**) was used to measure the approximate minimum over pressure to implode the Philips Frost Incandescent Lamps and the Philips Energy Saver lamp. The bulbs were tested non-powered and powered for ~30 min by Gregory Green and Michael Sapko of OMSHR. The lamp was suspended in the 20-L chamber and the chamber air pressure was slowly increased with the addition of air from a compressed air cylinder until the lamp imploded or the electrode access port to the chamber started to leak. The implosion pressure was determined from the output of a 0-200 psig strain gage transducer located in the wall of the chamber. Shown **in Figures 6 and 7** are the test set ups for the non-powered tests and shown in **Figures 8 and 9** are the test set ups for the powered tests. The results of Philips Frost Incandescent Lamps tests are shown in **Table 1** and the results of Philips Energy Saver are shown in **Table 2**.

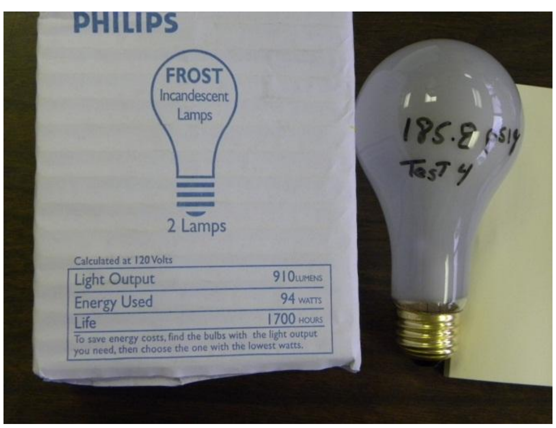


Figure 3. Philips Frost Incandescent Lamp.

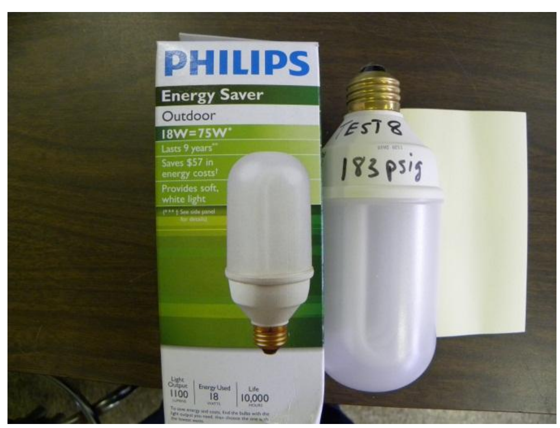


Figure 4. Philips Energy Saver.

Figure 5. OMSHR 20-L Test Chamber.

Figure 6. Philips Frost Incandescent Lamp

Figure 7. Philips Energy Saver.

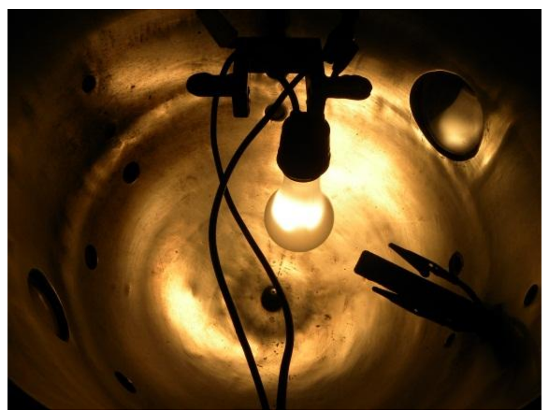


Figure 8. Philips Frost Incandescent Lamp

Figure 9. Philips Energy Saver.

Another reasonable indicator of explosion pressure was an empty spray paint can found in crosscut 48, between tailgate entries 6 and 7 just outby the longwall face. This can was on the mine floor in a slight depression protected from the winds of the explosion, but not from the static pressure. Heat had burned away the paper label on the exposed surface but that portion of the can against the mine floor was unburned. The can was not at all collapsed by the static pressure. See photos in **Figures 10, 11 and 12**. Another empty spray paint can was found not collapsed near survey station 22629, in the headgate 21 entries just inby 21 crossover.

Figure 10. Spray can in crosscut 48 between entries 6 and 7 outby LW shearer View looking WEST.

Figure 11. Spray can in crosscut 48 between entries 6 and 7 outby LW shearer. View looking South

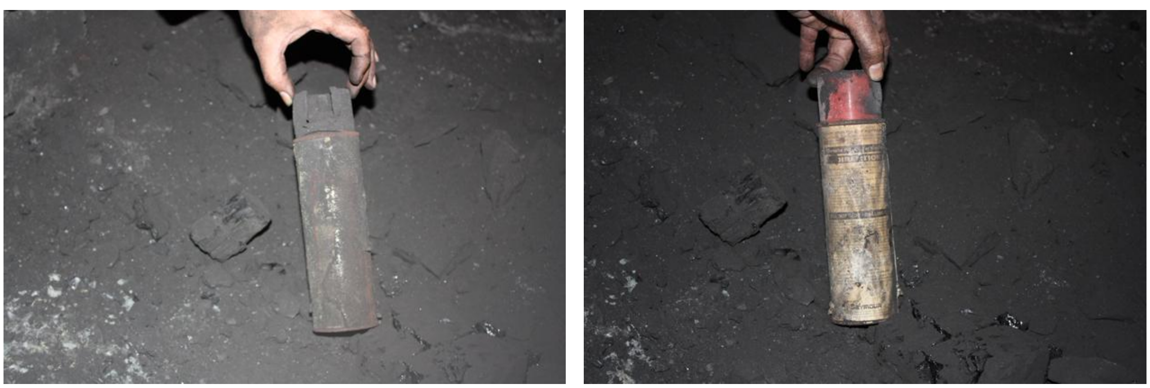


Figure 12. The paper label on the exposed side (LEFT) of the spray can is partially burned away, while the paper under the can is intact (RIGHT).

NIOSH was asked to evaluate pressure required to collapse the can. Their report, which follows, indicates that a static overpressure of about 13.2 psi will crush the can. Therefore, assuming the can was empty, the static explosion pressure in the crosscut was less than 13 psi.

Tests to Determine the Approximate Differential Pressure to Implode an Empty Spray Paint Can

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested assistance from the National Institute for Occupational Safety and Health's Office of Mine Safety and Health Research (OMSHR) to determine the approximate external static overpressure to implode a Seymour spray paint can. One full can was provided by Monte Hieb of WVOMHS&T for testing and is shown in **Figure 13**.
To determine the approximate static pressure to implode this can, it was first emptied by spraying the contents into a plastic lined cardboard box. An ⅛-in diameter hole vent was drilled through the can valve and a test tube septum with a feed through adapter bushing containing a small "O" ring (**Figure 14**) was held against the vent by gently clamping between two parallel plates to provide airtight seal. The barometric pressure was recorded at 14.2 psig and the pressure was slowly reduced inside the can by using a vacuum pump attached to the 20-L test chamber (**Figure 15**). The implosion pressure was determined from the output of a 0 – 200 psig strain gage transducer located in the wall of the 20-L chamber. The can abruptly collapsed when the inside pressure reached 1.04 psia (**Figure 16**). Therefore the minimum differential pressure between inside and outside to deform this spray can was 13.2 psig (14.2 -1.04 =13.2 psig).

Figure 13. Seymour spray paint can.

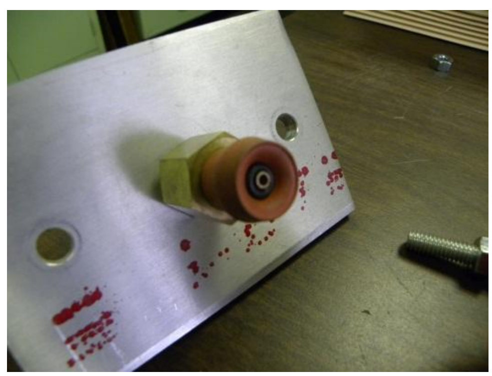


Figure 14. O-ring septum interfaces.

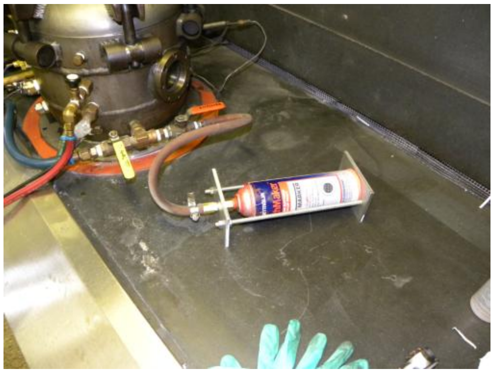


Figure 15. Can attached to chamber vacuum system.

Figure 16. Can imploded.

APPENDIX 8.1-1

TAILGATE INTERSECTION

WVOMHS&T investigators have concluded that there is a need to remind and inform the mining community of the importance of adequate ventilation at the tailgate junction with the longwall face. The longwall face intersection with the tailgate entry is a critical area for methane control. Longwall gobs have become extensive. The UBB gob was 1,000 feet wide, and gobs this extensive have low permeability in the center of the gob due to pressure from the overburden. Methane liberated from the immediate roof or floor as the face advances tends to flow along the gob behind the longwall face supports. The methane then is funneled through into the intersection of the gob with the tailgate entry. How this methane enters the return and then the bleeder entries is dictated by the ventilation arrangement at the tailgate intersection. Some call this location the "T-split" junction.

One can readily understand if the ventilation air current is directed over the tailgate corner of the gob into the returns methane coming off the gob at that location will be swept away and that intersection, where the shearer cuts out into the tailgate entry will be kept clear. However, if roof falls are allowed to restrict or redirect the air flow away from the gob and outby in the tailgate entry, even for a short distance, methane can be induced to flow outby to the area of the shearer operation.

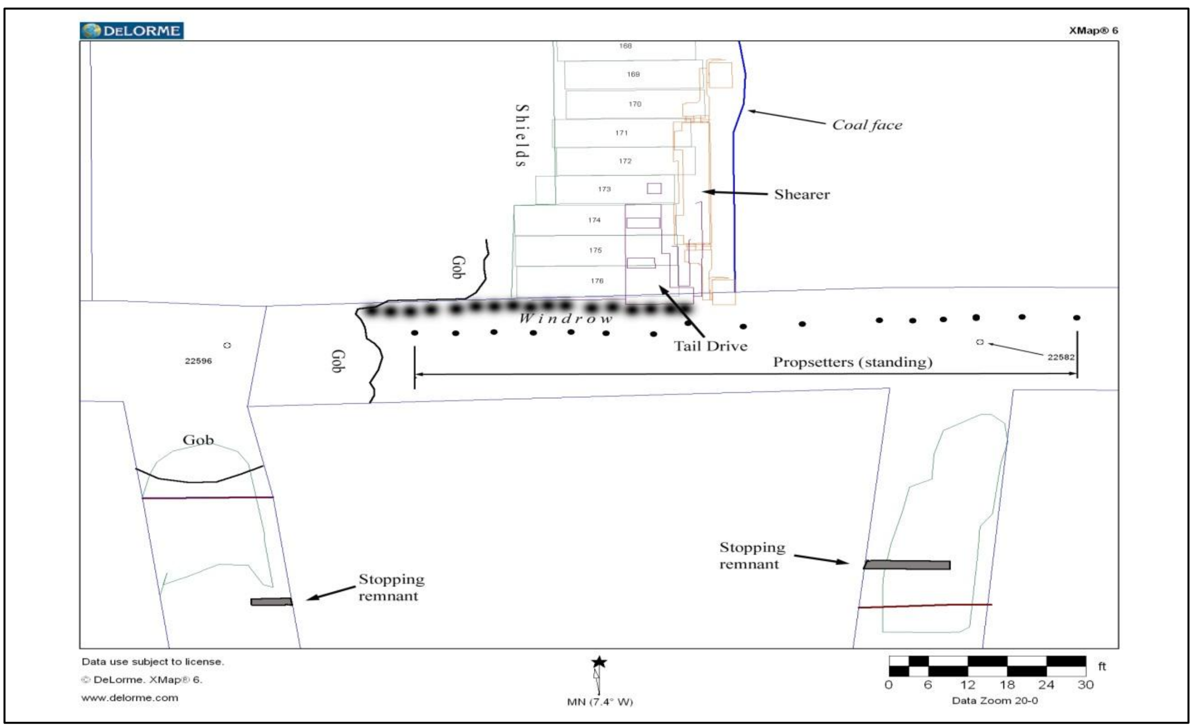
The investigators thought it was worthwhile to develop a visual aid to depict how the methane can be induced into the zone of mining if the tailgate is blocked, as was the case at UBB. NIOSH was willing and able to prepare such a visual aid at our request and we believe it will be a valuable aid in improving ventilation knowledge of the mining community. Michael J. Sapko prepared the following report with illustrations.

Computation Fluid Dynamic Simulations of Methane-air Mixing and Flow Patterns near a "T" Intersection between Longwall Face and the Tailgate Entry

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested assistance from the National Institute for Occupational Safety and Health's Office of Mine Safety and Health Research (OMSHR) to understand methane-air mixing and general flow patterns that might occur near the intersection of longwall face and the immediate tailgate entry where a rock fall blocked the tailgate entry inby the face.

To help WVOMHS&T visualize complex flow patterns that might occur at or near this intersection, OMSHR researcher Mike Sapko suggested using the NIST Fire Dynamics Simulator (FDS) program. FDS can be downloaded from the National Institute of Standards and Technology (NIST) web site: http://fire.nist.gov/fds/

Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The software solves numerically a form of the Navies-Stokes equations appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires.



Map 1 -Generalized description of longwall "T-split" on 4-5-2010

Although primarily designed for simulating and analyzing gas flows in a building or structure fire, the combustion process can be turned off providing a useful tool for predicting methane air mixing and flow processes in complex geometries.

For model construction Monte Hieb provided Map 1, which generally depicts the intersection of the Longwall face and intersection with the #7 entry.

Monte indicated that in September 2010, MSHA and WV State investigators conducted a post explosion ventilation survey near the UBB tailgate and provided the following information. Survey results indicated a flow of about 4,900 cfm in the #7 tailgate entry inby the longwall face exiting approximately equally in two inby partially open crosscuts between entries #7 and #6. They also indicated 19,500 cfm exiting the longwall face and 4,000 cfm traveling inby in the #7 entry approaching the shearer. Several CFD model runs were conducted to match the 4,900 cfm using the post-explosion measured face and outby tailgate quantities. The FDS model opening size was fitted to match this 4,900 cfm quantity, using the post-explosion face and outby tailgate quantities measured by MSHA. Under the above flow conditions an effective area of 0.723 m^2 was determined for the passage of ~4900 cfm inby the shields in entry #7. The model assumes one opening for this air current although in reality several distinct small passageways probably existed.

A model was constructed using basic geometric information provided by the investigators. The model is a simplified approach that does not duplicate all the geometric entities at the actual mine location. To duplicate the mine conditions one would have to construct an actual model of the mine, but the model can illustrate basic ventilation principles involved, and help the investigators visualize what could have occurred.

Model Parameters and Assumptions:

The inby (left) end of the #7 entry is restricted to a small opening of about 0.723 m^2 representing the caved gob and outlined in red as "gob vent hole" in the following figures. The longwall face is partially restricted by a gob plate / windrow 2 m wide and 1.8 m high. The outby crosscut is partially restricted by a partial stopping covering about 2/3 of the cross section. The longwall face flow was held constant at 56,000 cfm, and air approaching the tailgate in #7 entry was held constant at 10,000 cfm. The vent area was held constant at 0.732 m2 and the following three simulations were conducted using 250, 500 and 1,000 cfm of methane entering #7 entry from behind the shields and the results are shown in figures 1, 2 and 3 respectively. Each figure was captured at 60 seconds into the simulation. Black colors show concentrations above 15%, the upper flammable limit.

Simulation Runs:

Figure 1: Simulation -250 CFM Methane Liberated From Behind the Shields

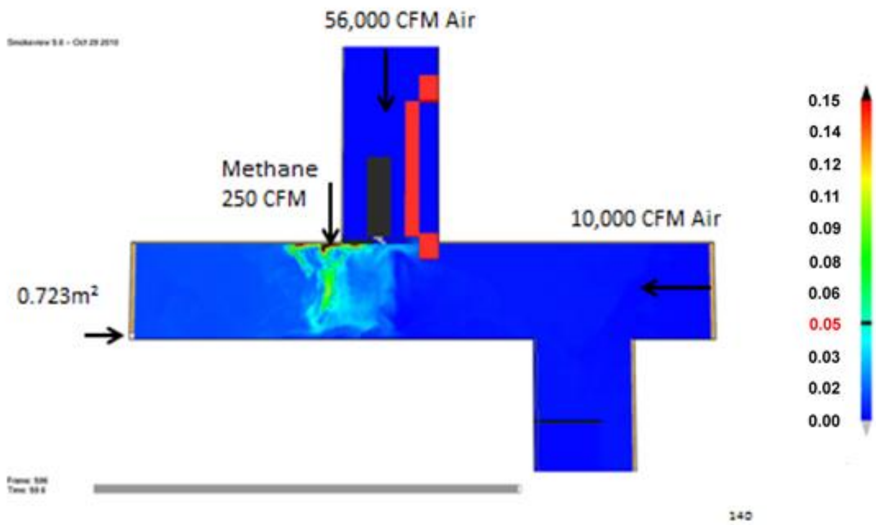
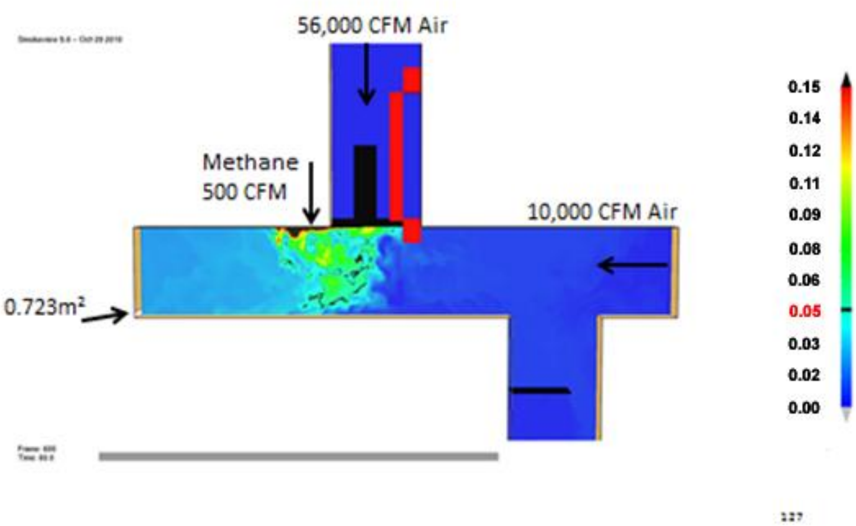


Figure 2: Simulation -500 CFM Methane Liberated From Behind the Shields



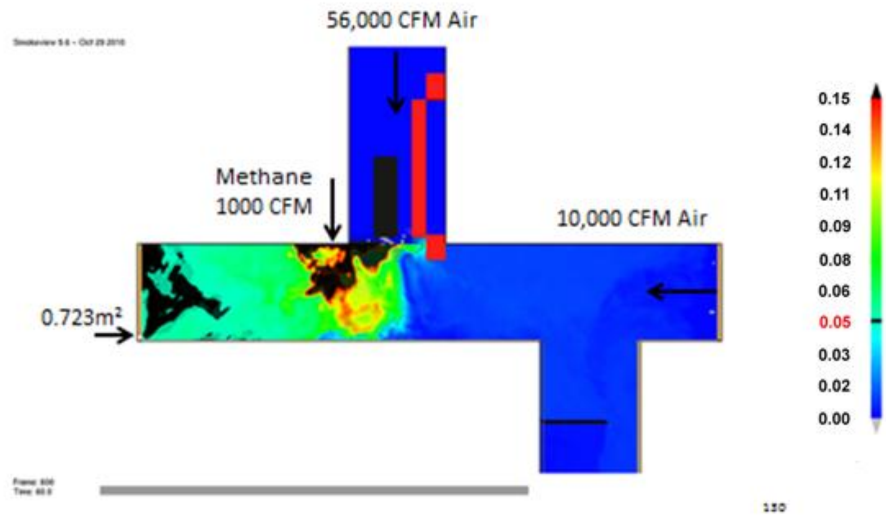


Figure 3: Simulation -1000 CFM Methane Liberated From Behind the Shields

An eddy is formed in the shadow of the gob plate/windrow, confining the flammable mixture to a limited area behind the gob plate. The methane that eventually exhausts through the gob opening into the tailgate is a rich mixture while the methane that is carried to the crosscut is highly diluted. It should be evident that the flow patterns are dependent upon the selection of variables representing the obstructions to airflow. Even though simulations are useful discussion tools, they are not portrayed to duplicate the events of April 5, 2010 due to the simplified geometry used in the simulations.

From these simulations the gas seems to be drawn from behind the shields along the plate /windrow towards the shearer drum as the 56,000 cfm exits the tailgate and heads towards the first outby partially open crosscut and vents to #6 entry. The size if the combustible volume and non-uniformity of mixture increases with methane release rate.

Two more simulations were conducted at a constant methane release of 1,000 cfm while the #7 entry was assumed to be 50% open (Figure 4) and 100% open (Figure 5). The simulation shows that the size of combustible volume decreases as the #7 entry opening increases. Also noted is that the combustible gas mixture moves away from the shearer heading inby.

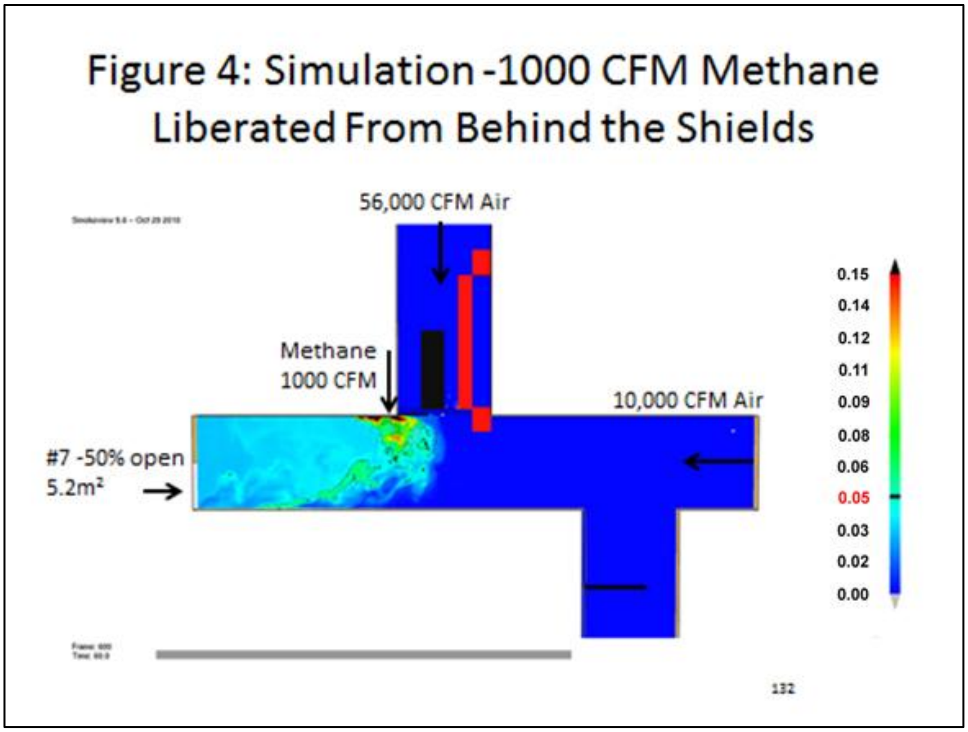


Figure 4: Simulation -1000 CFM Methane
Liberated From Behind the Shields
56,000 CFM Air
Methane
1000 CFM
10,000 CFM Air
#7 -50% open
5.2m²
0.15
0.14
0.12
0.11
0.09
0.08
0.06
0.05
0.03
0.02
0.00
132

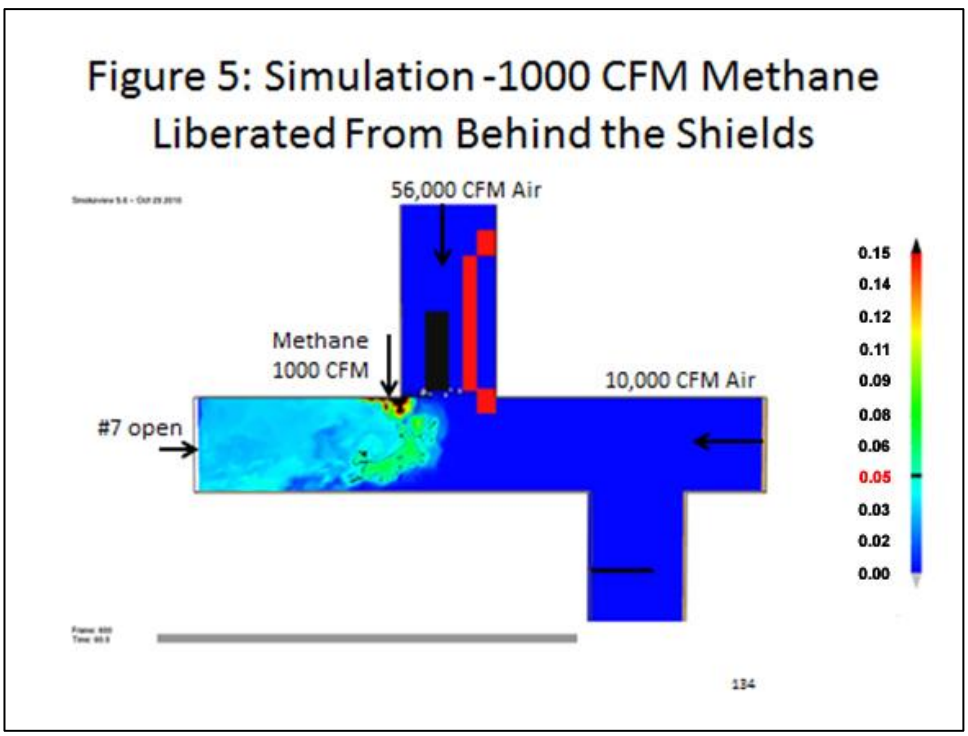


Figure 5: Simulation -1000 CFM Methane
Liberated From Behind the Shields
56,000 CFM Air
Methane
1000 CFM
10,000 CFM Air
#7 open
0.15
0.14
0.12
0.11
0.09
0.08
0.06
0.05
0.03
0.02
0.00
134

MINE DUSTS AND ROCK DUST

Dusts on coal ribs

The Top Coal bench of the Eagle seam fractures easily and contains partings of fine, friable coal that collects on the ribs and mine floor over time. WVOMHS&T investigators noticed these new accumulations of fresh, fine dust over soot-covered coal and decided to investigate the character of the dust and its potential to contribute to explosion propagation.

In August 2011, about 1½ years into the investigation, WVOMHS&T investigators collected dust samples from the ribs in the area of #21 Tailgate entries (the current longwall tailgate). This is approximately the same length of time between original development of these entries and the April 5, 2010 explosion. There is no record which would indicate these entries were rock dusted subsequent to their initial applications. Between August, 2009 and February, 2010 the #1 entry of the #21 Cross-over along with #1 and #2 entries of #21 Tailgate served as return airways when the #21 Cross-over and the Cut-across were being mined. These entries continued to be returns from the #22 headgate and tailgate developments. For an unknown period of time before April 5, 2010 explosion, return airflows from the longwall were also traveling through the #7 entry, west of the #21 Cross-over. During these time periods suspended dusts could have collected on rib surfaces, and would be additional to the accumulations from rib spalling. WVOMHS&T limited this analysis just to the spalled dust accumulations and the evaluation of the explosibility of the rib dust just in the tailgate entries, due to time and resources.

Nine locations were sampled and two to three samples were taken from each location, as shown in **Figure 1**. The coal seam was divided into two benches by shale parting. This parting and the difference in strength of the two coal benches influenced the manner in which the coal seam spalled, and since the Top Coal was more friable a profile of ledges was created at and below the parting on the Bottom Coal where the fine coal from the Top Coal accumulated. Coal spalling from the Bottom Coal accumulated where the rib contacted the mine floor; see **Figure 2** for examples of the rib profile and locations where samples were taken on the rib.

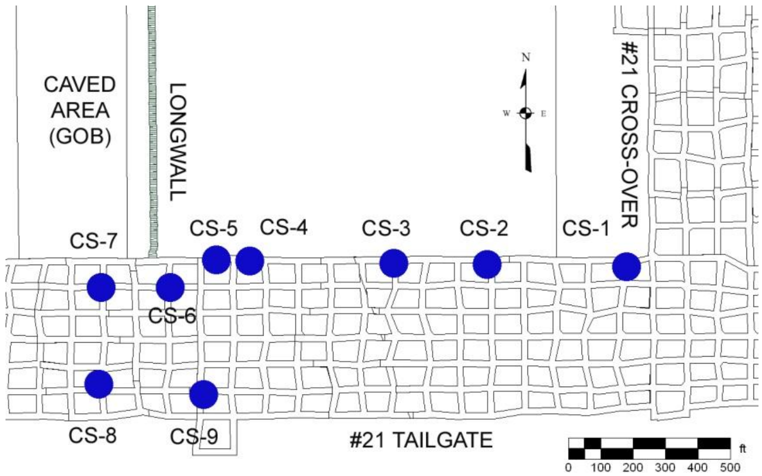


Figure 1. Sampling locations in #21 Tailgate of channel samples and samples of spalled rib dust.

The two benches are highly disparate in petrographic composition. The Top Coal is more brittle, probably as a result of the high total vitrinite contents (average 82%) coupled with the coal being near the boundary between high volatile and medium volatile coals. The Bottom Coal was more of a durain lithotype which contributed to its greater strength and much lower spalling, compared to the Top Coal.[1] These ledges became elevated platforms for the gradual accumulation of dust as the coal benches spalled off. Also these ledges would collect float dust deposited from the airstream downwind from the coal cutting machinery.

Despite the fact that the Bottom Coal contained nearly four times more fusinite/semi-fusinite than the Top Coal, this material may have contributed to the friability of the Top Coal due to the fact it occurred in discrete, visible partings in the middle of the Top Coal, whereas it was interstitial to the lower bench. Further, the lenticular fusinite/semifusinite partings in the Top Coal were of a fine, sooty texture, which easily crumbles to a fine powder, making it a comparatively greater hazard.

NIOSH assisted in evaluating the characteristics of the spalled rib dust, particularly the measurement of particle size distribution of the minus 20 mesh material, incombustible content, and the relative explosibility. The samples were tested by NIOSH in their 20-liter constant volume chamber and the results indicate that the dust is explosive.[2]

[1] Eble, Courtland F., Petrographic Analysis of Coal Samples-WV Eagle Coal Bed, Kentucky Geological Survey, November 11, 2011. (**Exhibit 1**, attached)
[2] Measuring the Particle Size Distribution and the Relative Explosibility of Rib and Talus Dust Samples collected by the West Virginia Office of Miners' Health, Safety and Training Accident Investigators from the UBB mine, NIOSH.

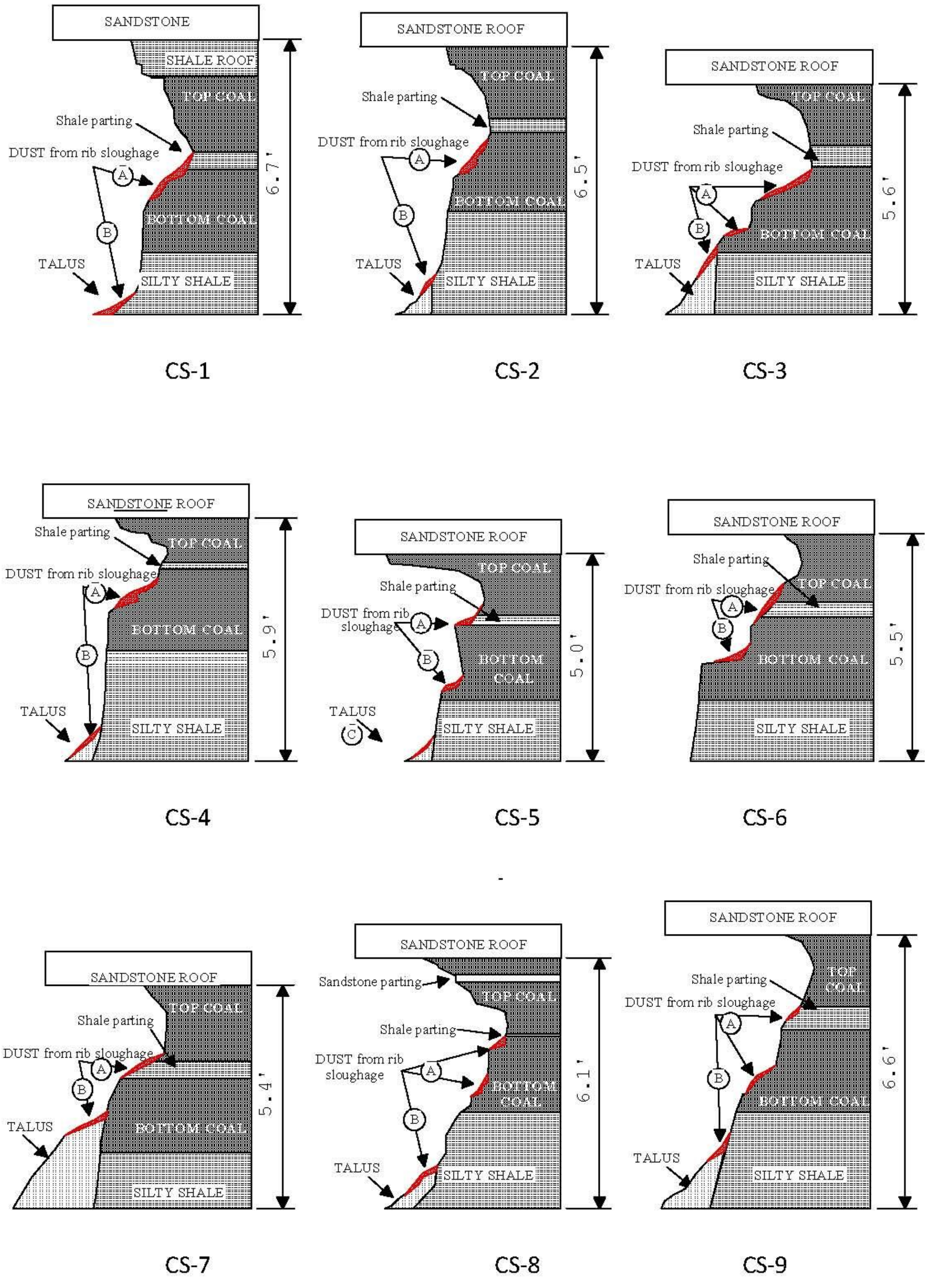


Figure 2. Geologic profiles where samples were collected of spalled rib dust that had accumulated in the 1.5 years since the explosion.

The lower, lean mixture, limit for propagation of a coal dust explosion decreases with the particle size. Results from the experimental mine at Bruceton, Pennsylvania indicate that the lower explosive limit for mine size dusts (20% < 200 mesh) is 2.83 grams per cubic foot (gr/ft^3) and for pulverized coal (80% < 200 mesh) the lower limit is 1.98 gr/ft.^{3} Research at the Lake Lynn Experimental Mine, with larger mine openings, shows that mine size dusts have a lower explosive limit of about 2.1 gr/ft.^{3} Pulverized dusts have a lower explosive limit (about 1.4 gr/ft^3) and the volatile matter of the coal does not affect this lower limit. The applicable values for the mine entries at UBB are believed to fall somewhere between the values for these two experimental mines. Total incombustible content needed to prevent flame propagation of a uniform coal and rock dust mixture with 80% minus 200 mesh is 80%.[3]

Cross-sectional areas of the entries at the rib sample locations ranged from 112 to 132 ft^2, with the average being 116 ft.^{2} The amount of minus 60 mesh material on the benches and floor along the rib toe averaged about 46.3 grams per linear foot, and 21.5 grams of that was minus 200 mesh. Based on the lean mixture needed for an explosion propagation about 243 grams per foot of entry is needed. If the dust were all minus 200 mesh only about 162 grams per foot of entry would be needed.

A close examination of the rib outlines indicate that much material was spalled off during the passage of time. The ribs as originally cut with a continuous miner would have been a straight line roof to floor. Top Coal spalled might yield more than the lean mixture needed to propagate an explosion. Additionally, spalled material was observed to have been ejected 10 feet or more from ribs) and would be in addition to float dusts generated by mining. Fine accumulations are sometimes difficult to appreciate visually, but they are what pose the greatest risk of explosion. The fine sooty dust, contributed by the fusain partings of the Top Coal are unusual in their abundance. What might have happened at UBB is that the aggregated concentrations of float dust and rib spalling created a hazard that was not appreciated because it didn't "look that bad" and/or the dust contributions from mining seemed remote and insignificant.

The spalled dust found after the explosion did not exist at all locations in the same quantity, but where it did collect it would be available to be dispersed and aid in the explosion propagation. These ledges and dust deposits are formed naturally, over time and are believed to have been available prior to the explosion as elevated horizontal locations to collect additional float dust. This natural collection of dusts and the deposition of float dust created by normal mining emphasize the need for repeated rock dusting.

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[3] Weiss, E.S., Greninger, N.B., Sapko, M.J., Recent Results of Explosion Studies at the Lake Lynn Experimental Mine, Proceedings of The 23rd International Conference of Safety in Mines Research Institute, Washington, DC, September 11-15, 1989, pages 847.

Rock dust

Also of importance is the quality of the rock dust. The West Virginia Code, 22A-2-24(d), and the Federal Regulations, 30 CFR Part 75.2 define rock dust. Among the requirements is that 100% of the dust must pass through a 20 mesh screen and at least 70% must pass through a 200 mesh screen. It is also required that particles when wetted and dried will not cake and can be dispersed by a light blast of air. The added danger of rock dust either caked or in paste form can provide a non-dispersible substrate for hydrophobic coal dust to sit on and be preferentially scoured off. If the rock dust and coal dust are deposited together, such as with a trickle duster, and the rock dust picks up moisture the cake form binds the coal and rock together removing both from participating in the combustion process.

Samples of rock dust collected by MSHA from supplies at the mine did not meet the size requirements. One sample contained only 28.8% minus 200 mesh.[4] Results from other analysis of rock dust from the mine by MSHA indicate the minus 200 mesh portion to be generally less than 70%. WVOMHS&T collected a rock dust[5] sample near crosscut 75 of the 1 North Mains to determine compliance with 22A-2-24(d) and the analysis by NIOSH indicated it was compliant with 73% 200 mesh. In October 2011 NIOSH, as part of an ongoing investigation, analyzed samples collected at 278 underground coal mines and 47% were found to contain less than 70% passing through a 200 mesh sieve.[6] The quality of the rock dust used in the explosion area is suspect but it could not be accurately determined.

Finer rock dust particles are more effective in rapidly extracting heat from the combustion front reducing the flame temperature below 1,300 K and quenching coal combustion and suppressing flame propagation. Researchers found that the most effective material is one in which about 70% or higher passes through a 200 mesh sieve.

Research has shown that mine entries can contain 80% or higher TIC based on band sample analysis yet still propagate a dust explosion if the entry surfaces contain sufficient surface accumulations of float coal dusts. Float coal dust are coal particles with diameters minus 200 mesh (75 microns) that can be carried by the ventilating air and deposited along the ventilated air ways, see 30 CFR 75.400-1(b). This reactive fine thin coal dust layer can be scoured up and propagate flame over large distances. For example, research has shown that float dust concentrations require a significant increase in TIC to prevent flame propagation, up to about 90% incombustible if the float dust is 30% of the nominal loading of 2.83gr/ft^3 and on elevated surfaces. Float coal dust research forcefully demonstrates the need to continually disperse rock dust into the ventilating air such that the downstream fresh accumulations contain an intimate

[4] Report of Analysis for sample collected August 31,2010, Mount Hope National Air and Dust Laboratory, MSHA.
[5] Sampled from a bag of unopened rock dust that survived the explosion.
[6] Hazard ID, National Institute for Occupational Safety and Health, HID 16 October 2011

marriage of at least 4 parts rock dust for each part of float coal dust as it accumulates along the return airways.[7]

Records available show that the region of #21 Tailgate entries, between the #21 Crossover and approximately 10 crosscuts inby the current longwall tail (the region where the initial dust explosion first started and propagated), had not been sampled during the routine sampling procedures by MSHA. There are no records or testimonies indicating that the tailgate entries had been re-rock dusted after initial development was completed. The #21 Longwall was not using a trickle duster or any other means to periodically apply rock dust in the tailgate entries. This lack of ongoing application of rock dust in the tailgate entries along with the longwall mining process resulted in accumulations of un-neutralized float coal dust.

It is logical to assume that the explosion dispersed the dust that accumulated on the coal rib ledges before the explosion. The observed accumulation recurred in the 1½ years after the explosion. This leads to the conclusion that additional spalled fine dust was available on the ribs, coupled with un-neutralized float dust from the mining operations, at the time of the explosion and was dispersed contributing to the coal dust explosion.

Even though the area was probably rock dusted as the entries were mined, and observations by inspectors and mine examiners and officials did not recognize the need for additional rock dust, there was obviously a deficiency in the rock dust applications.

What seems to have been overlooked is the conversion of intakes to returns, triggering additional requirements for rock dust. Under the regulations, returns required 80% rock dust while intakes needed only 65%. Several entries, not limited to #21 Tailgate, were alternately used as intakes and returns, and no indication exists in the records that additional rock dust was applied, or that sampling was done to ensure compliance with the additional rock dust needs.

Rock dust quality and application needs to be monitored to ensure effective rock dust is applied, but even then all rock dust applied in an entry might not be dispersed by an explosion due to caking or being stuck to the ribs. Also, some developed areas are difficult to access with rock dusting machinery for additional applications. Effective aerodynamic distribution techniques are necessary to continually marry the rock dust with the float coal dust.

In areas where there can be significant accumulations of coal dust, for example along belt lines, passive and trigger barriers should be considered as supplemental protection to limit the range of flame propagation. Such systems have been successfully employed in European countries and have documented cases where barriers have saved lives by preventing extensive flame

[7] Sapko, M.J., Weiss, E. S., Watson, R. Explosibility of Float Coal Dust Distributed Over a Coal-Dust Substratum, Bureau of Mines, Pittsburgh Pa.

propagation. The circumstances at UBB illustrate a condition where explosion prevention barriers might be a good option for supplemental protection to limit the range of explosion propagation. European mine geometries differ from the US and research is needed to optimize deployment strategies for US mining operations using multiple parallel entries, and provide information as to what kind and how barriers should be deployed.

Petrographic Analysis of Coal Samples - WV Eagle Coal Bed

Submitted By: Cortland F. Eble, Geologist, Kentucky Geological Survey

Submitted To: Monte Hieb, Chief Engineer, WV Office of Miners' Health, Safety and Training

Date: 11 November, 2011

Methods

18 samples of the WV Eagle coal bed were received in October, 2011 for petrographic analysis. All samples were first reduced in size to -20 mesh (particle top size, 850 microns), and then split to obtain a representative subsample for pellet preparation. Particle mounts of the -20 mesh coal were constructed by mixing approximately 5 g of coal with epoxy resin, and then pouring the coal/epoxy mixture into 1 inch diameter ring forms. Once hardened, the pellets were ground and polished using 400 and 600 grit papers, 1 micron and 0.5 micron alumina slurries and 0.05 micron colloidal silica. The polished mounts were point counted (500 counts /sample) at a magnification of 640X on a Zeiss compound research microscope, using both white and fluorescent (UV) light.

Results

A complete list of maceral percentages for all of the examined samples is shown in Tables 1 and 2. Photographs of macerals discussed in the text below are shown in Figures 1 through 5.

Top Bench

The top bench is dominated by vitrinite macerals (average 82 %, range 78 to 87.6 %, mineral matter free basis). Telovitrinite is the dominant maceral subgroup (average 65 %, range 55.2 to 72.4 %, mmf) compared with

detrovitrinite, which averages 17 % (range 11.2 to 22.8 %, mmf) in the top bench samples. Vitrinite reflectance measurements from one of the top bench samples indicates a Ro maximum of 1.06 (high volatile A bituminous).
Liptinite macerals in the top bench samples average 10 % (range 8 to 11.6 %, mmf), with sporinite being the most commonly observed liptinite maceral. The liptinites in the top bench fluoresce in the yellow-orange range, which agrees well with the vitrinite reflectance data.
Inertinite macerals in the top bench samples average 8 % (range 4 to 12.4 %, mmf), with fusinite being the most common inertinite maceral.
Collectively, the high vitrinite content, combined with relatively high rank, are most likely the principle reasons why the top bench is "brittle". Depleted volatile matter contents (estimated to be 30 to 34 %, dry ash-free basis, based on vitrinite reflectance) appear to be the principle cause.

Bottom Bench

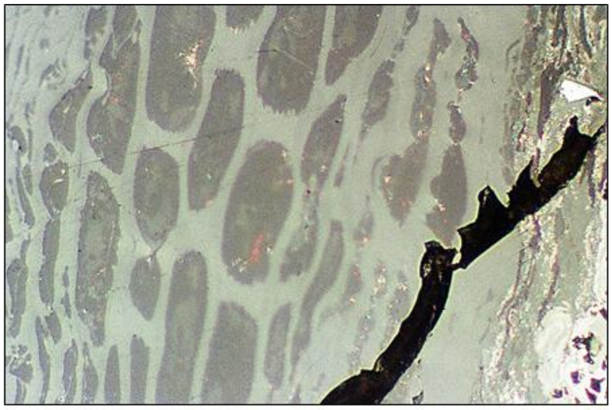
The petrographic composition of the bottom bench is significantly different than the top bench. Vitrinite contents are much lower (average 48.1 %, range 43.6 to 52 %, mmf), with detrovitrinite being a more significant component of the total vitrinite content (average 21.7 %, range 18 to 26 %, mmf). The average ratio of telovitrinite to detrovitrinite in the bottom bench samples is 1.2:1; in the top bench, the ratio is 4:1.
Liptinite macerals are more abundant in the lower bench samples, averaging 16.8 % (range 13.6 to 20.8 %, mmf), with sporinite being the most common liptinite maceral. Inertinite macerals are also more abundant in the lower bench samples (average 35.1 % (range 30.8 to 40.8 %, mmf), with fusinite and semifusinite being the most abundant inertinite macerals (average 14.7 and 14.4 %, mmf, respectively).
The increased "hardness" of the lower bench is most likely a result of the increased liptinite and inertinite. High concentrations of these two components in bituminous coal results in lower Hardgrove Grindability indices and a "duller" appearance (more durain-like, than clarain-like) in hand section. The increased percentages of inertinite in the bottom bench are of additional importance from a metallurgical standpoint, as it affects the ratio of "reactives" (vitrinite + liptinite) to "inerts" (inertinite + ⅔semifusinite + mineral matter), and thus the composition balance index (CBI) and strength index (SI).

Table 1 – Distribution of macerals in top bench coal samples

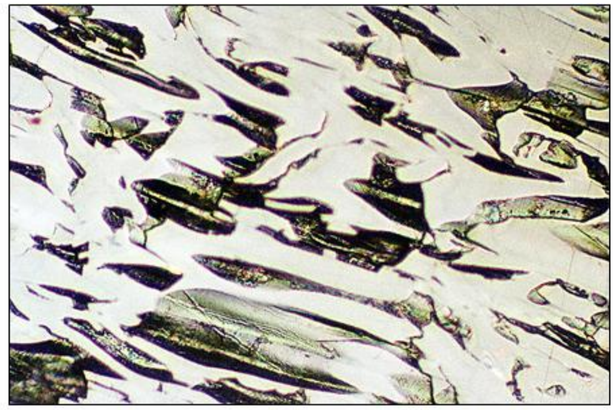
	1163966	1164293	1163968	113967	1164294-7	1163969	1164301-7	1164296-7	1164300	Average	Maximum	Minimum
maceral												
maceral group												
telinite	2.80	2.00	0.40	2.00	3.20	2.00	0.80	2.40	1.60	1.91	3.20	0.40
collotelinite	52.40	70.40	70.40	56.80	66.00	66.00	69.60	56.80	59.20	63.07	70.40	52.40
collodetrinite	22.40	10.40	10.00	17.20	13.20	13.20	12.00	15.20	16.00	14.40	22.40	10.00
vitrodetrinite												
corpogelinite			0.40	2.40	1.20	1.20	2.00	1.20	1.20	1.37	2.40	0.40
gelinite	0.40	1.20	0.80	2.80	1.60	0.40	3.20	2.40	0.80	1.51	3.20	0.40
Total Vitrinite	**78.00**	**84.00**	**82.00**	**81.20**	**85.20**	**82.80**	**87.60**	**78.00**	**78.80**	**81.96**	**87.60**	**78.00**
Telovitrinite	55.20	72.40	70.80	58.80	69.20	68.00	70.40	59.20	60.80	64.98	72.40	55.20
Detrovitrinite	22.80	11.60	11.20	22.40	16.00	14.80	17.20	18.80	18.00	16.98	22.80	11.20
TV/DV	2.42	6.24	6.32	2.63	4.33	4.59	4.09	3.15	3.38	4.13	6.32	2.42
sporinite	9.60	9.20	11.20	9.60	8.00	11.20	8.40	8.80	10.80	9.64	11.20	8.00
cutinite	0.40									0.40	0.40	0.40
resinite												
exsudatinite												
liptodetrinite	1.20			0.40		0.40		0.80	0.40	0.64	1.20	0.40
Total Liptinite	**11.20**	**9.20**	**11.20**	**10.00**	**8.00**	**11.60**	**8.40**	**9.60**	**11.20**	**10.04**	**11.60**	**8.00**
fusinite	5.60	1.20	2.40	4.80	2.40	4.00	1.20	7.20	5.60	3.82	7.20	1.20
semifusinite	1.20	3.20	1.20	0.80	0.80		0.40	2.40	1.20	1.40	3.20	0.40
macrinite						0.40				0.40	0.40	0.40
micrinite	3.20	2.00	3.20	2.40	3.20	1.20	2.40	2.80	2.40	2.53	3.20	1.20
secretinite												
funginite												
inertodetrinite	0.80	0.40		0.80	0.40				0.80	0.64	0.80	0.40
Total Inertinite	**10.80**	**6.80**	**6.80**	**8.80**	**6.80**	**5.60**	**4.00**	**12.40**	**10.00**	**8.00**	**12.40**	**4.00**
Random Ro					0.99							
Maximum Ro					1.05							
Minimum Ro					0.90							
Standard Deviation					0.04							
Count					50.00							
Calculated Ro max					**1.06**							
(Rorandom * 1.066)												

Table 2 - Distribution of macerals in bottom bench coal samples

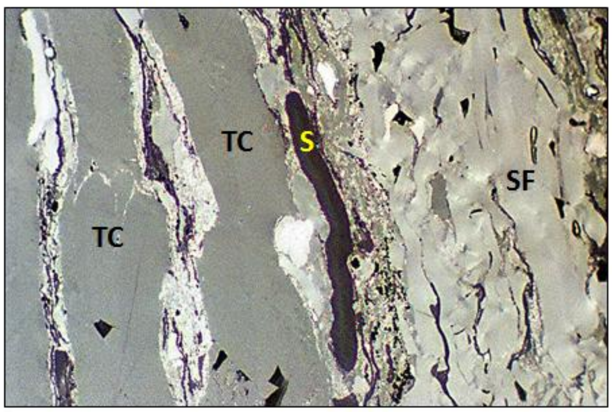
	1163966	1164293	1163968	1163967	116294-7	1163969	1164301-7	1164296-7	1164300	Average	Maximum	Minimum
maceral												
maceral group												
telinite				0.80	0.80	0.40	1.20	0.40	0.40	0.67	1.20	0.40
collotelinite	22.80	26.00	30.00	25.20	30.00	26.80	24.40	21.20	27.20	25.96	30.00	21.20
collodetrinite	17.60	22.00	18.80	21.60	16.40	15.20	18.00	16.00	18.00	18.18	22.00	15.20
vitrodetrinite												
corpogelinite	1.60		0.80	3.20	1.20	1.20	2.80	2.00	2.00	1.85	3.20	0.80
gelinite	4.00	0.40	1.20	1.20	0.80	1.60	2.00	4.00	1.60	1.87	4.00	0.40
Total Vitrinite	**46.00**	**48.40**	**50.80**	**52.00**	**49.20**	**45.20**	**48.40**	**43.60**	**49.20**	**48.09**	**52.00**	**43.60**
Telovitrinite	22.80	26.00	30.00	26.00	30.80	27.20	25.60	21.60	27.60	26.40	30.80	21.60
Detrovitrinite	23.20	22.40	20.80	26.00	18.40	18.00	22.80	22.00	21.60	21.69	26.00	18.00
TV/DV	0.98	1.16	1.44	1.00	1.67	1.51	1.12	0.98	1.28	1.24	1.67	0.98
sporinite	12.80	20.40	17.20	17.20	16.40	20.40	14.00	15.60	15.60	16.62	20.40	12.80
cutinite												
resinite												
exsudatinite												
liptodetrinite	0.80	0.40	0.40							0.53	0.80	0.40
Total Liptinite	**13.60**	**20.80**	**17.60**	**17.20**	**16.40**	**20.40**	**14.00**	**15.60**	**15.60**	**16.80**	**20.80**	**13.60**
fusinite	18.40	12.40	12.40	12.40	12.40	14.80	14.00	17.20	18.00	14.67	18.40	12.40
semifusinite	16.40	14.40	15.20	12.00	14.40	12.00	17.20	16.40	11.20	14.36	17.20	11.20
macrinite	0.40			0.80	1.60	1.60	1.20	2.00	1.20	1.26	2.00	0.40
micrinite	5.20	4.00	4.00	4.80	5.20	3.20	4.00	4.80	4.00	4.36	5.20	3.20
secretinite					0.40					0.40	0.40	0.40
funginite												
inertodetrinite				0.80	0.40	2.80	1.20	0.40	0.80	1.07	2.80	0.40
Total Inertinite	**40.40**	**30.80**	**31.60**	**30.80**	**34.40**	**34.40**	**37.60**	**40.80**	**35.20**	**35.11**	**40.80**	**30.80**



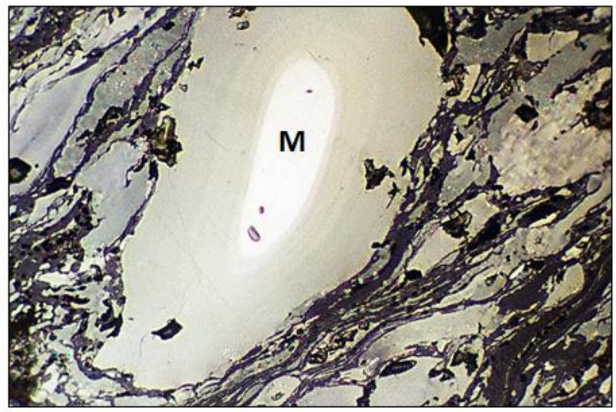
telinite (light gray) and gelocollinite dark gray)



fusinite

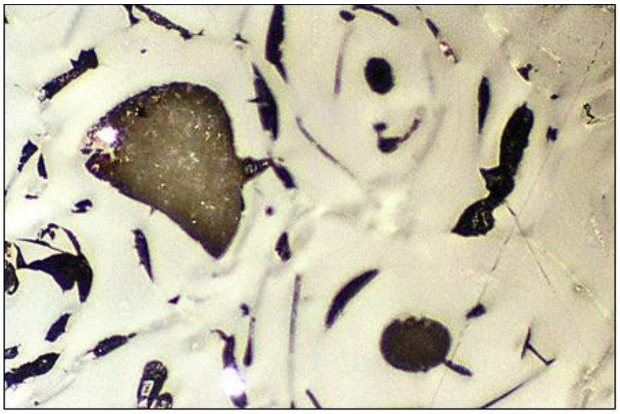


telocollinite (TC), sporinite (S) and semifusinite (SF)

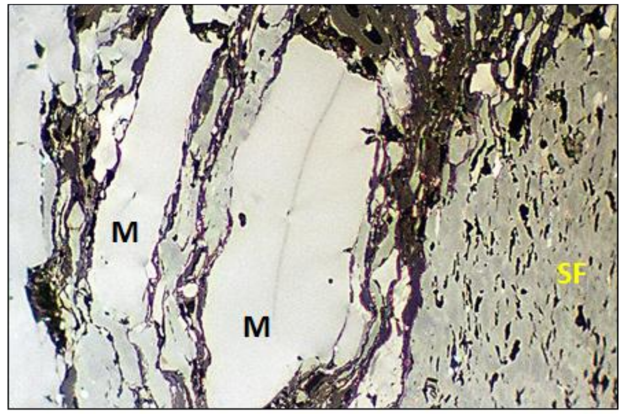


Macrinite (M)

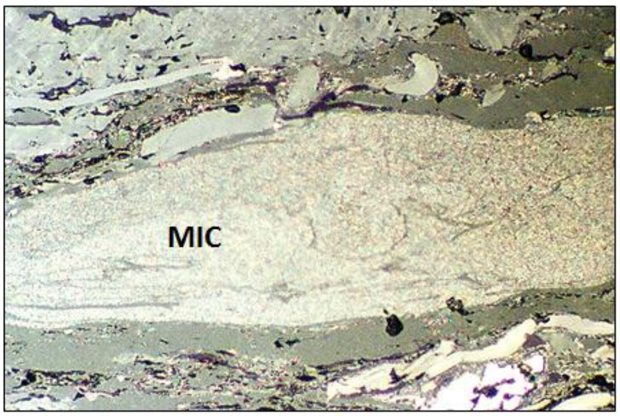
Figure 1 - Examples of macerals in the WV Eagle coal bed, polished section, reflected light. The long dimension of each photo is 150 microns.



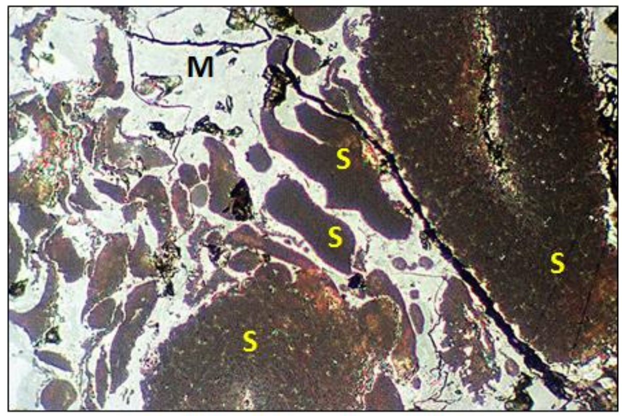
secretinite



macrinite (M) and semifusinite (SF)



micrinite (MIC)



macrinite (M) and sporinite (S)

Figure 2 - Examples of macerals in the WV Eagle coal bed, polished section, reflected light. The long dimension of each photo is 150 microns.

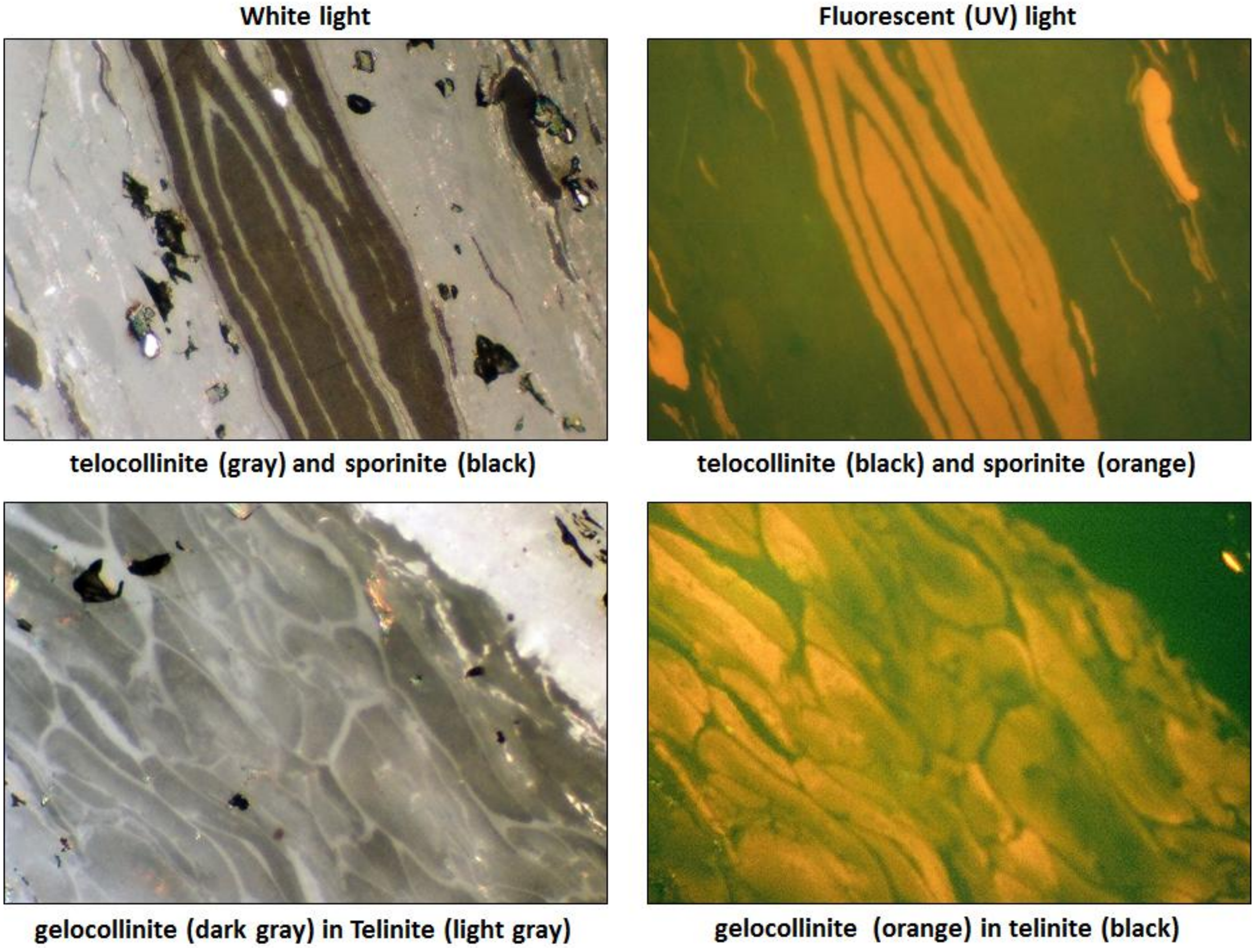
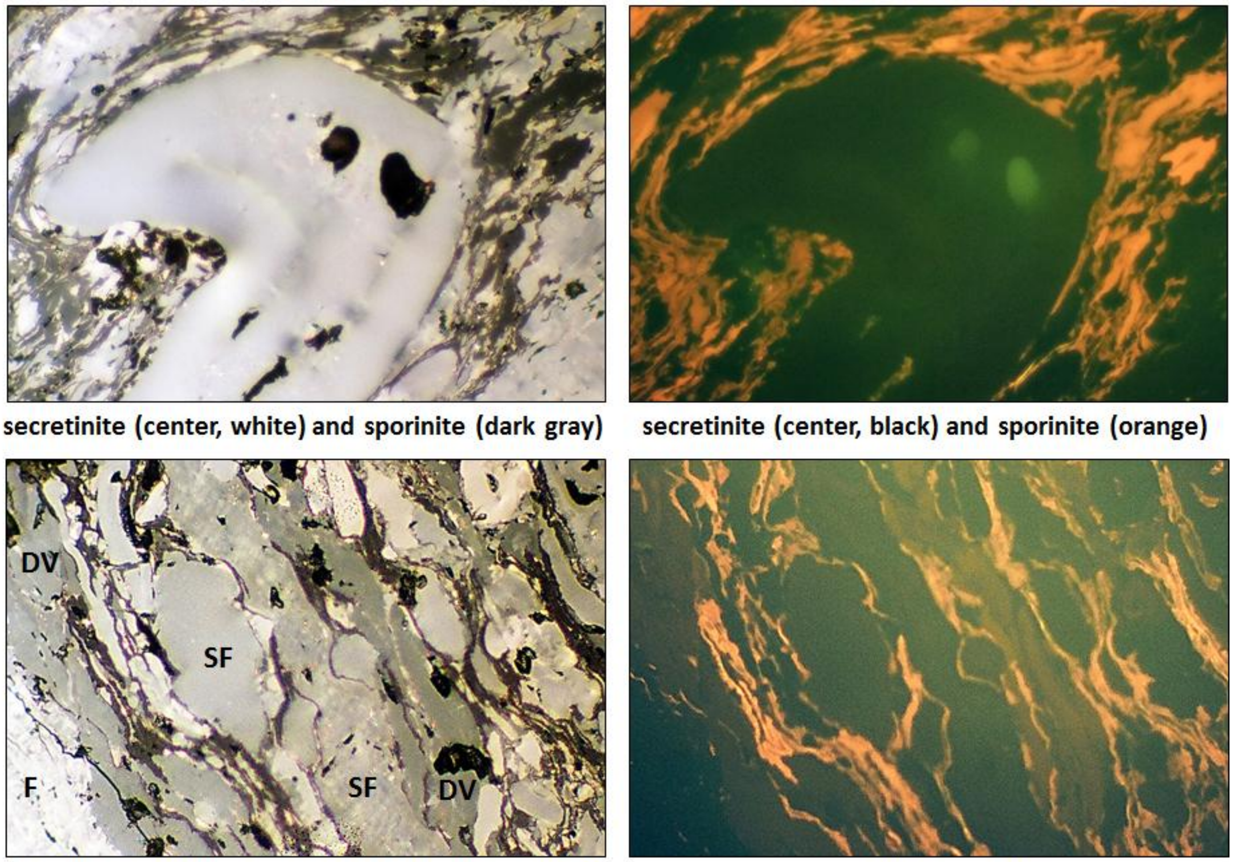


Figure 3 - Examples of macerals in the WV Eagle coal bed, polished section, reflected light. The long dimension of each photo is 150 microns.



White light | **Fluorescent (UV) light**

secretinite (center, white) and sporinite (dark gray) | secretinite (center, black) and sporinite (orange)

detrovitrinite (DV), semifusinite (SF) and fusinite (F) | sporinite (orange)

Figure 4 - Examples of macerals in the WV Eagle coal bed, polished section, reflected light. The long dimension of each photo is 150 microns.

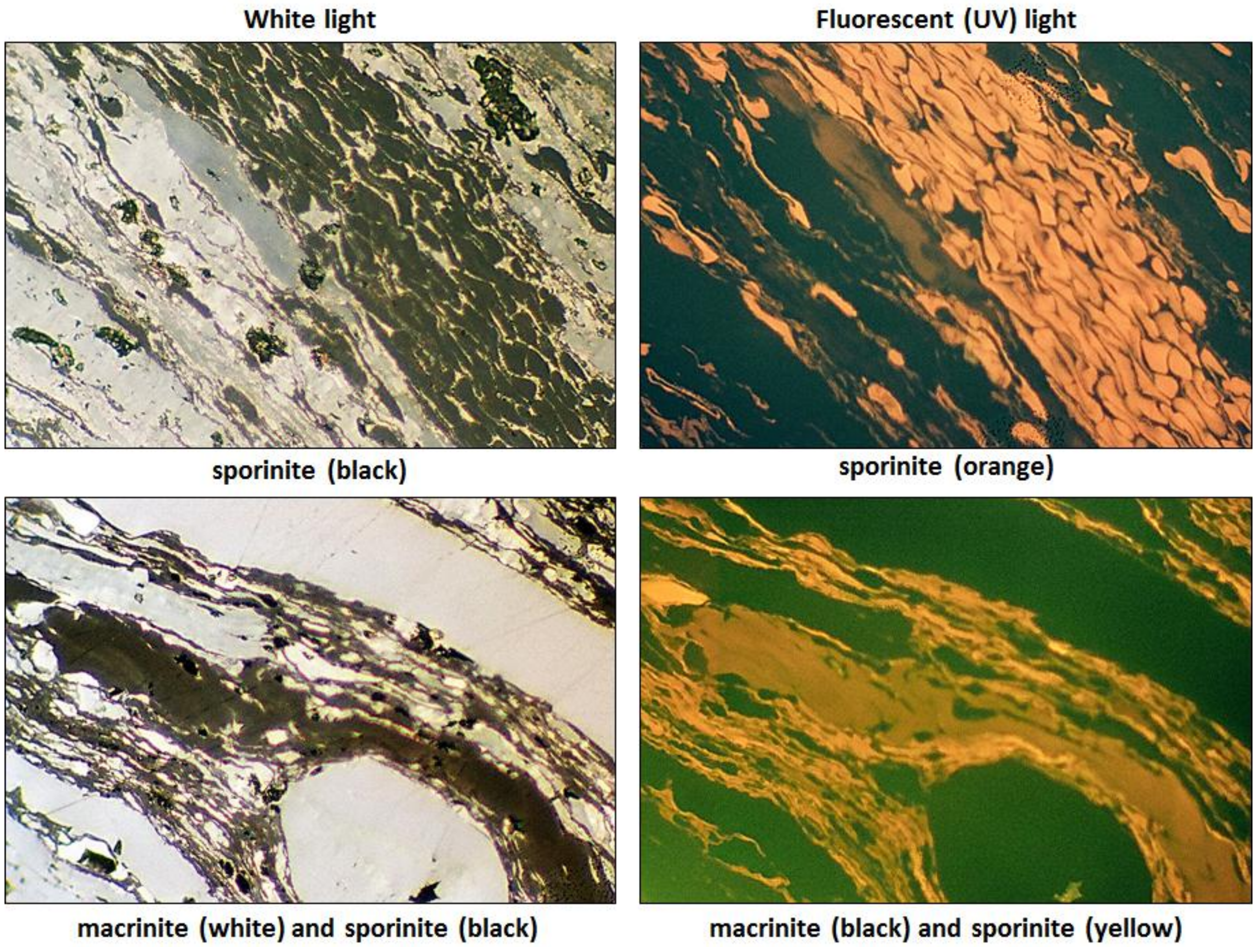


Figure 5 - Examples of macerals in the WV Eagle coal bed, polished section, reflected light. The long dimension of each photo is 150 microns.

APPENDIX 8.2-2

Measuring the Particle Size Distribution and the Relative Explosibility of Rib and Talus Dust Samples Collected by the West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) Accident Investigators from the UBB Mine[1]

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested assistance from the National Institute for Occupational Safety and Health's Office of Mine Safety and Health Research (OMSHR) to measure the particle size distribution of rib and talus dust samples and two rock dust samples. They also requested that OMSHR determine the relative explosibility of the rib and talus dust samples using its 20-L explosibility test chamber. WVOMHS&T also provided a lump of fusain to be ground and the relative explosibility determined using the 20-L test chamber. All dust samples were sent to Michael Sapko by Monte Hieb of WVOMHS&T. Samples were identified by WVOMHS&T as 903933, 903934, 903935, 903936, 903937, 903938, 903939, 903940, 903941, 903942, 903943, 903944, 903945, 903946, WV 1A 7-21-11, WV 1B 7-21-11, WV 1C 7-21-11, WV 2A 7-21-11 and WV 2B 7-21-11. The rock dust samples were identified as WV Rock Dust (A) 6/9/11 and WV Rock Dust (B) 4/26/11. The lump of fusain was reportedly identified as fusinite and semi-fusinite in petrographic analysis.

The particle size distributions were measured using the OMSHR Beckman Coulter shown in Figure 1. The % -200 and -60 mesh size fractions from the Beckman Coulter analysis are shown in Table 1.

Figure 1. Beckman Coulter LS 13 320 dry system.

[1] By National Institute for Occupational Safety and Health (NIOSH) and Office of Mine Safety and Health Research (OMSHR)

Detailed particle size distributions of rib and talus samples are included in a file on the attached CD called “Beckman particle size data”. Also, included on this CD is the sample location file provided by Monte Hieb and is called “CS-1 to CS-9 with bench dimensions”. (see **Appendix 8.2-1 Figure** 2)

Determination of % incombustible content (IC) content of rib and talus dust samples

Prior to sending the samples 903933 through 903946, Monte Hieb of WVOMHST sent these samples to G &C Coal Analysis Lab to determine the % IC of the minus -20 mesh material and the G&C results are shown in Table 1. Before conducting 20-L explosibility experiments, the -60 mesh material was removed at OMSHR by passing through a -60 mesh sieve and this material was used for 20-L explosibility tests. The % IC of the -60 mesh dust fraction was determined by OMSHR before conducting 20-L explosibility tests and the results are shown in Table 1. The low temperature ashing (LTA) procedure follows: the dried sample is heated in an oven that is ramped up over 1.5 hr and held at 515 °C for about 2.5 hr to burn off the combustible coal fraction, thereby leaving the ash and incombustible material. This LTA burns off the coal but does not decompose the limestone rock dust. The amount of the remaining ash material divided by the initial weight is reported as % IC.

20-L explosibility chamber

The dust explosibility experiments were conducted in the OMSHR 20-L chamber (Cashdollar & Hertzberg, 1982a; Cashdollar, 1994), which has been used extensively to study the explosibility of various dusts (Figure 2).

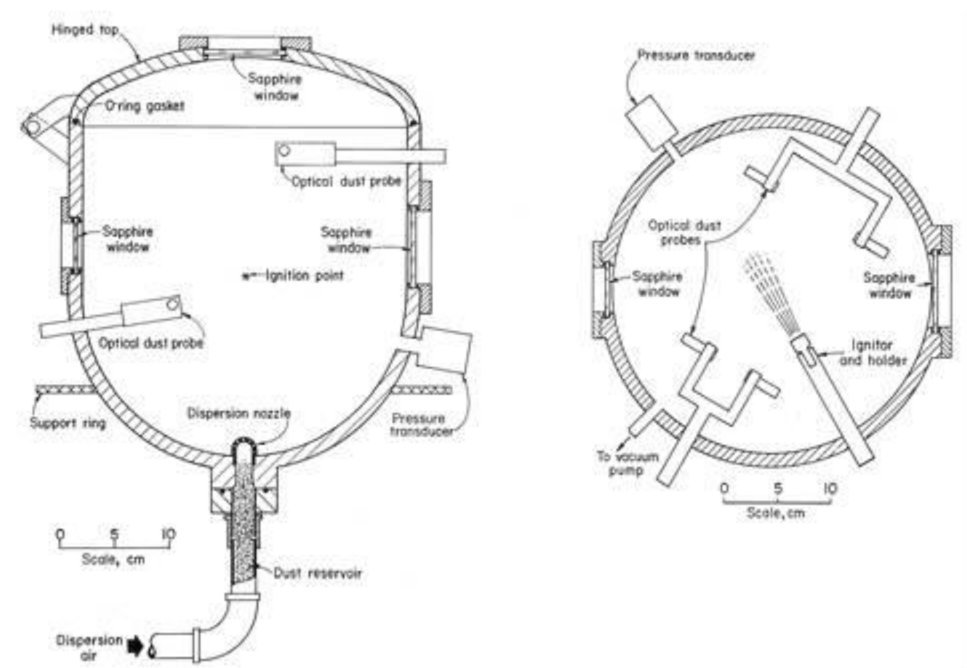


Figure 2. Schematic of 20-L explosibility chamber.

The test procedures for the 20-L chamber are briefly described here. Additional details of the 20-L chamber and test procedures are in Cashdollar & Hertzberg [1982a] and Cashdollar [1994]. The dust test sample was placed on top of the dispersion nozzle. After the dust and ignitor were placed in the chamber, the hinged top was closed and bolted, and then the chamber was partially evacuated to an absolute pressure of 0.14 bar. Then a 0.3 s blast of dry air (from a 16-L reservoir at 8 to 9 bar pressure) dispersed the dust and raised the chamber pressure to about 1 bar at ignition. The experimental dust concentration reported for the 20-L chamber is the mass of dust divided by the chamber volume. The ignition sources used for the 20-L tests were electrically activated, pyrotechnic ignitors manufactured by Fr. Sobbe of Germany. For the 20-L tests reported in this paper, 2500 J ignitors were used. This is the energy recommended in ASTM E1515 [2005a] Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts, E1226 00. The energy is the nominal calorimetric value based on the mass of pyrotechnic powder in the ignitor. The 2500 J ignitor by itself produces a pressure rise of about 0.3 bar in the 20-L chamber. The criterion used to determine explosibility under these test conditions is an absolute explosion pressure of 2 bar or, equivalently, a pressure rise of 1 bar.

Results

The explosion pressure ratios determined as the nominal dust concentrations are shown in Table 1. All rib and talus dust samples provided by WVOMHS&T except for sample WV 2B 7/21/11 resulted in explosion overpressures greater than 2 bar when tested in the 20-L chamber. Also shown for reference is the explosion overpressure obtained for our standard Pittsburgh Pulverized Coal (PPC) dust which contains about 6% inherent ash.

Table 1. Summary of 20-L explosibility experiments

WV rib and talus Samples	G & C Coal analysis		OMSHR (Beckman particle size)		OMSHR(LTA)		OMSHR 20 liter explosibility results		
WV ID #	< 20 mesh, g	% Dry IC <20 mesh material	% < 200 mesh (Beckman)	% < 60 mesh (Beckman)	% Dry IC < 60 mesh material LTA (by difference)	% combustible component (100-%IC)	Nominal conc, g/m3	Pressure Ratio	
903933	61.9	22.95	17.2	43.5	28.7	71.3	400	5.80	CS-1A
903934	66.5	31.17	25.3	47.2	43.2	56.8	400	4.90	CS-1B
903935	162.1	42.23	15.2	39.7	42.9	57.1	400	3.80	CS-2A
903936	24.4	37.8	21.4	46.8	40.7	59.3	400	4.90	CS-2B
903937	103.4	32.12	16.9	39.3	34.9	65.1	400	5.10	CS-3A
903938	70.9	42.06	12	36.4	44.5	55.5	400	4.30	CS-3B
903939	165.8	13.96	25.8	50.9	18.9	81.1	400	5.90	CS-6A
903940	78.1	15.75	25.7	47.6	24.3	75.7	400	5.10	CS-6B
903941	101.8	28.01	17.6	37.8	29.7	70.3	400	4.90	CS-7A
903942	26.3	30.26	23.7	46.8	30.3	69.7	400	5.30	CS-7B
903943	23.3	36.27	31.2	58.3	50.2	49.8	400	5.20	CS-8A
903944	110.5	40.61	28.4	54.9	57.8	42.2	400	4.50	CS-8B
903945	285.2	35.33	20.6	44.8	34.2	65.8	400	5.60	CS-9A-a
903946	158.6	21.99	21.5	46.2	20.7	79.3	400	5.30	CS-9A-b
WV 1A 7-21-11			14	33.5	14.3	85.7	250	5.70	CS-5A
WV 1B 7-21-11			17.3	37.9	26.4	73.6	250	4.67	CS-5B
WV 1C 7-21-11			17.9	35.8	19.4	80.6			CS-5C
WV 2A 7-21-11			23.9	11.7	30.9	69.1	400	5.69	CS-4A
WV 2A 7-21-11			23.9	11.7	30.9	69.1	400	6.04	CS-4A
WV 2B 7-21-11			21.2	46.1	41.0	59.0	400	4.20	CS-4B
WV 2B 7-21-11			21.2	46.1	41.0	59.0	300	1.45	CS-4B
*Fusain run # 1	N/A	N/A	100	100	3.8	96.2	395	6.39	
*Fusain run # 2	N/A	N/A	100	100	3.8	96.2	405	6.43	
*PPC lot 1157	N/A	N/A	100	100	6.0	94.0	400	6.74	
* Samples were hand seived -200 mesh and explosibility tests conducted with -200 mesh fraction									

References

Cashdollar, K. L., and Hertzberg, M. (1982a). 20-L Explosibility Test Chamber for Dusts and Gases. Review of Scientific Instruments, 56, 596-602.

Cashdollar, K. L. (1994). Flammability of Metals and Other Elemental Dusts. Process Safety Progress, 13, 139 145.

ASTM International (2005a). Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts, E1226 00. In Annual Book of ASTM Standards, vol 14.02. West Conshohocken, PA: ASTM International.

The Imaging of Post-Explosion Upper Big Branch Mine Samples using a Scanning Electron Microscope[1]

Introduction

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested assistance from the National Institute for Occupational Safety and Health (NIOSH), Office of Mine Safety and Health Research (OMSHR) in imaging post-explosion dust samples collected from various areas of the Upper Big Branch (UBB) coal mine. The objective was to ascertain if heated coal particles were present in the samples provided. Fifty mine dust samples in closed plastic bags that were labeled by Monte Hieb of the WVOMHS&T as 5, 20, 25, 39, 44, 53, 58, 64, 65, 68, 74, 76, 88, 94, 99, 103, 106, 113, 117, 148, 153, 158, 163, 192, 198, 203, 205, 209, 217, 240, 247, 252, 258, 269, 274, 279, 281, 283, 286, 297, 298, S135, S147A, S147B, S160, S162, S166A, S166B, S167A, and S167B were sent to Michael J. Sapko on August 15, 2011 and then given to Isaac A. Zlochower of the Fires and Explosions Branch of OMSHR.

Experimental Procedures

Sixteen specimens were prepared for scanning electron microscopy (SEM) on August 29, 2011 by direct sampling from the supplied sample bags, with a small amount distributed on an adhesive covered metal disk. The specimens were labeled WV-UBB: 76, 148, 153, 198, 203, 205, 209, 217, 240, 269, 274, 279, 281, 283, 286, and 298. Ten more specimens (WV-UBB: 5, 20, 44, 65, 68, 88, 94, 103, 158, and 163) were prepared on August 30, 2011, and an additional ten (WV-UBB: 25, 39, 58, 64, 74, 106, 113, 117, 192, and 258) were prepared on August 31, 2011. The SEM study commenced August 30, 2011 using the JEOL JSM-6400 instrument located at NIOSH-Morgantown. SEM examination of 20 of the above specimens (20, 65, 68, 76, 103, 148, 153, 198, 203, 205, 209, 217, 240, 269, 274, 279, 281, 283, 286, and 298) was completed September 02, 2011. The SEM study involved sputtering each of the specimens with an extremely thin, conductive gold-palladium coating to prevent particle charging, and then taking images of particles showing evidence of heating. Each specimen was examined using 4-8 view fields (labeled with no suffix or a, b, c, d, e, f, and g) and digital images at 512 x 408 pixel resolution were obtained. Each view consisted of both the normal secondary electron image and the backscattered electron image (BEI). The latter has less surface definition, but can provide some information on the types of element contained (carbon versus the heavier elements such as calcium, silicon, and aluminum), as well as subsurface structure. Thirty new specimens (WV-UBB: 5, 25, 39, 44, 53, 58, 64, 74, 88, 94, 99, 106, 113, 117, 158, 163, 192, 247, 252, 258, 297,

[1] By National Institute for Occupational Safety and Health (NISOH) and Office of Mine Safety and Health Research (OMSHR)

S135, S147A, S147B, S160, S162, S166A, S166B, S167A, and S167B) were then prepared by Michael Sapko on September 06, 2011 from the sample bags using alcohol flotation to concentrate the lighter material. The liquid with floating particles was collected on a spatula, transferred to an adhesive coated metal disk and allowed to dry (F specimens). This phase of the SEM study ran from September 07 through September 09, 2011. Specimens WV-UBB: 5, 25, 39, 44, 53, 58, 99, 247, and 297 were imaged using the JEOL instrument.

The newer SEM instrument, the Hitachi S-4800, then became available. This instrument features higher resolution than the JEOL and high-resolution digital imaging in an easily accessible format. Imaging at a 1280 x 960 pixel resolution was selected, as was the JPEG file format. Three of the older specimens (as received, rather than floated) were selected and run on September 09, 2011 (39HAR, 44HAR, and 58HAR). The study resumed September 13, 2011 on the "S" series of samples using the JEOL and Hitachi SEM instruments. Samples S135, S147A, S147B, S160, S162, S166A, S167A, and S167B were imaged on the Hitachi SEM (these are labeled with an H suffix), while S166B and S167A were imaged on the JEOL instrument. The latter instrument could not be operated in an optimal mode, but was more available for use than the Hitachi. On September 14, 2011, use again was made of the 2 instruments. Specimens labeled 94H, 106H, and 258H were run on the Hitachi SEM, while specimens labeled 64F and 74F were run on the JEOL SEM (the F label is used to distinguish the floated particle specimens from the as-received (AR) specimens). On September 15, 2011, the JEOL became inoperable, and all specimens were run on the Hitachi SEM. These were specimens 88FH, 113FH, 117FH, 158FH, 163FH, 192FH, and 258FH. On September 16, 2011, samples that had only limited view fields imaged were rerun. These were specimens labeled 25ARH, 94ARH, 117ARH, 158ARH, S135FH, S147BFH, S162FH, and S166AFH (note: the AR labels had not always been used before, nor had the F label been used for the "S" samples despite the fact that the 9 "S" samples and 21 others had provided the specimens with the floated particles, i.e., there is some inconsistency in the labeling).

Evidence of coal particle heating can consist of the melting or plasticization of the particle surface leading to rounding of the particle and smoothing or crinkling of the surface. Volatiles produced during such heating by degassing and decomposition of the coal can develop sufficient pressure to break through the melted surface and form blow holes, or, at least, swell areas of the particle to form "blisters." Where the interior of the particle is exposed, cellular structure resulting from such devolitalization can be observed. Exposure of the particle to higher temperatures can produce a porous skeletal residue giving the appearance of solid foam with open cells (or fragments of such "foams"). Even higher temperatures will melt the remaining ash-rich skeleton and produce empty hollow spheres (cenospheres). The above results of particle heating have been observed for bituminous coal particles in experimental coal dust explosions [Ng et al. 1983; Hertzberg and Cashdollar 1986; Conti et al. 1991]. In contrast, limestone and other rock dusts or mineral particles do not exhibit a melted surface and blisters or blow holes upon heating nor are these particles prone to produce cenospheres when intensely heated. The images obtained in the JEOL SEM were recorded by digital image capture of both the normal image mode (secondary electron imaging) and back-scattered electron imaging (BEI). The software for digital image acquisition does not include the information on the magnification and scale of the image; these are provided manually. The Hitachi SEM, on the other hand, provides higher resolution digital images that include the operating conditions and scale. X-ray spectra were taken of both some smooth-skinned and 'wrinkled' spheres in several samples. These showed appreciable amounts of silicon, aluminum, and calcium which indicate shells consisting of melted ash material from the coal.

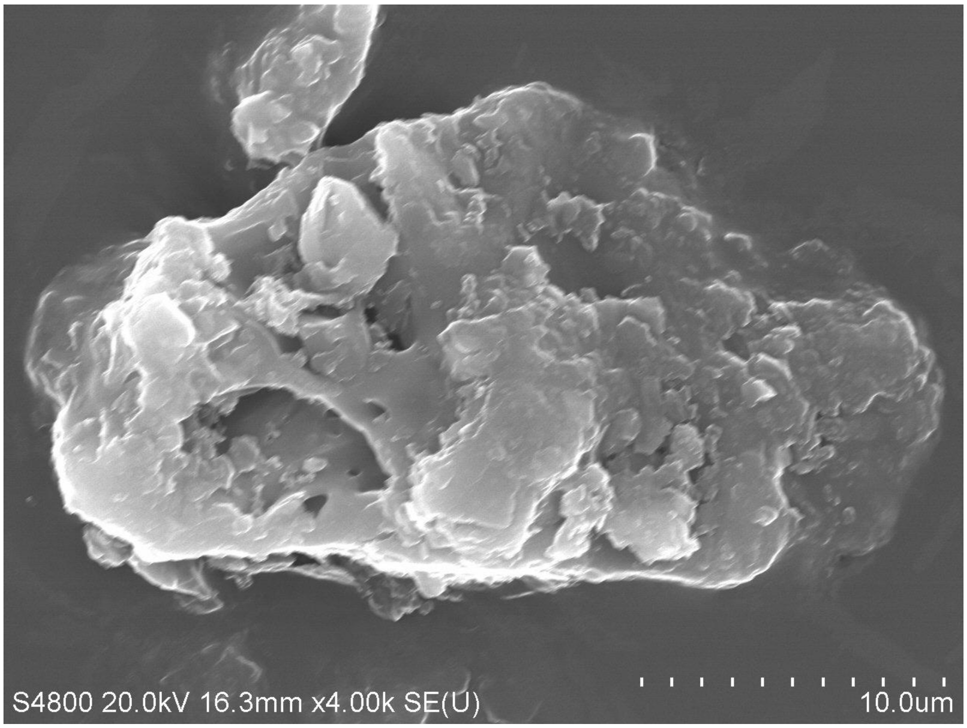
All of the digital images taken during this study are included in a CD file.[2]

Discussion

The images contained on the CD, representing the 50 WVOMHS&T mine samples studied, all demonstrate the presence of particles that have been heated. The degree of heating varies within a sample and between samples. The particles that were imaged were those which did provide evidence of heating. The heating was sufficient to at least melt the surface of particles, producing rounded edges and a smooth or wrinkled skin, and to produce sufficient vapor pressure through degassing and coal decomposition as to create blisters and blow holes (Figure 1). The particles and fragments showing a higher degree of heating were those which featured the skeletal remains of the original particles. These particles had lost much of their original mass through vapor formation from the thermal decomposition of the coal, and their subsequent release into the mine atmosphere via surface break-through and venting (Figure 2). The particles with the highest degree of heating were those exhibiting a thin spherical shell and an empty interior (cenospheres). Their heating was sufficient to convert much of the coal to vapor, and to melt the mineral rich residue to form an ash-rich, hollow sphere (Figure 3).

[2] This CD is not included in this WVOMHS&T report appendix.

Figure 1.- Examples where heating was sufficient to at least melt the surface of particles producing rounded edges and smooth or wrinkled skin, and to produce sufficient vapor pressure to create blisters and blowholes.



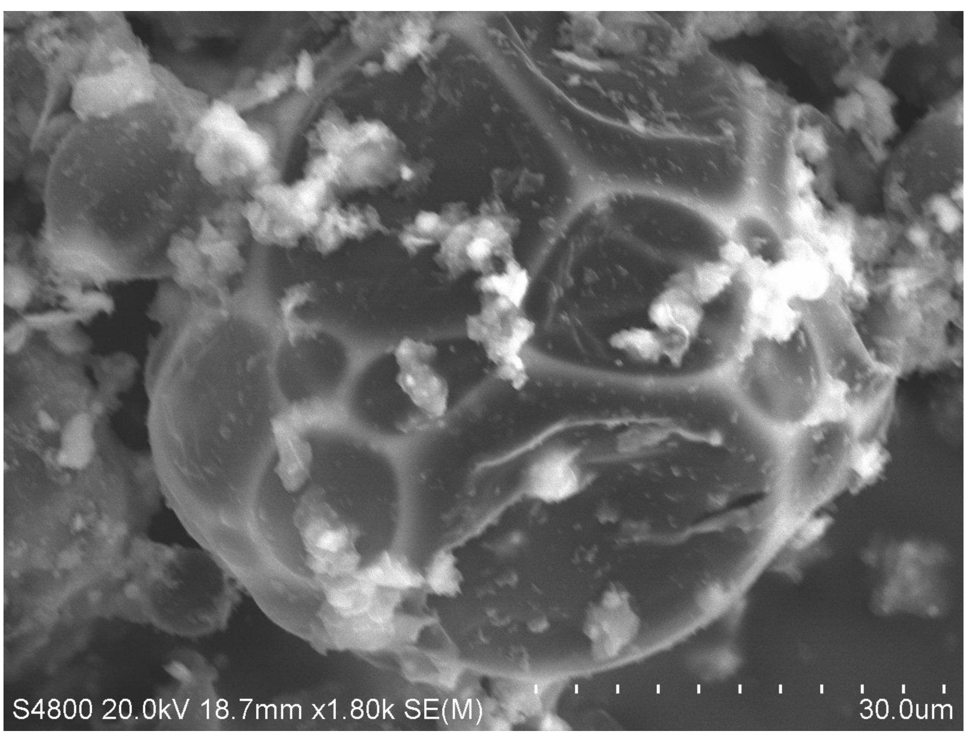


Figure 2.- Examples of particles and fragments showing a higher degree of heating were those which featured the skeletal remains of the original particles.

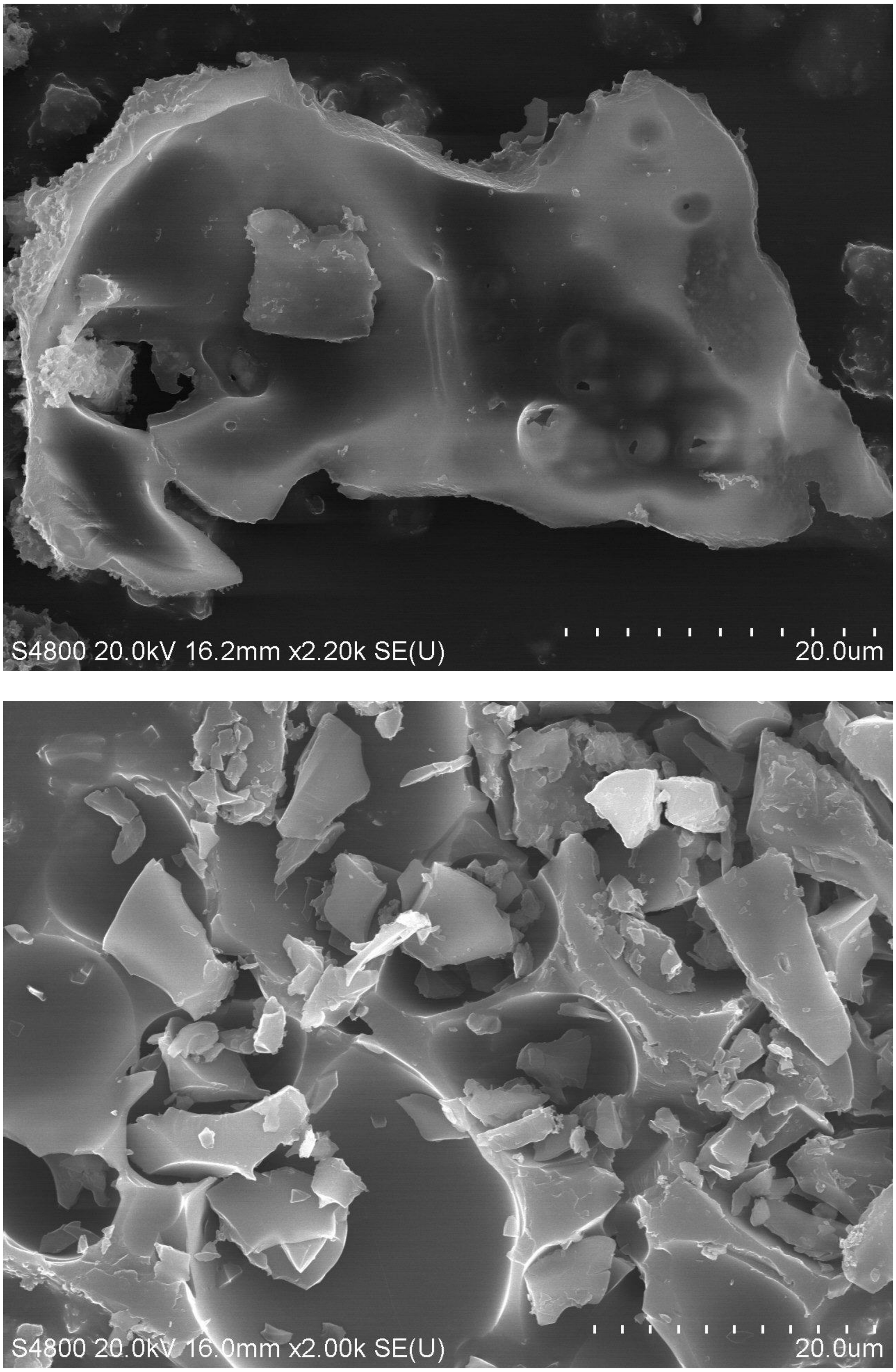
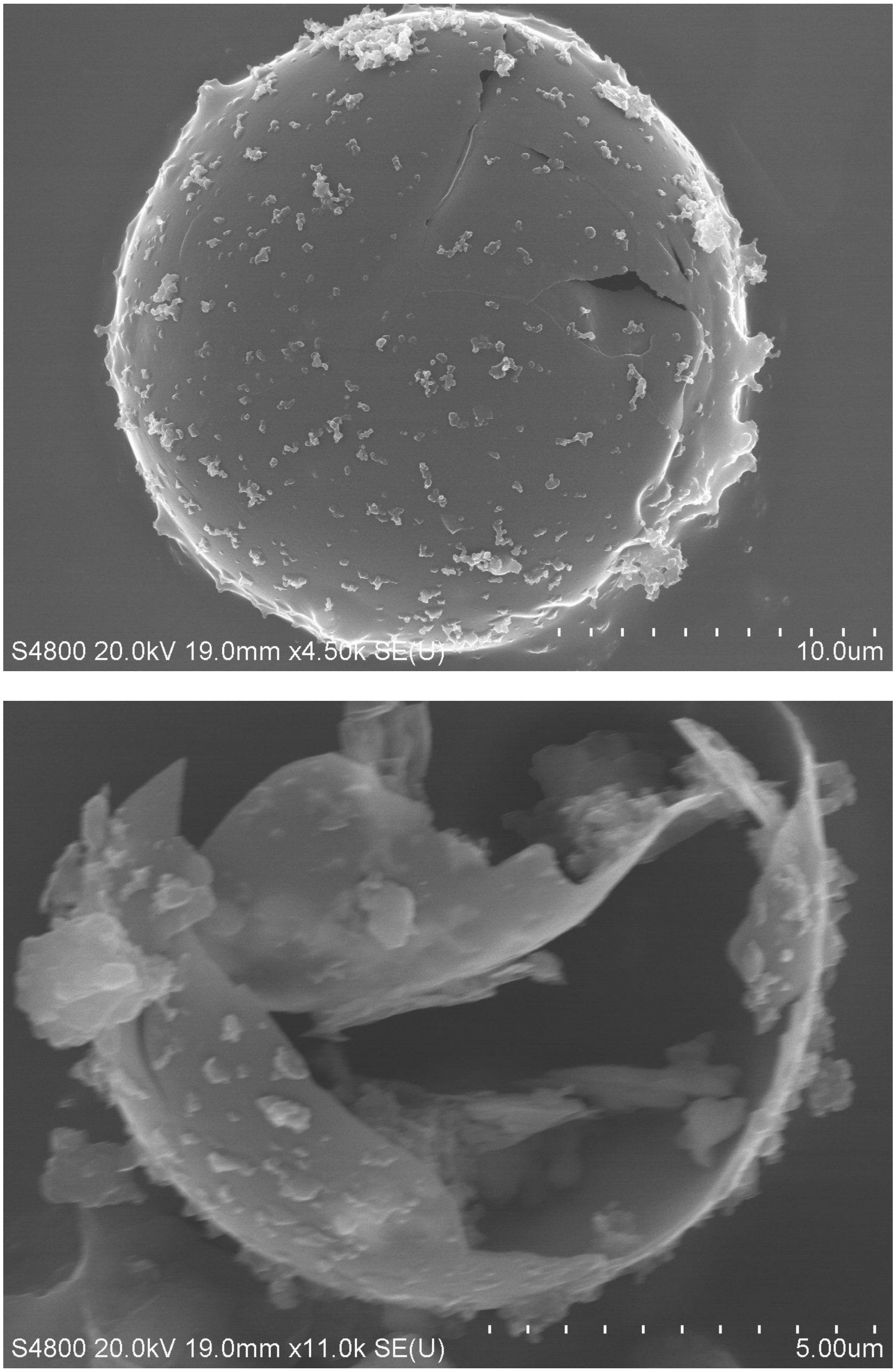


Figure 3.- Examples of particles with the highest degree of heating which formed ash-rich, hollow spheres.



Acknowledgment

This is to acknowledge indebtedness to William Chisholm and Diane Schwegler-Berry (NIOSH-HELD-Morgantown) for assistance with the SEM instrumentation, and to Richard Mainiero (NIOSH-OMSHR) for assistance with scaling and labeling the electronic images.

References

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3. RS Conti, IA Zlochower, and MJ Sapko [1991]. Rapid Sampling of Products During Coal Mine Explosions. Combustion Science and Technology, 75 (1991), pp.195-209.

APPENDIX 8.2-4

The Imaging of Additional Post-Explosion UBB Mine Samples using a Scanning Electron Microscope[1]

Introduction

The West Virginia Office of Miners' Health, Safety and Training (WVOMHS&T) requested that 15 additional samples taken from the Upper Big Branch (UBB) Mine following the large explosion on April, 5, 2010 be examined via a scanning electron microscope (SEM). This was in addition to the 50 such samples that had been so imaged in the period August 30 through September 16, 2011 which was reported to WVOMHS&T on October 18, 2011. The new samples were labeled 899224, 899228, 899230, 899232, 899234, 899235, 899237, 899238, 899240, 899241, 899243, 899245, 899247, 899249, and 899740. These were shipped by Monte Hieb of WVOMHS&T to Michael J. Sapko on October 31, 2011, who prepared the SEM specimens and gave them to Isaac A. Zlochower of the Fires and Explosions Branch of the Office of Mine Safety and Health Research (OMSHR) at the National Institute for Occupational Safety and Health (NIOSH). The specimens were to be run on the Hitachi S-4800 high resolution SEM available at NIOSH-Morgantown. The objective was to locate and image particles that provided evidence of heating.

Experimental Procedures

The 15 samples were contained in 50 ml vials. The vials were typically half filled with the mine dust, although sample 899237 contained very little dust. The SEM specimens were prepared by adding a small amount of denatured alcohol (ethanol) in a weighing dish, stirring, allowing particles to settle for at least a minute, and then skimming the surface with the tip of a spatula to collect some of the lighter material. A drop of the skimmed slurry was then dripped onto a copper disk that had a square of double-sided carpet tape on the top surface. The alcohol was allowed to evaporate. The SEM specimens so prepared were kept in individual labeled plastic containers. The SEM study began on November 1, 2011 and was completed on November 3, 2011. The procedure followed was to first provide the specimens with a conductive gold-palladium sputter coating to minimize sample charging from the high energy incident electron beam that is used for SEM imaging. The coated SEM specimen was then placed on a specimen holder and inserted into the Hitachi instrument specimen chamber. The high magnification option was selected and the magnified image of the particles in the field of view was brought into focus. The field of view was scanned until a particle showing signs of heating came into view. The magnification was increased and the image sharpness was optimized. The digital

[1] By National Institute for Occupational Safety and Health (NIOSH) and Office of Mine Safety and Health Research (OMSHR)

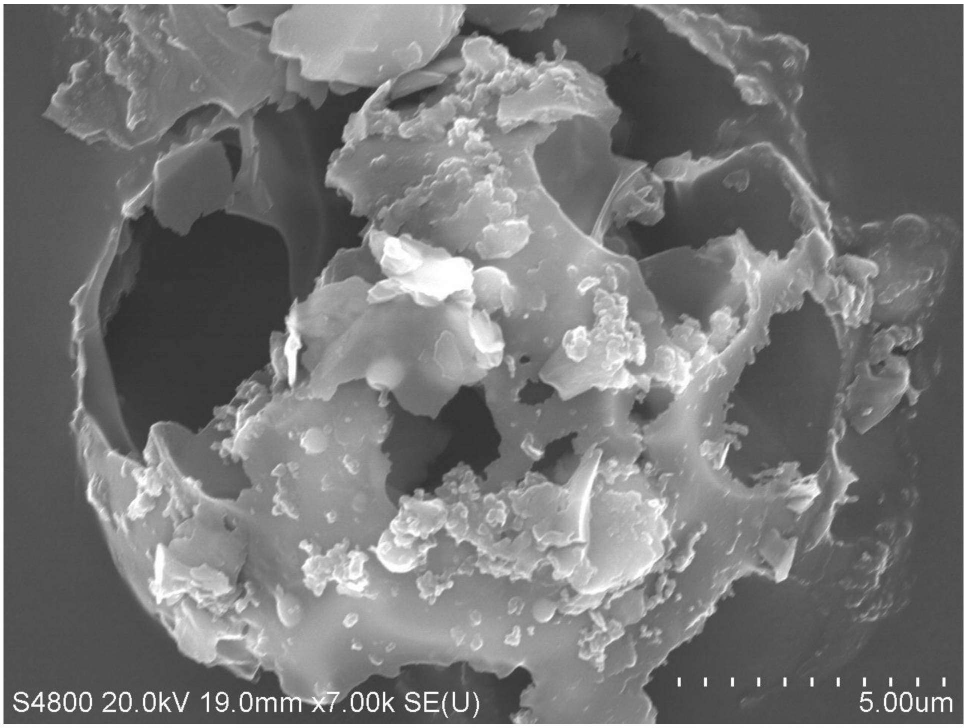
image was then collected in the JPEG format at a 1280x960 pixel resolution, labeled with the sample number, and stored in an electronic image file folder. The instrument superimposes on the image data related to the beam voltage (20kV), focal distance (approximately19 mm), magnification, and a graduated scale. The image label used was 899___HF_ to designate the sample number, the instrument (Hitachi), and the fact that the specimen contained floating solids (F). In addition, the suffixes a-e were used to designate the different imaged particles from a sample (the 1st image had no suffix).

Discussion

More difficulty was encountered in locating particles showing evidence of heating in this set of samples compared with the earlier, larger set. Evidence for coal particle heating that was sought included the plasticization of the particle (or areas of the particle) leading to rounding, and the swelling or bursting of rounded areas due to pressure from the volatiles produced by thermal coal decomposition. More extensive particle heating can produce a nearly hollow spherical particle or fragment of such a particle, or it can produce a skeletal particle or fragment containing broken, devolatilized cells. Such particles were found in all the current samples studied but represented only a small fraction of the particles in the view fields examined. In addition, a greater degree of heating will produce hollow, smooth, ash-rich spheres (cenospheres) akin to those produced in coal-fired power plants (fly ash). Such cenospheres, however, were only indicated by a close examination of several of the images collected (Figure 1a,b). The images were primarily of rounded or spherical particles with uneven surfaces (Figure 2a,b), the shells of such particle residues with holes (Figure 1a,b), and skeletal fragments of cellular structures (Figure 3a,b). All the images obtained are included in a CD image file.[2]

[2] This CD is not included in this WVOMHS&T report appendix.

Figure 1a (899238HF); 1b (899235HFc). Examples of particle residues consisting of spherical and near spherical thin hollow shells with large holes are shown. One or several 1µm spheres that appear to be cenospheres are visible.



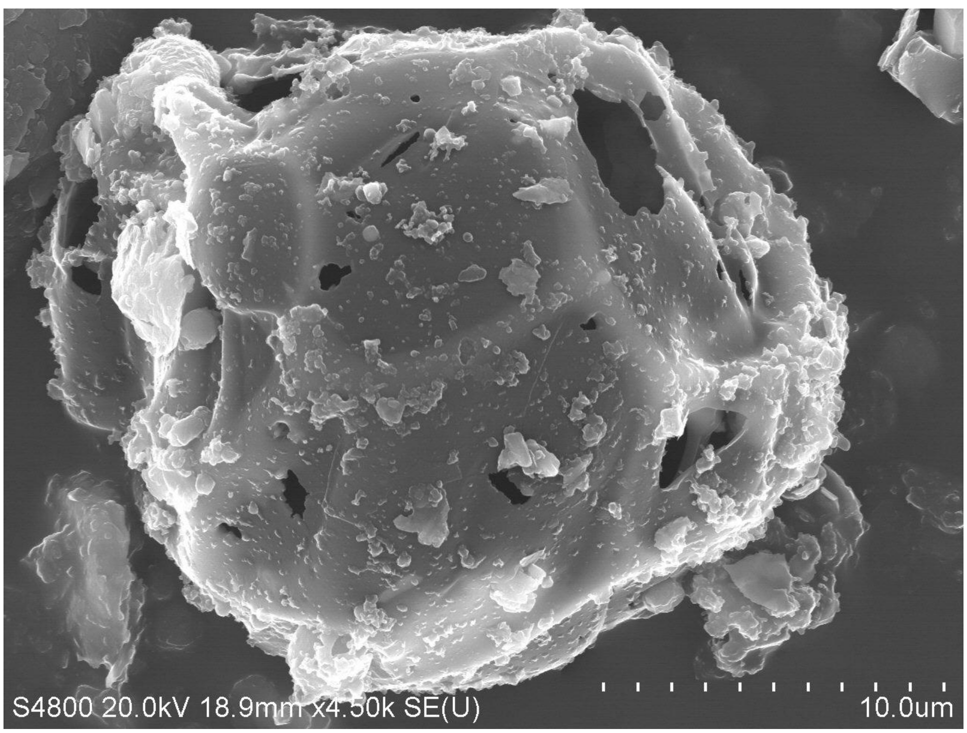
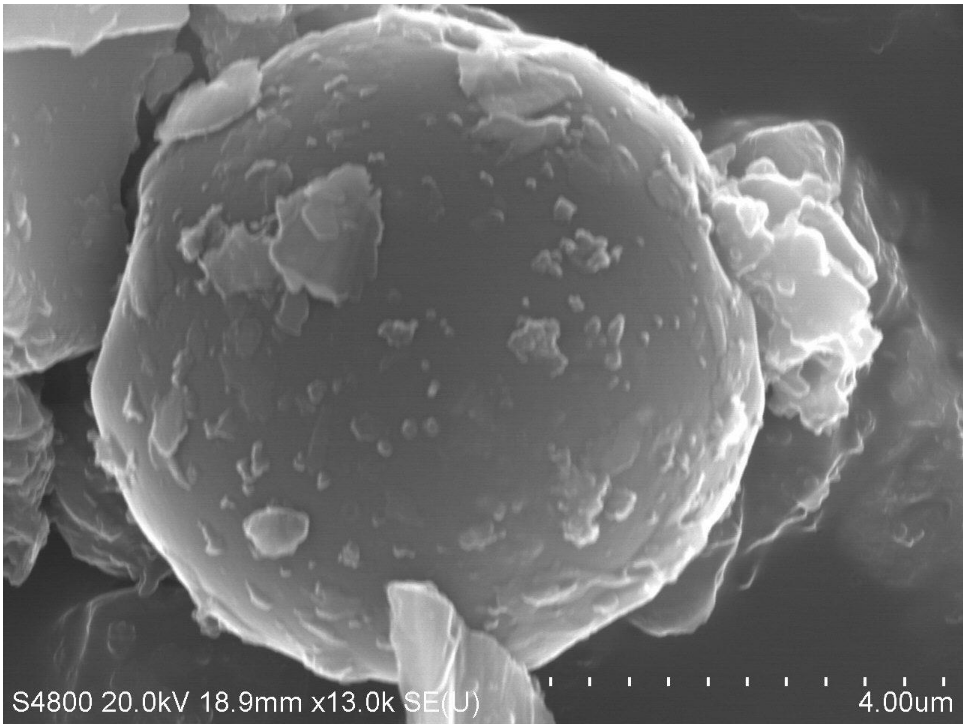


Figure 2a (899235HFe); 2b(899740HFc). Round particles.



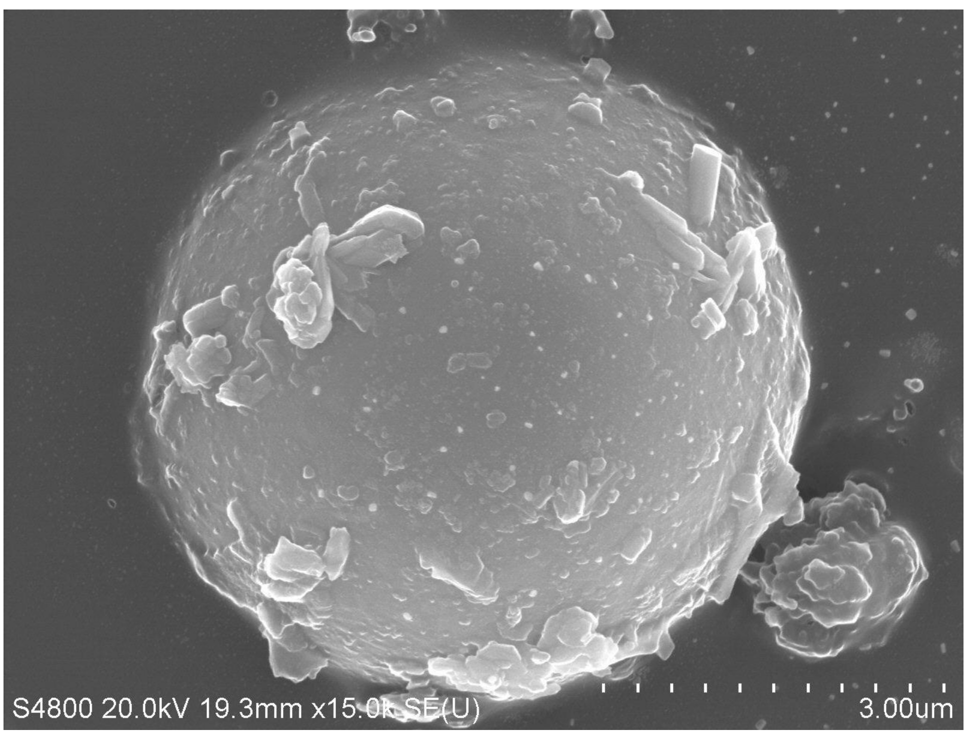


Figure 3a (899235HF); 3b (899235HFa). Cellular particle fragments.