

MITIGATING THE PERCY MINE FIRE¹

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Abstract. Mining has occurred in the Uniontown Syncline (coal basin) in Fayette County, Pennsylvania for over one hundred years. The thirty-year old Percy Mine Fire, a legacy of past mining, underlies approximately fifty acres on the eastern flank of the Uniontown Syncline.

To establish how to extinguish the fire, it was necessary to understand the geology and the fire's potential, if left unabated. The Pittsburgh Coal was extensively mined in the basin with interconnecting mine workings extending from Uniontown on the south to Connellsville on the north. Three mine pools, flooding most of the underground workings, are defined within this basin. The coal in the center of the basin can not burn in its current submerged condition. Along the rim or outcrop zone, the mine workings rise out of the mine pool and extend to the outcrop where they become susceptible to burning. This zone encompasses a perimeter of outcropping coal encircling the syncline. The Percy Mine Fire, lies within this perimeter. It has been a threat to the health, safety and welfare of those living near and over the fire and effectively lowers property values of those living in the vicinity of the fire.

This paper reports on the history of mitigation actions and future planning to extinguish the Percy Mine Fire using Low Permeability Cementitious Material[®] (LPC_{TM}), a coal combustion product (CCP), in a joint effort headed by Bureau of Abandoned Mine Reclamation (BAMR), Reliant Energy, GAI Consultants, Inc., and Howard Concrete Pumping, Inc.

Additional Key Words: mine fire, low permeability cementitious material, coal combustion product, Percy Mine Fire.

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Introduction

Mine fires occur on abandoned mine lands throughout the coal fields in the United States. They threaten the health and safety of the local populations destroy property values and consume a non-renewable resource. In general, mine fires are the most costly abandoned mine lands problem to mitigate. In active mines, fires are often quickly extinguished by the mining company as they present a direct threat to their economic resource. In abandoned mines, however, fires started by natural or other means are likely unnoticed for many years, or are ignored or otherwise unattended until they become a threat to nearby residents. Such fires often become a government responsibility (Michalski, 1990). The impact of the coal mine fire was best described by Magnuson in the 1970's as having:

“. . . a destructive and demoralizing effect upon a community. They are a hazard to the health and safety of people in the vicinity and pose a threat of fire and subsidence damage to property. They are a source of widespread pollution to the atmosphere, in addition, the fires consume coal reserves and menace forest and grazing lands.” (Magnuson, M. O., 1974)

Effective remedial measures may be a combination of mitigation technologies that depend on whether the goal is to extinguish or limit the spread of an underground mine fire. Such technologies include total excavation, trenching, flooding and quenching, bulk filling mine workings, surface seals, inert gas injection, chemical foams, etc. (Michalski, 1990). If fire control or extinguishment methods are not implemented, then the alternative is to abandon the surface and let the fire spread to its natural limits.

Case histories of mine fire projects in Pennsylvania's bituminous coal fields demonstrate successful extinguishment by utilizing one or a combination of mitigation technologies. This paper presents an explanation as to why there is a fire in the Percy-Youngstown area and proposes a mitigation plan to extinguish the Percy Mine Fire.

Background

The village of Percy is located in Union Township, Fayette County, Pennsylvania. South of the village of Percy, about one quarter mile away, lies the village of Youngstown. The Percy Mine Fire occupies the land between the villages and is currently encroaching on both villages (Fig. 1).

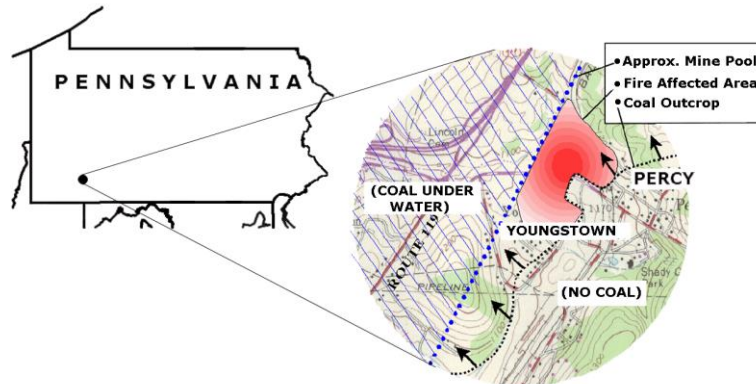


Figure 1. Location of the Percy Mine Fire.

Geology and Mining History

The Percy Mine Fire lies on the eastern flank of the Uniontown Syncline. The Uniontown Syncline, a significant geologic structure or basin, is a down-warping of the rock strata in this portion of the Appalachian Plateau. The Pittsburgh Coal, the lowermost member of the Monongahela Group, separates this group from the underlying Allegheny Group. Many more coal seams occupy the deeper layers in the Allegheny Group. The Monongahela Group, being the topmost member, is exposed at the ground surface and underlies the central portion of the basin. The Pittsburgh Coal rises from a low point in the center of the basin to outcrop along the perimeter of the syncline (Fig. 2). The basin within the Pittsburgh coal outcrop is approximately twenty miles long and five miles wide with an approximate circumference of more than fifty miles (Bureau of Topographic and Geologic Survey, 1985).

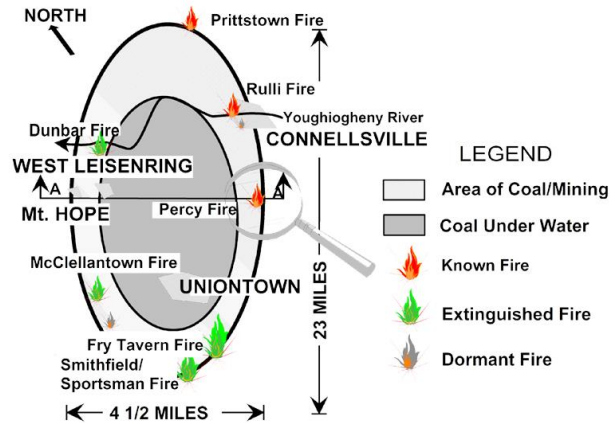


Figure 2. Uniontown Syncline – coal basin – mine fires.

Since the beginning in the 19th Century, the Pittsburgh Coal has been nearly 100 percent mined by room and pillar methods. As mining was conducted mostly below the groundwater table, pumping water from the mines was a common and necessary practice. Subsequent abandonment has resulted in groundwater returning to these workings, leaving a large portion of the Pittsburgh Coal Seam under water. Three discrete mine pools have been identified within the basin. These are the Southern, Central and Northern pools. The Percy Mine Fire is situated on the eastern flank of the Central pool. The interval between the outcrop and the mine pool is where the mine fires can occur along the entire perimeter of the Uniontown Syncline (Fig. 3).

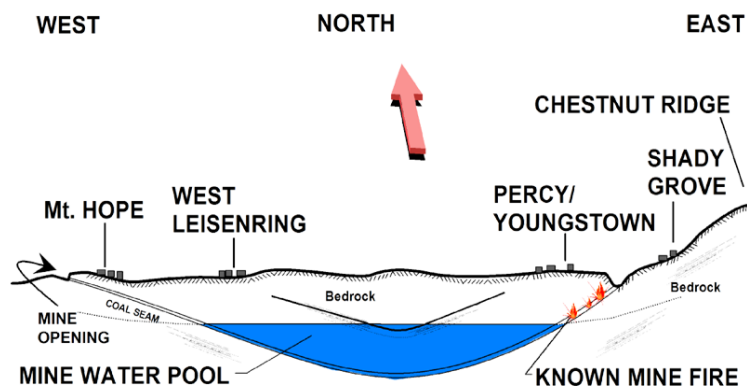


Figure 3. East-West cross section through the Uniontown Syncline.

The mine workings beneath Youngstown and much of Percy are contained within the Youngstown Mine. Adjacent mines include the Mt. Braddock Mine to the north and the Lemont Mine to the south. Connections above mine pool have been established between the Mt. Braddock Mine and the Youngstown Mine. Presumably, similar dry connections are likely between the Youngstown and Lemont Mines. Analysis of the mine maps for the entire basin will likely show the all adjacent mines will have connections above mine pool in that zone between the mine pool and the outcrop. Therefore, a fire occurring in any of the mines bounded by the outcrop has the potential of moving into the adjacent mine if left unabated. The Percy Mine Fire, to the best available knowledge, is wholly contained in the Youngstown Mine at the present time.

Room and pillar mining of the Pittsburgh Coal has removed approximately 50 to 60 percent of the seam, leaving a honeycomb of void space, support pillars and collapsed workings. Those portions of the mine between the mine pool and the outcrop are susceptible to ignition either through natural spontaneous combustion processes (Lewicki, 1987), accident or through design.

Historical Mitigation Efforts

The Pennsylvania Department of Environmental Resources (PADER) was first notified of an underground fire threatening the B&O Railroad near the village of Percy on July 25, 1974. It is believed the coal exposed in the outcrop was ignited as a result of burning trash on or near the outcrop. Since the initial response, several projects were undertaken by both the United States Office of Surface Mining, Reclamation and Enforcement (OSMRE) and the BAMR to abate the ensuing problems. These projects consisted mostly of fly ash injection around individual homes and did not attack the fire as a whole.

In the early 1980's, the OSMRE excavated a large cut-off trench adjacent to Youngstown and just south of Percy (Fig. 4). The excavation measured approximately 450 by 500 feet and contained approximately 200,000 cubic yards. The trench began at the coal outcrop and was extended westward down the slope of the coal towards the mine pool. The purpose was to remove the fuel leg of the fire triangle (Fig. 5), thus preventing the fire from crossing LR 26101 and moving into the mine workings beneath Youngstown. The effort did not attempt to extinguish the fire, but to simply restrain its movement. The

excavation functioned as a barrier for over ten years, but, unfortunately, was not extended to remove all the coal between the mine pool (downdip) and the outcrop (updip) resulting in eventual failure.

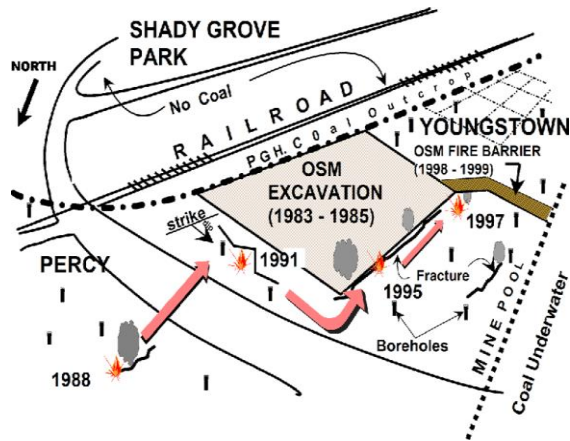


Figure 4. Historical perspective of the Percy Mine Fire.

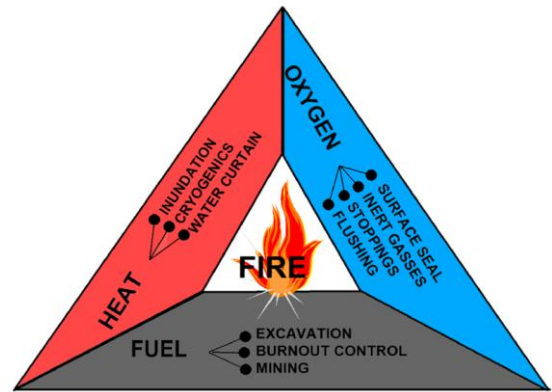


Figure 5. Fire triangle.

Upon completion of the OSMRE excavation, the BAMR began monitoring the fire in 1985, the year in which the first isotherm was drawn. From 1985 to 1991, the fire remained in the center field. There was no surface evidence of burning or venting. Temperatures fluctuated but the center of heat remained stagnate. In May of 1991, a linear fissure developed along the south side of Legislature Route 26101. This fissure was oriented parallel to the OSMRE excavation and was interpreted as a desiccation fracture caused by heat from the fire drying the fill material placed in the OSMRE trench. In the mid 1990's, the fire began moving toward Youngstown, crossing Legislature Route 26101 in 1991. The fire paralleled the road until it reached the downdip end of the excavation. From there, it turned south and began to occupy the workings between the mine pool and the west end of the excavation. By October 1991, fumaroles developed and surface venting was seen for the first time since the excavation. An overall increase in the temperature of the fire was recorded. The fire then continued south, moving along the downdip edge of the original excavation (Fig. 4).

For the first time, the fire was moving and in the direction of the village of Youngstown. The fire seemed to be following the excavation boundaries and moving at an accelerated rate. Surface seals were placed over the fissures in an attempt to slow the fires advancement.

In 1997 the OSMRE and the BAMR, in a cooperative agreement, developed a project to attempt to stop the fire's advance toward the village of Youngstown. The project entailed drilling injection

holes and pumping a fly ash cement grout through a tremie pipe for the purpose of filling mine voids. The holes were laid out in a linear pattern between the zone of active burning and the village of Youngstown. This subsurface barrier was keyed into the OSMRE excavation, on the south, and extended toward and eventually tied into the mine pool (to the east). Once this primary barrier was in place, a secondary barrier was placed between Youngstown and the area of burning (Fig. 4). The barriers were not intended to extinguish the fire, only to retard its movement in the direction of Youngstown. These barriers are in place; however, their effectiveness will require long term observation. In the mean time, the fire continues to burn.

Monitoring

During the OSMRE barrier placement project, it was apparent that precise data on the elevation of the mine pool was required to ensure the fire could not go around the barrier. A core-drilling contract was executed by the Commonwealth to find the precise location of the mine pool and the lithology of the roof rock overlying the Pittsburgh Coal. The mine pool was encountered at approximately elevation 970 msl, which required that the OSMRE grout barriers be extended approximately 200 feet to the west toward the center of the basin. Core borings through solid coal showed the main seam to average eight feet in thickness with the roof coals or riders an additional four feet in thickness. These findings indicated that barriers (excavated or constructed) must extend into the mine pool to where at least fifteen feet of water would permanently remain above the floor of the mine.

The various emergency projects conducted to date have all produced data, which laid the groundwork for a design to attempt total extinguishment.

Saturation Grouting from Outcrop to Mine Pool

This plan is the first attempt to extinguish the underground mine fire. Projects to date have been emergency response actions designed to deal with an immediate problem. Time, was generally unavailable for a thorough investigation, design and implementation of a fire extinguishment program. The various control projects conducted to date, however, have provided sufficient background data and have slowed the progress of the fire sufficiently to plan an extinguishment project.

This project is a cooperative agreement with the BAMR, Reliant Energy, Howard Concrete Pumping and GAI Consultants, Inc. The strength and experience of these organizations is being marshaled to plan a project that will provide the best option, at reasonable cost for extinguishing the Percy Mine Fire. It is hoped that this project will be implemented in 2004-2005. The goal of the project is to remove one leg of the fire triangle (Fig. 5). The success for extinguishment is dependent on the elimination of void space by sealing the conduits whereby air enters the mine to ventilate the fire. The filling of these void spaces will be accomplished by pumping a fluid, custom designed proprietary grout mix into the mine voids.

The project will use Low Permeability Cementitious Material[®] (LPC_{TM}). LPC_{TM} is a coal combustion product made at Reliant Energy's Elrama Power Station. LPC_{TM} is widely used throughout western Pennsylvania as a low cost structural fill material. The LPC_{TM} will be trucked in a moist state to the site where it will be mixed with water and Portland cement to form a pumpable slurry which will be injected into the mine workings through a tremie tube. The material has a construction shelf-life of two to three days before pozzolanic reaction begins to harden the material. The material will achieve a 60-day unconfined compressive strength of 200 to 300 pounds per square inch (psi) and will continue to increase in strength (600 to 1,000 psi) over longer periods of time. The material does not shrink as it cures and will provide an effective seal against the roof of the abandoned mine.

The benefits of LPC_{TM} Material are: (Bickerton, et al., 1999)

- Transports in a moist state
- Extinguishes fire
- Mitigates mine subsidence
- Self-hardening/dimensionally stable
- Non-erodable
- Inert
- Minimum surface disturbance
- Low permeability (blocks air flow)
- Speedy implementation
- Flowable (penetrates fissures)
- Pumpable
- Economical

The north and south rows of barrier boreholes will be injected first with a low slump LPC_{TM}. A similar row of barrier holes will be placed along the mine pool side to the west. The intent of this row is to contain the LPC_{TM} within the area to be treated for extinguishment. This procedure involves boxing in the fire on the north and south extent through the dry workings from the outcrop

to the mine pool where the roof coals are permanently submersed. Once the fire has been contained, the approximately fifty acres within these barriers will be drilled and flushed with LPC_{TM} in a way that will significantly fill the existing voids both in the mine workings and in the overburden (Fig. 6).

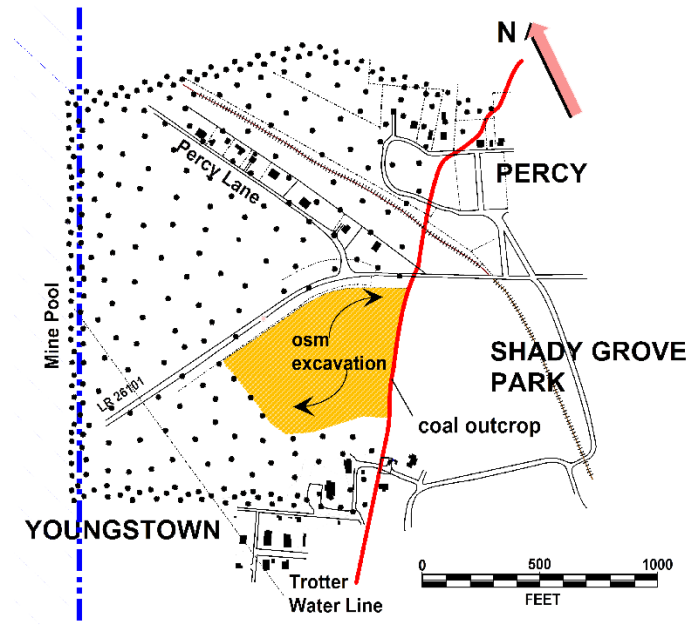


Figure 6. Proposed extinguishment plan.

Injection hole spacing will be tightened if 100 percent saturation of the mine workings is not achieved by using one hundred-foot center grid spacing. Drilling assurance/monitoring borings after an area is completed will determine the effectiveness of the LPC_{TM} as a bulk fill. A monitoring program, which will monitor subsurface temperatures and mine pool elevations, will continue for one year or more following completion of the project.

Successful completion of this project will result in the extinguishment of the Percy Mine Fire and will minimize or eliminate the potential for future subsidence in the area treated. This action will remove the constant threat to the health, safety and welfare of the residents and restore the property values of those living above and within the vicinity of the fire.

If total extinguishment of the Percy Mine Fire is achieved by this method, future fires occurring along the perimeter of the Uniontown Syncline, or within other similar geologic structures, can be

abated rapidly and in one design phase. This will eliminate the years of monitoring and small emergency action projects that do not attempt total extinguishment.

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