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Migration of Blasting Fumes Into a Western Pennsylvania Home

Background

Carbon monoxide (CO) is an odorless, colorless gas that can cause illness and death by asphyxiation. Although the toxicity of CO is understood, CO exposure can occur from unrecognized sources. On April 2, 2000, a couple and their newborn infant were poisoned by CO migrating through the ground from blasting at a nearby coal strip mine into their home near Kittanning, Armstrong County, PA. They were treated at the hospital and diagnosed with CO poisoning. The infant had a carboxyhemoglobin level of 31%, the father 28%, and the mother 17%. Carboxyhemoglobin is the compound formed in the blood when CO is breathed. Persons not exposed to CO have carboxyhemoglobin levels of 0.3%-0.7%, and cigarette smokers have levels of up to 9%. Following release from the hospital, the family installed a CO detector in the basement of their home with the help of the local fire department. This *Technology News* briefly describes this incident to help increase awareness of the problem. It is discussed in more detail by Eltschlager et al. [2001].

Figure 1 shows the coal strip mine believed to have generated the CO. The initial suspect for the source of the CO was the furnace in the house. Only later did it become apparent that blasting at the nearby strip mine might be the culprit. A State investigation concluded that CO had migrated approximately 500 ft from the blast, through the ground, and into the home.

Figure 2 shows the locations and order of blasts at the mine. Initially, the mine did not plan to blast. Overburden generally consisted of weathered shale that could be dug without blasting. However, the mine decided to blast when hard sandstone that could not be dug out was encountered within 3 ft of the coal top. The blasting was intended to break up the sandstone. Blasting was done using bulk ammonium nitrate-fuel oil (ANFO) in 6.25-in holes 25-30 ft deep on a 16-ft by 16-ft pattern, with charge weights ranging from 17 to 170 lb. The closest blast to the home was 430 ft on April 17, 2000. The distance from the home to the blast area on the day when CO was first reported (March 31, 2000) was 500 ft. Twenty blasts were detonated at the mine between March 7, 2000, and April 20, 2000. The blaster was careful to prevent flyrock since another home was only 150 ft away and a garage was 50 ft away. The quantity of explosive used in the blasts was sufficient to break the sandstone, but was less than would normally be used to blast overburden. The holes were typically one-third explosive and two-thirds stemming, with powder factors averaging 0.43 lb/yd^3. Additionally, the muck was not immediately excavated after each blast. The heavy confinement on the explosive acted to prevent the typical release of blasting fumes into the atmosphere.

Instances of CO migrating from blasts into homes have occurred before, but generally the distances involved were under 150 ft. It is believed that the blast design contributed to the confinement of CO in the ground, and discontinuities in the ground strata facilitated migration toward the residence. Upon inspection of the blast pit wall, a regular system of joints was observed. These joints are oriented roughly from the blast pit toward the house (figures 3-4). Blast-generated CO appears to have been driven into the joint system, displacing the air. When the joint system was saturated, the next succeeding blast pushed the CO into an uncased well next to the house (a high level of CO has been measured in the well shortly after a blast). From there, the CO entered the French drain system and then the basement of the house.

The joints are vertical cracks through rock layers that occur on a regular spacing (figure 3). They are most common near valley slopes and are caused when valley walls converge as the stream cuts down through the rock layers. Often called hillseams, they roughly parallel the valley walls, but can curve and split, creating a pathway for gas movement (figure 5). These fractures are often encountered when underground mining proceeds close to outcrop. The system of fractures at the Kittanning blast pit was well developed and provided a path for transmission of CO both through the sandstone and up and through the overlying shales. Blasting engineers should be able to distinguish naturally occurring fractures from blast fractures and note the frequency, development, and orientation of the hillseams and their proximity to occupied houses. The limits of transmission of

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blast-generated CO through naturally occurring fractures are not known, so blast engineers should proceed with caution near residential areas.

Recommendations

(1) When blasts are heavily confined, blasters should examine the blast site for any indicators that would identify the presence of underground pathways for CO migration.

(2) The blast should be excavated as soon as practical following detonation.

(3) Blasters should be aware that CO can travel through the ground to basements of homes or other confined spaces and take adequate precautions. Placing CO monitors and alarms in homes where this potential exists would be prudent.

For More Information

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References

Eltschlager KE, Shuss W, Kovalchuk TE [2001]. Carbon monoxide poisoning at a surface coal mine: a case study. In: Proceedings of the 27th Annual Conference on Explosives and Blasting Technique. Vol. II. Cleveland, OH: International Society of Explosives Engineers, pp. 121-132.

Figure 1.—Blasting in this coal strip mine generated CO that is believed to have poisoned nearby residents.

Figure 2.— Map showing blasting at the strip mine and the location of nearby residents. The house labeled "Residence #1" is where the family suffered CO poisoning.

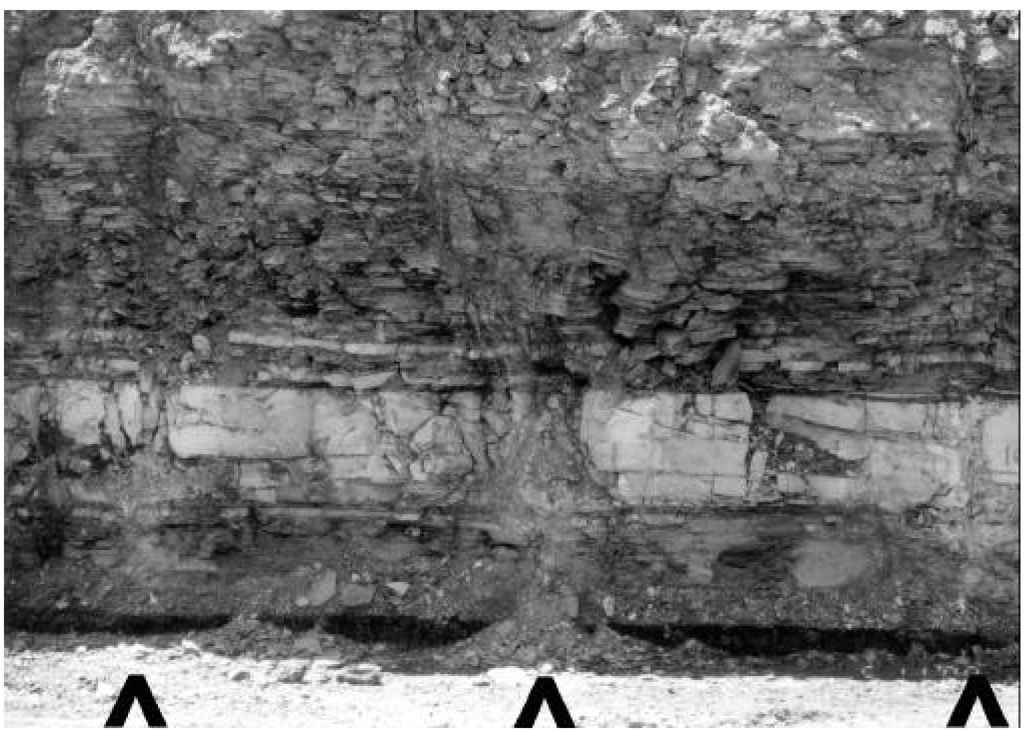

Figure 3.— Fractures (hillseams) in the pit wall marked with arrows. The fractures are oriented toward the house.

Figure 4.— A hillseam is a zone of fractures that cuts the sandstone.

Figure 5.— This photo from another site shows a hillseam discontinuity.