Leadership Characteristics in Escape from Three Underground Mine Fires

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ABSTRACT

The characteristics of leaders under the duress of an emergency are important in the development of emergency planning, training, and in the management of an actual emergency. Knowledge of human behavior is an important component in the formation of emergency strategies. The U.S. Bureau of Mines analyzed the leadership behavior in three underground mine fire escapes. The subjects described their escapes during open-ended interviews. Data were coded according to: (1) evidence of leadership behavior, (2) evidence of lack of leadership behavior, and (3) characteristics of the individual in each group who led the subjects out of the mines. This paper discusses the profile of six individual leadership characteristics which emerged from the data.

INTRODUCTION

This research explores leadership behavior in a life-threatening emergency situation, a fire in an underground coal mine. Underground coal mines are extremely dangerous environments as there is constant threat of accidents due to massive machinery operating in close, dark areas, the numerous electrical and water hazards, unsafe "top" which can result in roof falls, and the threat of fire and explosions. Since 1949, there have been at least 18 major explosions and more than 1,000 fires in underground coal mines in the United States (McDonald & Baker, 1979; Richmond, et al. 1983).

While mine fires and explosions are not uncommon in the industry, they are infrequent events from the perspective of individual miners. Little is known about behavior in these circumstances. The opportunity to learn more about this topic came in March 1988 when a major fire occurred in an underground coal mine in the eastern United States. The fire forced the evacuation of miners who were working in areas of the mine that were located beyond the site of the fire. Twenty-seven miners had to travel through smoke-filled passages in order to escape and reach fresh air. Fortunately, no lives were lost. Researchers interviewed 21 of the 27 miners who escaped this fire to learn more about their experiences.

Since this 1988 fire, researchers have had the opportunity to study two other fires in which miners were forced to escape through hostile environments. To date, 48 miners have been interviewed about their escape experiences. The information, contained in more than 2000 pages of transcribed testimony, has been analyzed along several different subject lines. The focus of this paper is leadership behavior during the escapes.

This investigation examines leadership behavior in crisis. It looks at the authority structure before the fires, leadership behaviors and lack of leadership behaviors during the escapes, and the behaviors associated with the emergence of leadership. According to Bardo, (1978, p.78) "emergent behaviors are those forms of action, and the norms, values and beliefs governing those actions, that rise out of the disaster situation." This paper examines the emergent behaviors of leaders under duress.

PREVIOUS STUDIES

Previous research on leadership in crisis is limited and focuses mainly on simulations and escapes from structure fires. Much of the recent research on leadership behavior in crisis is from Japan. Hayashi (1988) emphasized the importance of studying leadership behavior patterns as opposed to concentrating on circumstances. Studies have shown that leaders can have a calming influence and be instrumental in helping others avoid panic (Misumi & Sako, 1982). The research also shows that information and knowledge can be significant to survival (Abe, 1976).

Panic is not automatic in crisis and in fact individuals have the tendency to follow the prevailing social order (Hodgkinson, 1990; Johnston & Johnston, 1988). People tend to

follow the route of others and/or familiar paths (Hodgkinson). In addition, attachment and affiliation during escape may have survival value (Sime, 1983; Bowlby, 1973 in Sime) and cooperation contributes to successful escape (Kelley, et al., 1965 in Sugiman & Misumi, 1988).

Little data has been collected in the area of leadership in actual life-threatening situations. It is important to note that the only perspective on an emergency event and subsequent behavior is from the view of the survivors and from circumstantial data evaluated after the event. Rescuers may provide some "after the fact information" but in all cases survivors and rescuers have been under physical and emotional stress which may influence their reports of the incident.

METHOD OF STUDY

After learning of each of three mine fires, referred to as Mines A, B, and C in the study, researchers at the Bureau of Mines contacted officials from the affected companies and the United Mine Workers of America, the labor union which represented the employees. Cooperation with the Bureau in an on-going study of miners' responses to underground mine fires was requested. Across the three subject mines, eight separate groups of miners escaped through smoke. Forty-eight individual interviews were conducted with subject volunteers from each of these groups. Data tapes were transcribed verbatim and entered into computer files for ease of text-based analyses.

Table 1 shows the number of miners in each escape group and the number interviewed. Data from forty-five interviews were included in the analysis. Average age and years experience for each group are shown in Table 2. The average age of the miners interviewed was 41.7 years. They had a mean of 16.8 years of mining experience with an average 15 years at the mine where they were working at the time of the fire.

All subjects escaped under extremely difficult environmental conditions. Mine entries were dark with the miners' cap lamps as the only light source. In most instances, the subjects were confronted with heavy smoke reducing visibility to less than four feet. They literally "ran into each other." The dense smoke made it difficult to see tripping hazards and overhead obstacles.

Table 1: Number of Miners in Each Escape Group and Number In Sample

Group	Mine	Population N (Total = 64)	Sample N (Total =48)
1	A	10	8
2	A	8	6
3	A	10	7
N/A	A	N/A	1
4	B	16	7
5	B		7
6	B	3	1
N/A	B	N/A	1
7	C	8	5
8	C	9	5

Table 2: Average Ages and Years Experience of Miners Who Were Part of Escape Groups (N=46)

Group	Mine	Average Age (N=42)	Average Years (Total =16.8)	Average Years This Mine (Total=15.2)
1	A	41.8	17.1	17.1
2	A	39.3	14.3	14.0
3	A	39.7	17.6	15.0
4	B	41.7	17.2	16.7
5	B	40.3	17.6	14.4
6	B	56.*	25.*	15.*
7	C	38.8	13.9	13.9
8	C	40.0	14.7	13.9
Total		41.8	16.8	15.2

* Only one person was interviewed from this group.

While emergency breathing apparatus, Self-Contained Self-Rescuers (SCSRs), provided miners with a source of life-sustaining oxygen, breathing through the devices is unlike normal breathing and created problems during the escapes. See Figure 1 for an example of miners donning their rescuers. Several of the miners had difficulty with the SCSRs and this impacted group dynamics and the leaders' decisions. The apparatus, because of the design, produces restricted airflow. When miners "out breathe" the devices, they tend to feel as if they can't get enough air, creating added tension and even panic. Under the emotional and physical distress of escape, these problems compound in an already dangerous environment.

THE STUDY

The Escapes

Across the three mines, eight escape groups were identified and studied. This paper presents an example from Mine C. The general layout of the mine workings of Mine C is shown in Figure 2. The distances traveled by each group during the escapes was substantial, ranging from as little as 1.0 km to, in one case, nearly 4 km. This distance, substantial under normal walking conditions, was complicated under the mining conditions of limited visibility and irregular bottom, which made for poor footing and walking hazards. Each group was

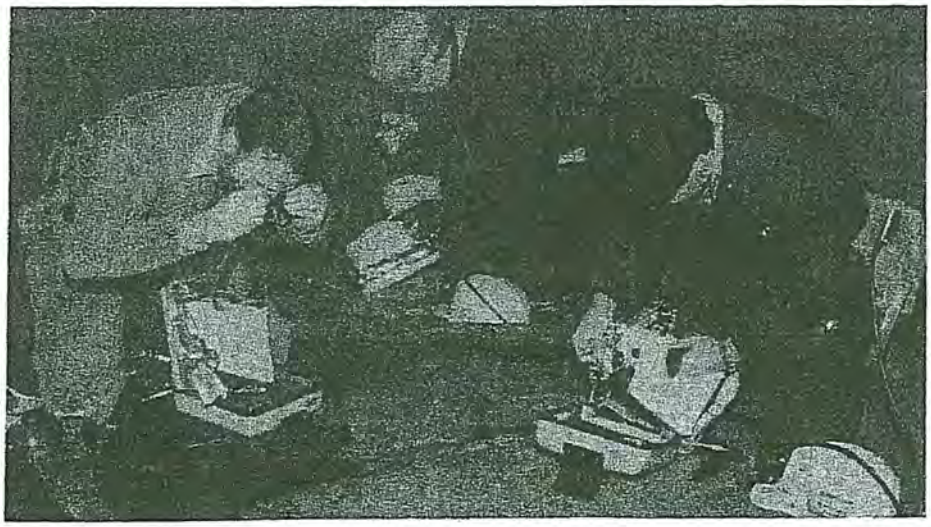

Figure 1: Miner's Donning SCSR's

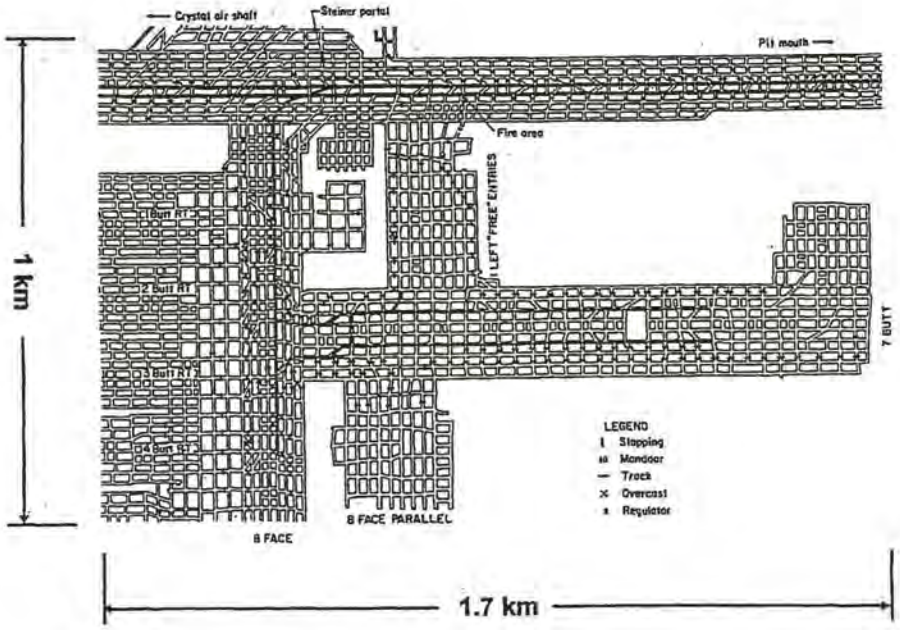

Figure 2: Mine C

unique in their escape. In several groups, a strong leader emerged and led the escape while in some groups, the decision making was conflicted. One group, Group 8 from Mine C, had an ineffective leader and subsequently escaped in chaos and panic. A discussion of this group's experience follows.

Group 8 was not a regular working group as none of the members were involved in coal production. Instead, most typically performed maintenance and support tasks throughout the mine. On the day the fire occurred at Mine C, miners in this group were doing construction and moving supplies. In addition, there happened to be two locomotive operators driving through the section when notified of the fire. Miners in Group 8 gathered at the beginning of the primary escapeway and proceeded to travel the escapeway on foot about .5 km before being confronted with heavy smoke. Upon encountering the smoke, the crew turned around and followed the primary escapeway back to the working section. After returning to the section, the group then walked to the section's left return air course. The group followed the left return air course for about .4 km before realizing that they were not in a designated

escapeway. The group turned around and followed this air course back to the section. At this point, the group crossed the section and made their way into the right return airway (the designated alternate escapeway) and followed it for .2 km before turning left. After turning left, the group continued on foot through the alternate escapeway for about .4 km before turning right. After turning right, the group continued on foot for another .5 km before turning left into the main alternate escapeway. After turning into the main alternate escapeway, the crew continued for about 1.6 km before reaching clear air. One member of this group estimated they spent some 20 minutes traveling through the mine before reaching the alternate escapeway.

Group 8 was effectively out of control most of the time during their escape. The foreman, who was the authority figure, was not in control and there was considerable notation of blame and emotion evidenced in the interviews of this group. The manner in which the group donned their SCSR's was indicative of the lack of leadership. When asked who decided it was time to put them on, one miner responded, "Well, I think everybody decided together but, you know, I already had mine on." Another miner said he kept asking, should we put these on and the foreman never answered.

In short, the foreman was incompetent as a leader. As one miner described, "...the guys were more or less talking amongst themselves and I said, you know, this is real serious and this boss, if we're not careful, he's going to get us killed." A miner, who was not familiar with the section and became concerned, noted, "I can understand how people could be excited and you know, improper decisions could be made. But, you know, it kept snowballing. You know, his (the foreman's) improper decisions that he was making, you know. I was getting more

and more negative about following this man as we went." But the fear level was starting to rise... "There was a lot of confusion...the (foreman) couldn't figure out how to get into the intake escapeway... alot of the guys started getting kind of real, losing alot of confidence in him."

In the course of this group's escape, a leader did emerge. This miner, a General Inside Laborer (GIL) was knowledgeable and discerning, his leadership evolved, and he was responsive to others in the group. He began functioning as an advisor to the foreman and was

one of the first miners to recognize the gravity of the situation. This miner recognized that the men were getting upset and as he explained,

> I am a personal friend of (The foreman) and .. the situation, I wanted to talk to (him) but I did not want other people to hear what I wanted to tell him because people were getting upset right off the get go...I was thinkin' of people I can count on .. I guess you would say that it was kind of a feeling of if you were in an airplane and you had to count on someone to hold that parachute for you could you count on that person.

This leader was continually evaluating the situation and was conscious of the behavior of other members and careful in how he presented his advice to them. When some members of the group left their lunch buckets behind, the leader was concerned: "How can I say it, being a foreman for eight years its hard not to say things sometime...I could see things going on that was wrong, especially the discarding (of the buckets). So I would say, "I sure wouldn't throw that away. I wouldn't say don't throw that away you don't know how long we're going to be here or what's going to happen."

The statement above characterized this miner. He presented himself as the foreman's helper during his interview, whereas the other members of the group clearly indicated their foreman was inept and that the GIL led them out. He placed himself in a peer relationship with the group and a peer relationship with the foreman. The interview with the foreman quoted the GIL often and was resplendent with "I should have." At one point he stated, "I plain, freely admit, I screwed up. I should....

Observations

A profile of leadership in crisis emerged from the analysis of the eight escapes. The data suggests several characteristics based on the behavior of the leaders. The leader of each escape may be described as an **aware, knowledgeable** person or as an individual who is alert to his environment, attentive, and discerning. This person notices things - more so than do other people. This astute quality is probably not limited to the mine environment or to crisis circumstances. This individual is naturally curious all the time and is the type of individual who excels at incidental learning. Each of the leaders retained information that was

instrumental to the escapes. They "remembered" specific details and repeatedly referred to the fact that they "knew" through information or deduction.

A second, generally shared characteristic of the leaders was the manner in which they took charge. In the groups where the authority led the subjects out of the mine, the leadership was a natural evolution of the group dynamics. It was a continuation of the social order before the disaster. Yet, the same dynamic occurred in the groups where there was a definite emerging leader. These leaders did not force themselves and their suggestions on the group - the leadership **developed in a natural way**.

Third, the leaders were **decisive, yet flexible**. They made decisions; yet if circumstances changed they adapted.

Fourth, the leaders were **open to input** from others. There is evidence that in most of the escape groups there was a "second lieutenant," an individual who offered worthwhile suggestions, support, and served as a "sounding board." In instances where there was emergent leadership, many times the leader began in a consulting function to the authority.

Fifth, effective leaders seemed to have a **calming** effect on their group. They were aware of others' levels of fear and offered reassurance when it was needed. Miners in each group had **confidence** in the leader's ability to direct them to safety.

Finally, there was a **logic** to the leadership. Decisions were appropriate and congruent with the available information.

RECOMMENDATIONS FOR FUTURE RESEARCH

There are several areas for further inquiry. Are characteristics identified in the profile presented in this study *required* for an individual to fulfill the role of leader during a crisis situation? What if an individual has some, but not all of the noted characteristics? There were individuals identified during this study who evidenced some, but not all, of the profile characteristics. Further analyses are needed to determine the fit of these individuals in the group dynamics and their contributions to the successful escapes.

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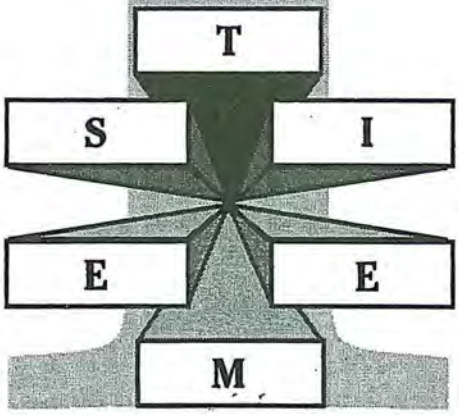

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