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Looking ahead to significant improvements in mining safety and health through innovative research and effective diffusion into the industry

Jeffery L. Kohler *

The Pennsylvania State University, PA 16802, USA

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ABSTRACT

Mining safety and health improvements over the past decades are remarkable by many metrics, and yet the expectation of society, and the goal of the mining industry, is zero harm. If we examine the underlying enablers for the significant gains that have been achieved, the key role that research to help understand the causes of problems and to develop lasting solutions is clear. Many of the remaining challenges have been resistant to solutions by various approaches. Some, such as fatalities and injuries from ground control or powered haulage are prominent year after year. Different approaches are indicated and new solutions will be required if we are to achieve a goal of zero harm. These will originate with research, but into which topics, and what are some of these different approaches? This paper examines the current state of mine safety in the United States and highlights areas of significant opportunity for research that will lead to solutions. The likely direction of research that will enable realization of the "zero harm" goal is described in terms of evolutionary and revolutionary approaches. Both are important, but the author's view is that some of the largest gains will be made with trans-disciplinary approaches that break from the past. Topical areas of research are suggested and several research questions are given to illustrate the direction of future research in mining safety and health.

1. Introduction

The global economy continues to be powered by the mining and mined products – energy sources like coal, construction materials that utilize iron, copper, and aggregates, or the rare earth minerals that underpin the technology on which society is increasingly dependent. Pharmaceuticals, agricultural products, jewelry, and thousands of everyday products depend on mined products. Further, the mining and processing operations that bring these minerals to commercial reality are a significant driver for the economies of the producer countries. Fundamental economic value and wealth are created in the transformation of materials from the Earth's crust. Not surprisingly, the world's strongest economies today historically have had robust mining industries. Today, many of the emerging economies are developing major mining industries.

Given the obvious benefits that mining brings to a country's economy, one could imagine a reality in which mining was acknowledged for its contributions and highly valued by the citizenry! Quite the opposite is true, and especially in the countries with the most well developed economies. The belief structure underlying these contrarian attitudes is in part founded on ignorance and misinformation, but is also based on poor behaviors by some in the mining community. Admittedly, many of the egregious practices that led to environmental damage, loss of human life, and damage to local social and cultural fabric are in the past, but not entirely. It is still possible to identify examples of poor practices around the globe.

Solutions to many of the problems that led to adverse societal outcomes have come from research. Universities and government agencies have contributed significantly to these favorable outcomes, and in many cases it has been the partnership or collaboration among the other stakeholders, e.g. companies, labor unions, and manufacturers, that have led to the greatest and most lasting gains. This is especially true in the area of mining safety and health. The changing landscape of mining safety and health in the United States will be reviewed with a focus on the role of research in achieving the gains; and this will serve as a foundation to examine the likely directions of future mining safety and health research. The perspectives presented in this paper are informed by the surveillance data, needs as articulated by mining industry stakeholders, and the author's forty-plus years of work in mining safety and health.

* Corresponding author. Tel.: +1 8148659834.
E-mail address: JK9@psu.edu

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2. Historical perspective

Fig. 1 illustrates the significant improvement in mining safety over the past hundred years, and figure is annotated with the passage of major mine safety legislation. The decline in the fatality rate is dramatic, and given the inflection points in the curve that correspond to legislative actions, it would be easy to conclude that the improvement was the result of legislative action. Indeed, legislation forces change by establishing minimum standards of practice, e.g. maximum allowable concentration of methane, the minimum air velocity at a location, the practice of rock dusting to maintain a minimum incombustible content, the maximum allowable exposure to noise, and the requirement for approved ground control plans, among thousands of requirements codified in the mining safety and health legislation. In many cases, the requirements of the new legislation are not immediately achievable for lack of knowledge or technology, and this creates a "demand" for research and technical solutions.

The knowledge to comply with the mandated standards sometimes follows from engineering design or the application of well-known products or practices. In an important number of cases, the better practice being mandated by the regulation was developed through research, and voluntarily adopted by part of the industry. The value of rock dusting to prevent coal dust explosions was established through Bureau of Mines research in the 1920s, and their work with manufacturers led to commercialized rock dusting equipment in the early 1930s. By 1940, over half the coal produced in the U.S. came from mines that had adopted the practice, but it took a federal mandate in the form of the 1952 Federal Coal Mine Safety Act to bring the practice to all underground coal mines. And this, unfortunately is a pattern that has repeated far too many times right up to the present: the proactive, and often larger companies with more resources, voluntarily adopt more protective practices, whereas others do not; and often it is from the latter group that the attention-grabbing headlines come, resulting in legislative action.

A recent example of the "technology-forcing" behavior of a regulation is the communications and tracking mandate of the MINER Act of 2006. Congress determined that such technology should be required, but recognized that such technology did not exist. Through congressionally appropriated funds, NIOSH led a partnership research program to develop and commercialize the enabling technologies mandated by the Act. Today, all underground coal mines utilize this technology. Similar examples can be given for other legislation, but the 1969 Federal Coal Mine Safety Act drew upon the Nation's research infrastructure in a way never seen before.

The 1969 Act was unique in its scope, attempting to eliminate injuries and fatalities from every known class of hazards, as well as to tackle the most severe health problem-black lung. The regulations promulgated under the authority of the 1969 Act touched on every system in the mine, and without exception, there was a need to define new engineering and design practices and tools, new or improved technologies, and different operating practices. The U.S. Bureau of Mines played a major role both in conducting research and in funding research at several U.S. universities. This effort continued for more than a decade, and ultimately resulted not only in a major advance in knowledge, technologies, and practices, but also in the development of a major research infrastructure for mining. Hundreds of graduate students were trained at the universities during this time period, and many went on to make significant contributions in industry, government, and academia.

The 1977 Federal Mine Safety and Health Act brought new protections to coal mining, but importantly, it brought new requirements to metal/nonmetal mining. Along with these new requirements came in many cases a need for research-based solutions. Notably, and for reasons that will become cleared later in this paper, the 1977 Act codified the first comprehensive set of training requirements for all miners. Fig. 2 illustrates the combined effect of legislative drivers and research solutions on mine safety since the 1969 Act using fatality rates as a surrogate for safety improvement.

The many research advances that occurred over those four decades are well documented in the literature, but what will be the important advances that define the coming decades? Where are the next frontiers? These are questions of interest to researchers, and particularly those who are choosing to address topics that are likely to lead to noteworthy improvements in mineworker safety and health. These questions are of high interest to those who allocate resources for research, e.g. funding agencies, and those for whom research is a results-driven mission rather than an academic pursuit, e.g. NIOSH. A goal of this paper is to describe a plausible path of research activities that could define significant improvements in mine safety and health in the coming years.

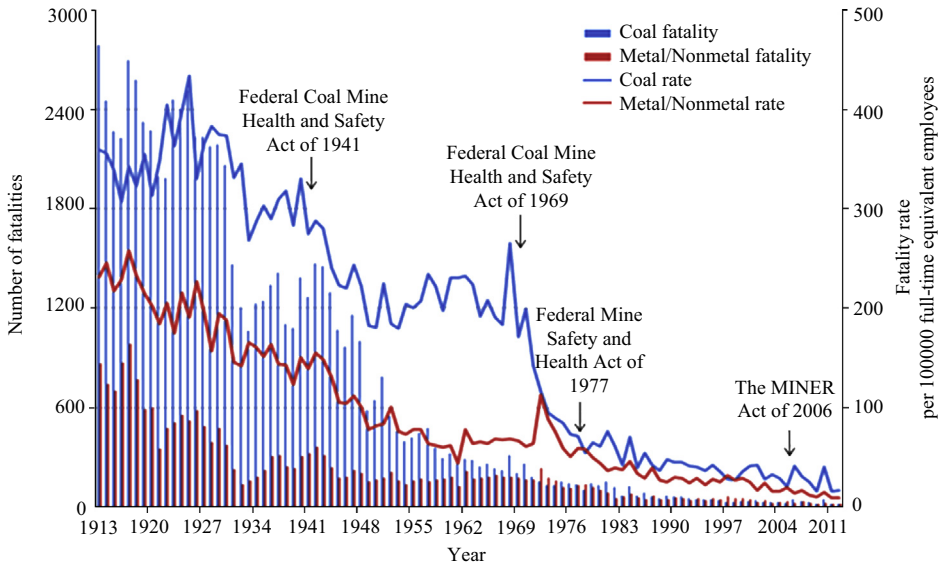

Fig. 1. Number of fatalities and fatality rates in the mining industry by commodity and year with key legislative milestones, 1913–2012.