



## Man-Made Major Hazards Like Earthquake or Explosion; Case Study, Turkish Mine Explosion (13 May 2014)

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### Abstract

In all over the world, mining is considered as a high-risk activity that is pregnant with serious disasters not only for miners, engineers, and other people into it, but also for people who live near the mines. In this article, our main purpose is to examine some major mine disasters and safety in mines and the case study is a coal mine in Turkey. Safety in mines is one of the most important issues that need attention. Therefore, it is suggested that existing deficiencies in mines should be removed by continuous monitoring in all devices, equipments, control of Methane and safe separation of coal from a mine. Moreover, we recommend that early warning systems should be installed to alert some explosions, fires and other dangerous events to the fire departments, hospitals, Red Crescent and other major reliefs. Experiences from previous events in mines can help managers and miners. With some plans and projects related to disasters in mines and solution for them, some diseases such as black lung disease or other problems in mines such as carbon monoxide poisoning can forestall a danger. Before Mine owners begin their activity, they must research about the environmental and social effects of their activities. Therefore, they should identify some important hazards and determine some essential tasks to remove them or control risks via collaboration with other scientists.

**Keywords:** Explosions, Soma mine disaster, Mine disasters, Turkey

### Introduction

A disaster followed by fire and a strong explosion that led to the death of many workers because of carbon monoxide poisoning on May 13, 2014 at a coal mine in Soma, Manisa, Turkey (1). With nearly 12.3 billion tons of reserved coal, Turkey produces almost 22% of its electricity needs by burning their reserved fuels (2). The cause of the explosion was an underground mine fire that continued until 15<sup>th</sup> of May. Its coordinate was 39°4'37.90"N 27°31'30.93"E (3). It is situated in western Turkey (Fig.1). Unfortunately, from 787 workers that were underground, 301 people died in the disaster that is suspected to be caused by electrical equipment (4). In late 2013, miners expressed their opposition to dangerous mining

conditions, but unfortunately, their demand to investigate the mine's safety was rejected in the National Assembly of Turkey only weeks before the disaster (5, 6).

#### *Induced Seismicity*

There are some threats like natural seismicity or sometimes human activities in the world that is called "induced seismicity". The human activities include mining, deep quarrying, hydro-geological extraction or fluid disposal. Induced seismicity creates some earthquakes with different magnitudes. There are some published examples of induced earthquakes occurred since 1929 in the world. Davies et al. (7) subdivided the seismicity by likely trigger mechanism.



**Fig. 1:** Location of the coal mine in Soma, Manisa, Turkey/ Source:

<http://news.nationalpost.com/2014/05/14/turkey-mine-disaster-kills-232-fate-of-more-than-100-miners-unknown/>

These magnitudes are:

1. Mining ( $M = 1.6 - 5.6$ ),
2. Oil and gas field depletion ( $M = 1.0 - 3.8$ ),
3. Water injection for secondary oil recovery ( $M = 1.9 - 5.1$ ),
4. Reservoir impoundment ( $M = 2.0 - 7.9$ ),
5. Waste disposal ( $M = 2.0 - 5.3$ ),
6. Academic research boreholes investigating induced seismicity and stress ( $M = 2.8 - 3.1$ ),
7. Solution mining ( $M = 1.0 - 5.2$ ),
8. Geothermal operations ( $M = 1.0 - 4.6$ ),
9. Hydraulic fracturing for recovery of gas and oil from low-permeability sedimentary rocks ( $M = 1.0 - 3.8$ ).

Some important earthquakes induced by mine subsidence that causes a collapse of mine workings (e.g., 8- 10). These events range from 1.6 to 5.6. For the case study in Turkey, the fire was started by an explosion about 2 km under the surface. We obtained some information from TurkishPress.com on May 15, 2014 saying that this event is doubted to have been caused by electrical equipment. We believed that it needs essential and

exact methods to identify the cause of the fire or explosion. It can help us to improve safety in mines, stopping some occurrences of similar events. There were other hazards for workers in the mines, especially underground coal mine such as repairable dust. The 1969 coal mine health and safety act was the most comprehensive occupational safety and health law ever performed in the world (11). The rate of coal fatalities decreased 37 percent after five years from passing of this law of the federal mine and health act in 1977.

### *Investigation of Explosion in Mines*

There are several methods to investigate fire or explosion events. It needs a considerable time and a team consisting of various specialists in different fields. I believe that every mine needs some safety experts. This team should be comprised of doctors, mine and industry engineers, and some experts for everything that need to be checked in mines. Mines need an advanced and modern laboratory, which can provide different techniques for testing and designing of occurrence some actual events by examining some chemical and thermal analyses and electrical tools that may be prone to massive fire or explosions. These methods are called simulation of event. These days' seismologists use simulation of event for major events in natural seismicity or earthquakes in different regions. Therefore, we can examine this procedure for fire, explosion in mines too. Results of such trial and error are a good method for taking control of hazards in mines. The results can be publishing in a form of an international report, so that the experiments can be used in other countries' mining industry. An initial report on possible causes of the mine event in Turkey cited by prosecutor Bekir Sahiner showed that the fire may have been triggered by coal heating up after making contact with the air, sending harmful carbon monoxide through the mine (12).

The Mine's elevator was stopped due to the explosion. Most of the workers died of carbon monoxide poisoning (13). The fire broke out after the explosion. Brnich and Kowalski-Trakofker (14) in 2011 presented some major coal mine disasters in U.S. Bureau of Mines, in three periods.

They categorized causes into six cases that they have occurred in three periods: 1900-1909, 1910-1969 and 1970-present. They showed disasters by number of fatalities in Tables 1, 2 and 3, respectively. These causes are: 1) explosion; 2) fire; 3)

haulage (transportation of personnel, materials, or equipment); 4) ground fall/bump (fall of roof rock or an outward, violent burst of a pillar); 5) inundation (the sudden inrush of water or toxic gases from old workings); and 6) other (15).

**Table 1:** Number of underground coalmine worker fatalities by type of disaster 1900 through 2008

Type incident	Number of events	Number of fatalities
Explosion	420	10,390
Fire	35	727
Haulage	21	145
Ground fall/Bump	14	92
Inundation	7	62
Other	17	199

**Table 2:** Major U.S. underground coal mine disasters, 1900-1909

Year	Mine	Type disaster	No. killed
1902	Fraterville	Explosion	184
1902	Rolling Mill	Explosion	112
1903	Hanna No. 1	Explosion	169
1904	Harwick	Explosion	117
1905	Virginia City	Explosion	112
1907	Stuart	Explosion	84
1907*	Naomi	Explosion	34
1907*	Monongah Nos. 6 & 8	Explosion	362
1907*	Yolande	Explosion	57
1907*	Darr	Explosion	239
1907*	Bernal	Explosion	11
1908	Hanna No. 1	Explosion	59
1908	Rachel and Agnes	Explosion	154
1908	Lick Branch	Explosion	50
1909	Lick Branch	Explosion	67
1909	Cherry	Fire	259

\*Occurred in December, 1907

### **Why do we need coal?**

The most important fuel in the production of electricity is coal, which has been widely used since the 1880s. Coal is also one of the most abundant fuels in the world that is used in industry as well as in smelting and alloy. The United States has more coal reserves than any other country in the world. In fact, one-fourth of all the known coal in the world is in the United States. Coal mining developed during the industrial revolution, the most important application of which is

as a fuel in energy production and in the process industry. Besides, one of the important sources of energy up until 1960s was coal. Moreover, coal is the most plentiful fuel in the fossil family. The Industrial Revolution in 18th century started in Britain and then spread to continental Europe, North America, and Japan, was due to the availability of coal to power steam engines. Coal was cheaper and much more efficient than wood fuel in most steam engines (16). Today, most of countries use a lot of coal, because they have a lot of it.

**Table 3:** Underground coal mine disasters, 1977-1999

Year	Mine	Type disaster	No. killed
1977	Porter Tunnel	Inundation	9
1980	Ferrell No. 17	Explosion	5
1981	Dutch Creek No. 1	Explosion	15
1981	Adkins Coal No. 11	Explosion	8
1981	Grundy Mining No. 21	Explosion	13
1982	RFH Coal No. 1	Explosion	7
1983	Clinchfield No. 1	Explosion	8
1984	Wilberg	Fire	27
1986	Loveridge No. 22	Other*	5
1989	William Station	Explosion	10
1992	South Mountain	Explosion	8

\*Stock pile collapse/As a result, according to the statistics in these mines presented in tables, the explosion is the highest event and then fire.

#### *Environmental impact assessment of mining*

We know that all mines should protect the environment from threats by their activities. Coal is the most accessible source of fossil energy in the world, but it contains natural radioactivity. Demir and Kursun, 2012 (17) find results of particle size analysis in the laboratory with coal samples from Manisa-Soma coal in Turkey. Their study concentrated on the radioactive elements in Manisa-Soma and Istanbul-Agaci coals, and thermal power plant ashes taken from Manisa-Soma were used. Their samples were analyzed with respect to air-polluting elements. They were obtained that As, Co and Mn were concentrated on floating coals; Be, Cd, Hg and Ni were concentrated on the ashes of these coals, and Se was concentrated on sinking coal and its ash. Because Istanbul-Agaci lignite is low in thermal value, they noticed in their analysis that trace element sedimentations settling in coal during geological formation of the area is higher than worldwide coal average. According to the major and trace element results of the Float and Sink Experiment made on Manisa-Soma coal in Turkey, whereas radioactive element content of Th is 3.26 ppm in the feeding coal, it is 1.00 ppm in floating coal and 5.30 ppm in sinking coal. Moreover, they examined post-combustion ashes of these coals. Therefore, these results show that Th element collects in the sinking part after coal

dressings and gets concentrated in the ash after combustion (17). On the other hand, researchers believe that almost 40% more carbon dioxide exists in the atmosphere than before the Industrial Revolution. They believed that current CO<sub>2</sub> level is higher than at any point in the last 650000 years (18). Research has shown that mining causes widespread deforestation, soil erosion, water shortages and pollution, smouldering coal fires and the emission of greenhouse gases. Moreover, huge excavation operations strip land bare, lower water tables, generate great waste mountains surrounding communities with dust particles and debris.



**Fig. 2-a:** Coal-fired power plants like the Tennessee Valley Authority's Cumberland Fossil Plant near Clarksville, Tenn., are cited in a new report as contributing to thousands of premature deaths each year, Ron Schmitt / AP file (19)





**Fig. 2-b:** Emissions from coal-fired power plants include sulfur dioxide, mercury, nitrogen oxides and carbon dioxide, Phillip J. Redman / U.S. Geological Survey (19)

Other environmental impacts are: the loss of fertile soils through the erosion and runoff into nearby water bodies clogs rivers that led to smother aquatic life. According to the reports by World Health Organization in 2008 and environmental groups in 2004, coal particulates pollution (Fig. 2 a & b) are assessed to shorten approximately 1000,000 lives annually worldwide, including nearly 24000 lives a year in the United States (19, 20).

### ***How to avoid the risk of explosion or fire in mines?***

We can reduce the risks in mines. We should identify some important hazards and determine some essential tasks to do that. Some scientists tried to control risks via some plans. A large number of casualties are related to mine workers. One of the most important plans for decreasing hazards in mines is to control the risk assessments by flammable materials. For example, we can identify some sources of fire and explosion (or man-made

earthquakes) in mines, and continually control and monitor the electrical equipment and anything related to it that is prone to produce an explosion such as smoking by workers and managers. If the event in Turkey has been caused by electrical equipment, then it needs more attention in the future. All mine owners and managers in mines must permanently check and control electrical equipment to avoid future risks. Disregarding some minor flaws create a dangerous disaster and led to an ignition source.

Managers in mine should prepare suitable equipment. There are some regulations that introduce concepts and definitions: 1. The type of explosion protected equipment. 2. The groups of the explosion protected equipment. 3. The methods that these groups are to be used in explosive and potentially explosive atmospheres. 4. The explosive atmosphere being formed by gas, mist, vapor or flammable dust under normal atmospheric conditions. Moreover, the level of risk for each person in mines depends on some factors such as: 1. How each person is close to fire or explosion? 2. Are they on the intake side or downstream? 3. How far they are from the closest safe place? 4. How long it will take them to reach the nearest safe place? (21). Therefore, deployment and safety checking systems in mines should be considered as an important issue. I believe that some cases must be monitored and controlled permanently in mines, for example, instruments and equipments monitoring, the rate of flammable gas, etc. Early warning systems must be active for number of flammable gas, so that they can send warnings when number of flammable gas increase or it is suspected for explosion. Permanent monitoring can detect some problems in mines quickly, and workers, managers or other people in mine can save themselves from risks. Moreover, Vasheghani-Farahani and Zare, 2013 (22) believed that in order to improve the environmental safety and sustainable development, it is better to research on explosions based on the ground motion prediction model and soil effect to have a sufficient standard of explosives as a necessity. These researches led to the reduction of some destructive environmental hazards.

### *Lessons from Mine Disaster in Turkey*

I believe that mine disaster in Turkey has lessons for other mining companies. They should adopt a stronger view for prevention of hazards. Perhaps, Turkey mine explosion could be a preventable incident. Some news from this disaster indicates that the accident victims died mostly from toxic gases (23). In this news, we studied that "a prosecutor said: a preliminary report shows that coal had been smoldering for days before the disaster, causing a roof collapse and releasing toxic gases that spread inside the mine". Therefore, officials admitted that most of the victims died from toxic gases (23). If the mine event in Turkey have been caused by electrical equipment or if many of the dead in Manisa-Soma coal in Turkey died from toxic gases, our question is: whether this event was preventable or not? This accident in which 301 people lost their lives is very heartbreaking. Unfortunately, mining accidents occur frequently in Turkey. An explosion occurred at the Kozlu mine stemming from a methane gas leak and killed eight workers. Moreover, Turkey's worst mining event occurred in 1992, too. Unfortunately, gas explosion killed about 263 workers in the Black Sea province of Zonguldak, and another event took place in Zonguldak province in May 2010. Between 1991 and 2008, 2554 miners died in work-related accidents, and more than 13000 people experienced working disability (24). Unfortunately, lessons not learned from previous mining disasters. Miner Erdal Bicak believed that Turkey mine disaster (May 2014) is due to the negligence on the part of the company. Bicack told that the company was guilty about that (25). He told the Associated Press that the managers had machines to measure methane gas levels. "The new gas levels had gotten too high and they didn't tell us in time." Akin Celik, the Soma mine's operations manager, has said thick smoke from the underground fire killed many miners who had no gas masks. High levels of carbon dioxide and carbon monoxide have also been a problem for rescue workers as well (25).

## Conclusion

An explosion and fire occurred in a coalmine in western Turkey that killed at least 301 workers. Plan and responses to problems in mines such as carbon monoxide poisoning can forestall a danger. Moreover, timely warnings to managers and workers can keep their lives from hazards. Mining kills workers by some events and diseases such as fire, explosion and black lung disease, respectively. In addition, people suffer from pollution emissions such as carbon dioxide, sulphur dioxide, nitrogen oxides and methane. Perhaps, a solution for people that live near the mines is evacuation of villagers affected by mining to a more suitable location. Finally, simulation of events in laboratories is a good solution in mines.

## Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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The authors declare that there is no conflict of interests.

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