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Use of Underground Mining Activities in Earthquake Search and Rescue Works

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Abstract: Although the mining sector has the task of providing raw materials directly or indirectly to industrial establishments, it unfortunately contains great dangers and risks for its employees in terms of occupational health and safety. Especially in mining enterprises operating underground, roof collapse, sudden gas discharge, flooding, gas explosions etc. negativities that occur during production cause great material and moral destruction. In such big problems, well-trained rescue teams of mines play an important role in saving the lives of many miners. Earthquake disasters affecting 11 provinces in Turkey caused great destruction, many people died in building debris and collapses, and buildings and industrial facilities were severely damaged on Feb. 6 2023. In the search and rescue works that started after the earthquake, the outstanding efforts of the underground mine workers in the field and the methods they used in these studies attracted the attention of the public. In this study, evaluations were made by giving some underground rescue methods used in search and rescue activities in the Adıyaman earthquake region which is one of 11 provinces affected by the disaster in Turkey.

Keywords: Underground mining, hazards and risks, earthquake, search and rescue.

Introduction

Mining, which is one of the well known working areas of the world economy, is among the important sectors for many countries due to both the supply of raw materials needed by the industry and its contribution to exports.

Mining activities are always faced with some dangers and risks due to their nature. Mine production methods are divided into two as open pit mining and underground mining. Production with both methods has its own advantages and disadvantages (Şensöğüt & Sargın, 2021).

In underground mining enterprises, wooden or steel support equipment is used in the preparation and production roadways formed to reach the mineral deposits. The supporting methods used for rescue in all unfavorable situations such as roof and side walls collapse and explosion occurring in underground mining activities, were used effectively in search and rescue activities in earthquake disasters in 11 cities, and hundreds of people who were left in the debris were rescued alive.

Underground workers, who work in harmony with the personnel of all public and private institutions in earthquake search and rescue efforts, attracted the attention of the world public opinion and gained the trust of the people with their successful work in the field.

The tensions and compressions caused by the movements of the plates forming the earth's crust accumulate energy in some parts of the earth's crust for centuries, and these energies emerge from time to time. These moving sections in the earth's crust are called faults. There are 3 important faults in Turkey, namely the North Anatolian Fault, the East Anatolian Fault and the West Anatolian Fault, among others. Therefore, these faults break in certain periods and create important earthquakes (MREGD, 2023).

Turkey is among the countries most affected by earthquakes, and in recent years, earthquakes with a magnitude of 7 and above have caused many people to lose their lives, as well as great material and moral destruction. In this study, the contributions of the underground support elements and methods used in search and rescue works in the center of Adıyaman, which is among the provinces affected by the earthquake, are shared with their visuals. In addition, by giving brief information about Adıyaman province, the search and rescue activities carried out in the region were evaluated.

Earthquake Zones and Tectonics of Türkiye

Located on the most active fault zones in the world, Türkiye frequently experiences many natural disasters due to its geographical and geological characteristics. About 96% of the country's territory is located in regions with varying degrees of earthquake hazard, and 98% of the country's population lives in these regions. 66% of these regions are located in active fault zones. Seismic zones map in Türkiye shows different earthquake hazard zones and these zones are classified from 1 to 5 (Fig.1) (DEMP, 2023). These figures not only determine the level of earthquake hazard in a region, but also indicate the extent to which the ground can be shaken. It can be said that the regions marked with 5 are quite far from the main fault lines, and the regions marked with 1 are quite close to the main fault

lines. These maps are used as a reference when designing and calculating the structure to decide how much the ground will shake. The use of maps for this purpose ensures that structures are designed and constructed to withstand the shock they will be subjected to. The building in each region should be constructed in accordance with the earthquake hazard of that region.

Knowing which region you are in does not give information about the earthquake resistance of your building. You need to know how your building is made. In all danger zones, buildings can be earthquake resistant if they are built appropriately for that zone

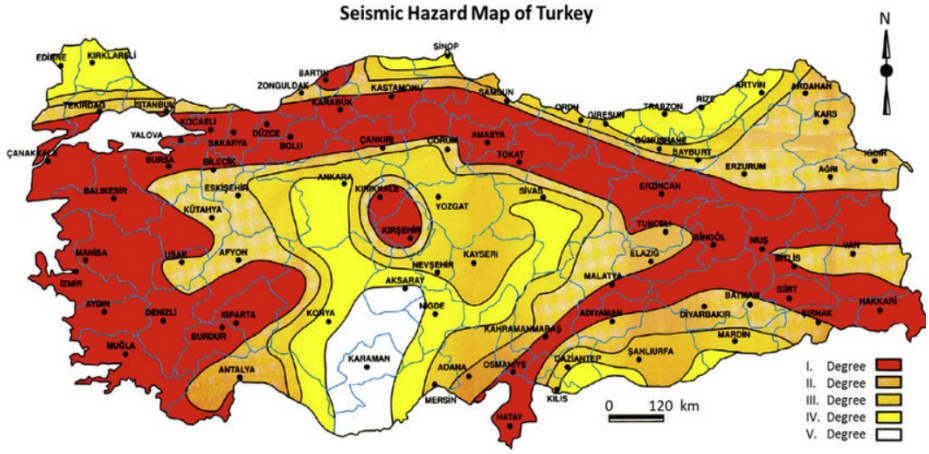


Fig. 1 Seismic hazard map of Türkiye (DEMP, 2023).

The majority of earthquakes in Turkey, which is located on the Alpine-Himalayan seismic belt, are related to the northward movement of the Arabian-African plates. GPS studies indicate that the Arabian plate is moving in the NW direction at a speed of about 18 mm/year relative to the Eurasian plate (Figure 2) (Jackson & McKenzie, 1984; Okay & Tüysüz, 1999; Aydın et al., 2013).

Fig. 2 Tectonic plates around Türkiye .

In Eastern Anatolia, the Arabian plate collides with the Anatolian plate along a deformation belt called the Bitlis Pütürge Suture Zone (BPSZ) (Eyidoğan, 1983). The current tectonics in southeastern Anatolia are supported by the focal mechanism solutions of the major earthquakes that have occurred in the region, as well as GPS studies (Mc Kenzie, 1972).

As a result of the movement, the Eastern Anatolia region, which is between the Eurasian continent and the Arabian plate, is affected by a compressional tectonic regime. Depending on this movement, which continued in geological time, the North Anatolian (NAF) and East Anatolian Fault (EAF) lines, which caused important earthquakes in Türkiye, were formed. Movements along these fault lines are the cause of most of the devastating earthquakes in Türkiye. In addition, most of the first degree earthquake zones coincide with these fault lines (Aydın et al., 2013).

The North Anatolian Fault line (NAF) is approximately 1500 km long and cuts Türkiye in an East-West direction, starting from Karlıova (Bingöl) to the Sea of Marmara (Fig. 2) (Aydın et al., 2013).

The Eastern Anatolian Fault (EAF), which affects Adıyaman province and its vicinity, starts from the triple junction of Karlıova (Bingöl) with the NAF at its northern end. It is connected to the Dead Sea fault system at its southern end in the Antakya region. The EAF traverses the country in the NE-SW general extension between Karlıova and Antakya. This transform fault system is 580 km long between Karlıova and Antakya (Aydın et al., 2013).

The East Anatolian Fault Zone starts at the intersection with the North Anatolian Fault Zone in the east of Karlıova, in the Kargapazarı region, and continues southwestward along the Göynük Valley in the northeast-southwest direction. The fault, which has a 17 km offset here (Şaroğlu et al., 1987), becomes a little unclear in the Bingöl region, but becomes evident again between Palu and Pütürge and continues towards the southwest. The segment, which ends in the north of Hazar Lake, continues to the west by leaping to the south (Hempton, 1982).

An Overview of the Earthquake Zone Adıyaman

Adıyaman province is located at the foot of the Taurus mountain range, where the Arabian deserts extend from the Arabian Peninsula in the south to the Taurus Mountains in the north end. In this region, the main land routes from Asia, Europe and Africa intersect each other. Adıyaman province has been a residential area where people prefer to live in every period of its history due to its suitable geographical features.

When Türkiye's earthquake zones map is examined, it is seen that Adıyaman province is located in the 1st and 2nd earthquake zones (Fig. 3) (DEMP, 2023).

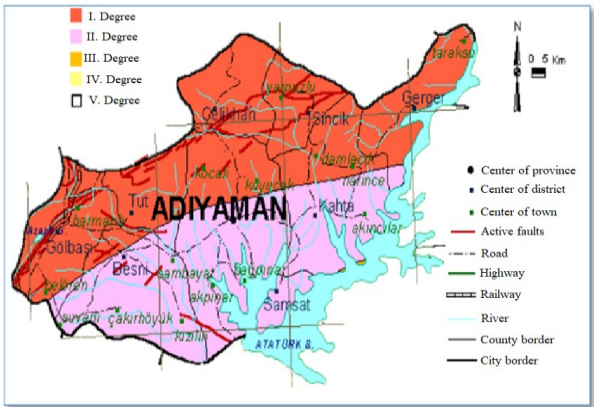


Fig. 3 Adiyaman province earthquake zones map

6 February 2023 Earthquakes

According to the Kandilli Observatory and Earthquake Research Institute (Türkiye) data on February 6, 2023, an earthquake with a magnitude of 7.8 occurred in Sofalaca-Şehitkamil-Gaziantep, followed by another earthquake with a magnitude of 7.5 in the center of Ekinözü-Kahramanmaraş. Approximately 14 million people living in Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye and Şanlıurfa provinces covering Southeast Anatolia, Eastern Anatolia, Central Anatolia and the Mediterranean Regions were affected by the earthquake (Fig. 4). According to official data, a total of 50,500 people have died so far (BBC News, 2023).

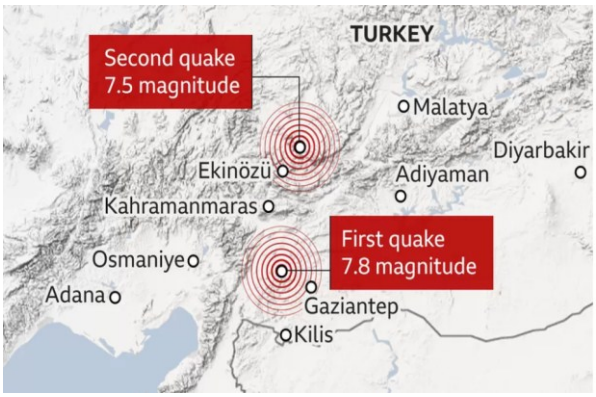


Fig. 4 Location 6 February 2023 eartquakes

Emergency Response Processes After Earthquake

The last earthquakes that took place on February 6, 2023 in Turkey were effective in a wide area covering 11 provinces and many people lost their lives.

After the earthquake, a state of emergency was declared in the earthquake regions and search and rescue efforts were started immediately. Many national and international institutions and organizations and volunteer teams participated in the search and rescue efforts. During the search and rescue efforts, sound listening was made in the debris of collapsed buildings, and the heat movements were monitored with thermal cameras and the rescue efforts were immediately started with the detection of live people and animals under the dent.

During the search and rescue efforts, many people were recovered from the wrecks and debris of collapsed buildings and workplaces as injured, alive or dead.

The personnel of the Emet Boron Operations Directorate, one of the institutions assigned to the Adıyaman earthquake region immediately after the earthquake, worked in coordination with the personnel of other local and foreign institutions and volunteer organizations in this region and contributed to the removal of many citizens from the wreckage as injured, alive or dead.

Underground Mining Activities in Search and Rescue Works after Eartquake

In the chaotic environment brought about by the earthquake, it is vital for people waiting to be rescued under the debris to intervene with the right equipment, construction equipment, personnel and the right search and rescue methods.

Initiating rescue activities with risky methods in terms of occupational safety, with the desire to hastily rescue the people who are trapped in the wreckage, may cause situations that will endanger the lives of search and rescue teams. Because during the process, some of the rescue teams lost their lives as a result of their urgent intervention in the collapsed buildings and debris.

Underground mining activities are in the category of very dangerous jobs in terms of the risks they involve by nature. Rescue activities of workers who are exposed to incidents such as roof and side walls collapse, working face and goaf collapses, firedamp explosions and mine fires, which are among the activities of extracting mine deposits hundreds of meters below the ground, are often encountered in the mining industry.

In Türkiye, especially in recent years, many personnel working in the underground mining sector have lost their lives in such accidents. In order to prevent or reduce these losses, it is extremely important to form

rescue teams from specially equipped and trained underground personnel who can intervene immediately in underground accidents.

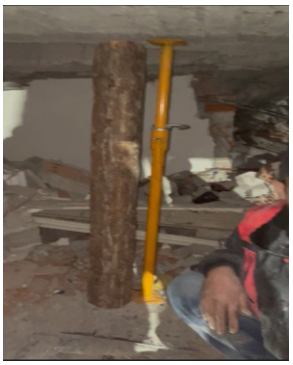
The underground miners and rescue teams, who were directed to the earthquake region after the disaster, have pulled many people out of the rubble by applying similar techniques in the collapsed buildings due to earthquake, thanks to the supporting methods they used underground while working and the experience they gained in adverse underground situations.

The planned and conscious activities of the miners in the passing throgh the rubble attracted the attention of the local and foreign public opinion and once again highlighted the importance of underground mining discipline in responding to such disasters.

In addition to other domestic and foreign institutions and organizations, the personnel of public and private sector mining companies (Turkish Hardcoal Corporation, Turkish Coal Board, Eti Mine Directorate, Imbat Mining, Coal Enterprises Inc., etc.) participated in the search and rescue efforts after the earthquake. After the live reports from the collapsed buildings, the underground mine workers and other search and rescue teams in the field went to the ruined buildings and the rescue efforts began after the location of the wreckage was determined with the help of thermal camera, sound listening devices and search and rescue dogs. Afterwards, it was tried to reach the people under the debris by making connections in the form of shafts from the appropriate floors of the buildings with the help of equipment such as electric drills from the closest distance to the wreckage (such as the sublevel connection work in mining) (Fig. 5).

Fig. 5 Shaft-shaped search and rescue operation.

The fact that the buildings where rescue activities will be carried out were severely affected by the earthquake and the removal of injured people by entering these buildings was noted as the most important difficulty encountered during these works. For this reason, the safety of the collapsed buildings was ensured first. The collapsed floors were supported by wooden supports against collapse. In addition, the works continued by making reinforcements with small steel supporting posts (Figure 6).



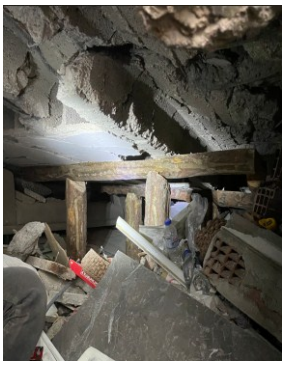


Fig. 6 Collapse control work by the use steel and wooden supports

In order to ensure the stability of the roof and side walls, wooden supports used at short intervals, wedges were tightened to the ceiling and side walls to provide a safe search and rescue environment (Fig. 7).

In order to carry out salvage works in buildings that were heavily damaged by the devastating effect of the earthquake, wooden supporting elements reinforced with wood cribs, which are widely used in underground mining operations, made progress by providing safety in collapsed buildings and many people were rescued from the debris (Fig. 8).

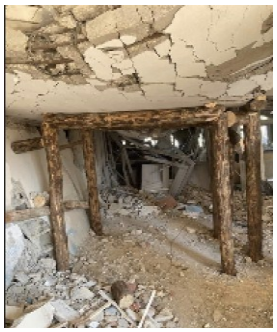


Fig. 7 Supporting work for roof and side walls control.

Fig. 8 Wood crib reinforced supporting work.

Results and Discussion

The vast majority of people living in Türkiye continue their lives in regions within the active fault lines. Again, in the current situation, some of the big cities listed along the fault lines are the locomotive of the country's economy having the large industrial facilities and factories operating within their borders.

The earthquake disaster reminded once again the fact that the country is an earthquake country and caused great losses for Türkiye. Many citizens lost their lives in the last earthquake, and thousands of buildings and industrial facilities were destroyed in the earthquake zones.

Among the main reasons for the large-scale disaster are the construction of buildings and industrial facilities on soils that are not resistant to earthquakes, and the use of cement and iron materials in constructions in insufficient quantities and sizes.

It is a scientific fact that fault lines extending in the east-west and north-south directions in the geography of Türkiye will break in certain periods and along different fault lines, causing earthquakes.

In order to encounter the painful tables caused by the last earthquake, new living centers should be established in accordance with the earthquake reality. The areas where these new living centers will be established should be determined according to the climate, geological, geophysical and hydrogeological characteristics of the region. Before starting the construction activities, the ground studies of the buildings must be carried out in accordance with the rules and the buildings must be constructed with technically appropriate materials.

It has been observed that buildings constructed in the form of high-rise and adjacent systems are more risky in terms of earthquakes. It is a sad fact that the floors of high-rise buildings close to the ground are completely buried in the ground as blocks, and as a result, the loss of life has increased. In order to reduce material and moral losses in earthquakes that will occur in the next period, new settlements should be created in accordance with horizontal architecture at regular intervals instead of multi-storey buildings.

This great earthquake disaster in Türkiyr showed that after the earthquake, search and rescue activities are of vital importance. Many local and foreign institutions and organizations participated in the search and rescue efforts in the earthquake area. Since the dangers and risks of collapsed buildings are similar to the dangers and risks in underground mining activities, underground miners have demonstrated outstanding success by taking an active role in the field when other teams are insufficient.

In the following processes, institutions and organizations responsible for search and rescue activities should be shaped by associating with the underground mining discipline, and the methods used in underground mining should be evaluated in search and rescue activities.

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