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MŰSZAKI
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Explosive Ordnance Detection in Areas Designated for Mining

Nowadays, mining is becoming increasingly valued, as mines of various types provide a large part of the raw materials needed for construction. In order to ensure a continuous supply of extraction and raw materials, new areas need to be identified and opened up. However, some of these new areas may contain security risks such as explosive remnants of war. If we look back to the events of the World War II, there was perhaps no area in Europe that was not affected by the preparation or execution of some act of war. The warring parties deployed a full arsenal of weapons, some of which still pose a threat today. The various types of bombs, mines, projectiles and grenades were only partially operational. Explosive devices that were simply left behind or unexploded were buried beneath the surface, and continue to pose a growing threat to this day (almost eight decades later). The dismantling and disposal of the left-behind and often very poorly recovered explosive devices has been ongoing ever since. The problems of finding explosive devices and munitions tend to occur in areas where there has been no previous investment, construction or earthworks. Our aim is to illustrate the possibilities that mine operators can apply when a similar problem arises when opening a new area.

Keywords: *explosive device, area clearance, reconnaissance, mining*

Introduction

It is perhaps not surprising that, apart from the essential materials for life, the most important material for the continued maintenance of development is stone. I was surprised to hear this from the president of a European association at an international conference. If you think about it, everything that surrounds us and serves our development is made of stone, concrete and other materials related to mining. The man-made materials are also produced in some kind

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of building, transported by road networks to their destination or place of use, so they are also indirectly linked to this economic sector and this activity. Mining is therefore a fundamental part of our lives and our daily lives.

Unfortunately, there have been, and perhaps will continue to be, periods in history that have not been favourable to this activity, but the extraction of minerals has been and will continue to be necessary for development. This was the case during the period of the World War II, when the opposing sides did not consider the impact of trying to use the explosive devices at their disposal in the most effective way to carry out their military operations. Military operations in these times required the acceleration of military industrial production and the production of expendable war materials (such as explosive devices) in the largest possible quantities. This process, of course, could only be maintained if the quality requirements were slightly lowered. This means that in the production of explosives, for example, the main criteria were not that they should retain their properties for decades or be storable for long periods. The aim was to be able to cope with military operations in the weeks and months to come.

The materials used, and not only the explosives, ensured this at the time, but the acceleration of the manufacturing and production processes has significantly reduced the reliability of the materials and equipment. If we look at the mortar shell, for example, we can see that not only its design, but also the way in which it was filled with explosives left something to be desired. In many cases, air gaps in the explosive material may have been left during the loading of the shell, and there were also minor failures in the firing mechanisms. I do not have any information on which type of explosive device is most frequently found as a remnant of war in European countries, but it is certain that in Hungary it is the 82 mm Russian mortar shell.[3]

Figure 1–2: 82 mm Soviet shrapnel mortar shell engraving
Source: photograph of the authors

[3] Kovács–Ember 2023: 197–200.

- Original or abbreviated designation: O–832
- Characteristics: soviet shrapnel mine grenade, drop-shaped, with screw-in stabiliser, 6 wings with centring notches and spare charge breakthroughs, 4 compression grooves, 3/3 × 3 flame arrestor holes
- Weight: 3.26 kg
- Bullet body: Cast iron
- External dimensions (with igniter): 279 × 82 mm
- Weight of explosive material: 0.43 kg
- Type of e explosive material: AT–90[4] or TD–42[5]
- Armour piercing capacity: 100 mm
- Maximum Effective Range: 3180 m;[6] 4255 m[7]

The shrapnel-cumulative mortar grenade is designed to engage and destroy armoured targets, concrete fortifications, weakly covered and uncovered live forces. The shrapnel-cumulative mine grenade is equipped with a cumulative liner cone, a gas pressure-operated mechanical bottom fuse, high-explosive pressed bodies (hexogen, nitro-penta based) and a flexible ballistic tip to aid in elevation and cumulative operation.

The mortar is a short-barrelled, low gas pressure, usually muzzle-loading, indirect-fire gun that fires its projectile, the mortar shell, at a low initial velocity on a high ballistic projectile trajectory, which strikes at short range compared to the projectile of a cannon or a mortar. It belongs to the category of barrel firearms and was first developed at the end of the 19th century, making it one of the youngest artillery weapons. Its main feature is the length of the barrel, which is less than 15 times the diameter of the barrel, i.e. less than 15 times the length of the space. Because of its design, the mortar fires only with an overhead group of angles, making it ideal for engaging targets behind terrain, obstacles or structures.

Its ease of handling and rapid deployment made it popular during World War II. It is no coincidence that mortar rounds are usually found in large quantities during a demining operation.

The other device may not be as common as a mortar shell, but all media outlets report when a bomb is found. It should be noted that the term bomb itself is often misused in the media.

The bomb is the Air Force's most powerful weapon designed to destroy enemy objects and units, to damage, destroy targets, or to remove, overcome or damage obstacles, but it can also be used for area protection and to create fear or confusion. Therefore, any munition that is used for the intended purpose from an aircraft can be called a bomb.

With the development of technology and the constant demands and limits of weaponisation, many types and functions of bombs have been designed and developed. With regard to other military explosive devices, it can be said, and here I am referring primarily to artillery devices, that the design and sizing of the bomb was based only on the impact and the desired

4 Alloy of TNT and ammonium nitrate.
5 Mixture of TNT and dinitro-naphthalene.
6 With full variable charges.
7 With long range charge.

destruction rate, since there was no need to maintain the parameters resulting from the high stresses and strains that would occur during launching and firing.

The latest technical tool of warfare, still used in today's conflicts, is the use of unmanned aerial vehicles to drop small explosive devices on live forces or armoured vehicles. Most of these IEDs are low-budget, home-made and, due to manufacturing inaccuracies, may fail after deployment.[8]

Consequently, there was no need for large wall[9] thicknesses and the resulting volume could be filled with explosives. For example, a bomb and an artillery shell of the same weight could have a charge several times greater than the charge of the other shell. Since the amount of energy released during the explosion is directly proportional to the weight of the explosive, a bomb of the same weight will cause more destruction than an artillery shell.[10]

The weight of a bomb is determined primarily by the destructive effect it creates, the nature of the task and the transportability of the equipment. Based on their mass, the following devices can be distinguished:

- small bomb – total mass between 1 and 100 kilograms
- medium bomb – total mass between 100 and 500 kilograms
- heavy bomb – total mass between 500 and 2,000 kilograms
- giant bomb – total mass between 2,000 and 15,000 kilograms

Small and medium bombs include almost all special bombs, while medium, heavy and giant bombs include mainly destructive bombs. The weight given for the designation of bombs is only an approximate value, the actual value may vary by up to 10–15%. The inaccuracy of bomb weights is due to the different units of measurement, since the manufacturing countries do not designate the explosive bodies in the same units.[11]

In the case of bombs, we distinguish between the bomb body, the charge and the fuse as the main components, but the wing and the suspension eye are also important elements of these explosive devices.

- Bomb body: its external shape is determined by the laws of aerodynamics and the conditions of mass production. The bomb body can be divided into three main parts: the head, the midsection and the bottom. The head section, at the opposite end of the bomb from the wing, is where the nose cone and, in some types, the front hanger eye are located. The next part of the bomb body is the midsection, or cylindrical bomb casing, and this area contains the side fuse and the suspension eye(s) of some types of bombs. The cylindrical bomb casing is closed by the bomb's butt or butt section. This area contains the bottom fuse, the bottom bolt for charging and the fittings for connecting the guide vane.

[8] Pető 2014: 108–109; Pető 2016: 155–156; Pető 2017: 59–60.
[9] Exceptions to this claim are SAP (Semi Armour-Piercing) and AP (Armour-Piercing) bombs, which by their very function require a large wall thickness to achieve target penetration.
[10] Daruka 2014: 69.
[11] Daruka–Csurgó 2017: 50.

- Bomb fuse: the material filling the internal cavity of the bomb body, which may be an explosive in the sense of its function, or, in special bombs, an incendiary, illuminating, fog, gas or other material corresponding to the function of the bomb. In most cases, the charge is trinitrotoluene or trinitrotoluene mixed with ammonium nitrate (NH_4NO_3) (provided trotyl) 20–60 wt% TNT to 80–40 wt% ammonium nitrate. It is labelled with the indication of the substance: 60T/40An. 60T/40An is processed by casting, while 20T/80An remains granular and can only be shaped by pressing or tamping. It is coated with asphalt varnish or shellac before being placed in the bomb body because it reacts with the metals in direct contact. The part of the charge in contact with air during assembly is insulated against moisture by a layer of paraffin or TNT. The effect of stretched trotile is not much worse than that of homogeneous trotile. In some cases, nitro starch has been used as a substitute for trotile. Its explosive power is almost identical to that of trotile. It is a yellow, greenish-grey or greenish substance, sensitive only to sudden increases in temperature. Care must be taken to keep the temperature below 35 °C for bombs containing nitro-starch.
- A bomb initiating or firing device: a device which, at a predetermined time or place, causes an explosive to detonate in the course of its operation. The detonating device initiates the detonation of the explosive placed in the bomb, and is therefore the most important and sensitive part of the bomb. According to their use in bombs, bomb fuses are distinguished into head fuses, which can only be placed in the bomb head according to their application. On the same principle, detonators, which can only be placed on the bomb head are called bottom detonators. Combination or head and tail fuses can be placed in any of the above-mentioned places, so that the same fuse can be placed in either the head or the tail of the bomb. Side fuses can only be placed in the appropriate opening on the bomb casing, called the fuse socket.[12]
- Guide tail: to help the bomb to align with the direction of fall and impact with the tip. It may be cylindrical, box-shaped, or three- or four-plane in design. The three- or four-plane guide vane is made of iron, steel or aluminium plate, which is fixed to the bottom of the bomb by rivets or bolts. It is important that each guide plane is sufficiently stiffened so that it does not warp or break during transport or loading.
- Suspension eye, designed to facilitate safe movement on the surface of the bomb, on aircraft, and safe bomb loading. One eye for small devices, two for medium-sized bombs and three or four for larger devices are designed to facilitate bomb handling. This component plays an important role in the identification of devices.

Unfortunately, it is not possible to present all explosive devices that may be found in mining areas, so I have highlighted only those that are most commonly found in Central European areas. The very reason why devices that do occur in mining areas do not explode is very

[12] Daruka 2014: 78–79.

complicated. On the one hand, there may be a problem of manufacturing technology, there may be some kind of obstruction in the throwing or launching of the devices and, of course, there may have been obstacles or special circumstances in the impact.

Mining and quarrying

If you want to mine an area, there are a number of steps that you cannot skip before starting work. One such step is mapping the area. This means, of course, not only examining the area to see if it is suitable for mining, but also looking at what activities have been carried out in the area. We are often confronted with the fact that if we try to bring a new area under cultivation (this includes construction and any other activities involving excavation), some kind of explosive device may be or will be found in the area. Of course, this cannot be said in general, but that is why it is necessary to examine the area for historical purposes. If the site is adjacent to a major town and the town has been attacked during the wars, then the presence of an explosive device or its remains is to be expected. The same is true if the area in question has been the scene of direct combat, i.e. military operations have been carried out in the area.[13]

Explosive devices are often found in areas where war debris has been transported and buried among the rubble. It is also worth investigating whether the area in question was on a transport route for the transport of supplies to fight in battle. This could also be an indication that the area may have been contaminated and that explosive ordnance may have been found. Why is this important? If an area is to be mined, the first step (work process) is to remove the top layer of topsoil, which can be up to 3 or 5 metres. This is precisely the depth that may be relevant for blasting structures. A bomb, if it does not explode on impact, can be buried in soft soil in a marshy area to a depth of up to 3–4 metres. In the case of mines, artillery shells or grenades, the maximum depth is around 1 metre.

It is therefore worth examining the area first from the point of view of combat operations and then, if relevant, using metal detecting instruments or ground penetrating radar. The ground-penetrating radar method allows the spatial delineation of objects in different depth ranges depending on the frequency range used.[14] Further work processes may of course vary depending on the contamination of the area. The formula is very simple, if nothing is found in the preliminary investigations, then site preparation (excavation) can be carried out on an ongoing basis. If any ordnance is found during the search of the area, then it is necessary to check whether it is in a spent state or left on the site during the fighting. It is also possible that the explosive device may have been placed on the site during preventive earthmoving or backfilling. It may complicate the situation if only non-explosive ordnance is recovered. This could indicate that there was fighting in the area, but it could also be that the area is simply contaminated with scrap metal. In such cases, a search of the area is strongly recommended,

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[13] Daruka 2024.
[14] Elek et al. 2000: 1–3.

although this may be costly. In any case, it is also worth identifying the scrap metal, as it may well have once been a component of an explosive device (shrapnel). Where shrapnel is present, it is easy to find intact, spent explosive devices, which is a risk factor.

Clearance of areas from explosive devices

The first step in any modern investment or construction project is to scan and clear the area designated for the project of military contamination and materials. This is a practice that investors and contractors are increasingly insisting on. It is this wise foresight that avoids unforeseen problems during construction. As it was mentioned in the introduction, if an area has been affected in terms of military operations, it is certainly justified to carry out screening and de-ammunition of the planned investment area. Depending on the task to be performed, the options may vary from country to country. On the one hand, law enforcement agencies (police, armed forces) often have their own tasks in the field of explosive ordnance disposal, while on the other hand, many civilian organisations carry out search and screening activities.

It is important to stress that NGOs (non-governmental organisations) may only carry out the following activities:

- activities in support of the activities of the Bomb Disposal Service
- search only
- surveillance at certain sites[15]

They are not authorised to move or handle suspected explosive devices; in all cases, this is an activity to be carried out by the law enforcement agency under a statutory authorisation.

There are a number of organisations that claim to do the clean-up work, but do not actually do it themselves, but subcontract it out. This not only increases costs, but in the event of a problem it is not entirely clear where the subcontractor's or main contractor's responsibility lies.

When contracting out clearance tasks, it is a basic requirement to check the technical equipment of the contractor, which includes search equipment and a technological description of how the task will be carried out. Properly operating organisations have full liability and accident insurance for the performance of their activities and carry out their tasks in accordance with the requirements of a quality management system, with continuously documented training and monitoring.

The cost of conventional ammunition recovery can vary in magnitude, due to the fact that costs are quoted in EUR/m^2 or on a case-by-case basis. The cost of high depth – drilled hole – screening also varies because it depends to a large extent on the number of holes drilled and the depth of the screening. The price of underwater exploration is also different, with costs being determined on a case-by-case basis according to the nature of the work.

[15] Ember 2024: 70–71.

For several companies, it is specified as a parameter that they undertake archaeological works, new investments, roads, industrial parks, logistics centres, business centres, recreation parks, office buildings, apartment blocks, petrol stations, any kind of construction and other land before or during construction. I think it is important to note that archaeological activity is a completely different legal activity, which is not only time-consuming but also requires a different set of procedures. If archaeological finds are discovered during a project, this can usually affect the start of construction work by months, but depending on the quantity of finds and the size of the site, it can also affect the start of construction work by years. Add to this the costs and the continued presence of the demining company and the construction itself will start with a huge deficit. In addition, it should be borne in mind that in areas designated for demilitarisation, where demilitarisation and instrumental inspection are not possible, specialist supervision by a fire brigade will have to be provided for the duration of the excavation work, which may have a separate price and hourly rate.

Traditional instrumental search

During construction, environmental protection and other works and surveys, it is necessary to locate, identify and defuse explosive devices of military origin in order to protect the persons, machinery and equipment involved and to reduce safety risks. The traditional method is to search using ground-based instruments.

Figure 3: GARRETT ATX metal detector
Source: https://www.metector.hu/products-page/buvar-vizi-felhasznalas/garrett-atx-femkereso-detektor/

Ordnance clearance, ordnance survey, instrumented ground investigation

Main aspects of the work:

- marking out the area to be demined, the section to be drilled, using a high-precision locating device
- carrying out a search survey using a search instrument
- detection of markings and carry out primary identification
- taking the necessary safety measures, assisting in taking them in other cases
- preparation of technical documentation, acceptance of responsibility and certification

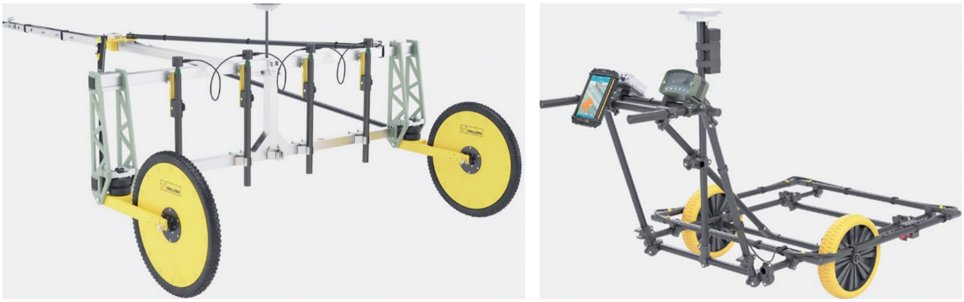

Figure 4–5: WALLON metal detector
Source: https://www.metector.hu/products-page/adatrogzitos-femdetektorok/adatrogzitos-femdetektor-nagy-terulet-felmeresehez/

Demilitarisation, firearms survey, instrumental ground survey with 2D and 3D map production

Main aspects of the work:

- marking of the area to be demined and the parts to be drilled with a high precision locating device
- carry out mapping, software evaluation, 2D and 3D mapping using computer aided exploration tools
- marking and exploration of markers based on software evaluation data
- carry out primary identification
- take the necessary safety measures and assist in taking them in other cases

Searching for ammunition at high depth

High-depth ordnance detection is usually used for searching in densely built-up urban areas or in backfilled areas to detect deep objects. These objects cannot be detected by surface inspection in most cases, as surface clearance is either too expensive or impossible if there are rails, pipelines or power lines. The method consists of drilling holes at 1 to 2 metre intervals in the search area, approximately 9 to 10 metres deep. In the case of sandy, loose soils, collapse must be prevented and non-magnetisable liner pipes must be used. Once the drill holes have been made, the instrument can be applied to each hole and the number of marks to be made at different depths can be determined by analysing the drilling points.

The drilling of holes to a depth of 8–10 metres take a considerable amount of time, at a rate of approximately 4–6 holes per working day. The analysis of the sounding and measurement data and the preparation of the documentation will be done in parallel with the drilling work and will therefore not result in any additional time loss.

Special munitions search missions

Often, due to extreme weather conditions or natural and man-made obstacles, standing or flowing water can develop in an area of interest to us. In this context, we must also be prepared for the possibility of having to carry out "special underwater munitions searches" in both stagnant and flowing water. This is limited to the following areas, depending on the type of task and the characteristics of the area:

- complete search of underwater areas, clearance of munitions, excavation of beds, or any work to be carried out safely in water
- search for lost (hidden) objects underwater
- search for wreckage, sunken vessels, barges, aircraft, search for ordnance, clearance of ammunition if necessary

The special munitions search method consists of searching the area from the surface of the water with the instrument and, if the detector indicates the presence of metal objects, the bed and subsoil are searched with the help of divers.

Project management, monitoring

Demilitarisation, fire inspection and instrumented soil testing is a complex activity, from the moment the need arises to the handover of a contamination, explosive and blast free area. In the cleared and screened areas, the explosive hazard can be eliminated or its risk greatly reduced. The activities of the service providers cover the process of munitions clearance, bomb clearance, fire safety screening, instrumented ground testing, and the management and control of the process.[16] In this context, the following workflows may occur:

During the period of technical preparation:

- preparing proposals for the safe execution of the works
- identification and assessment of time, equipment, materials and risks
- technical evaluation of tenders, making proposals to the client

During the technical execution phase:

- maintaining constant contact with the company carrying out the decontamination
- preparation of reports, continuous monitoring of the progress of the work
- monitoring the work of the demilitarisation company at the request of the client
- carrying out on-site inspections of the areas already cleared and awaiting construction as part of the technical handover[17]

[16] Vörös–Daruka 2012: 23.
[17] Daruka 2010: 4–5.

During the final phase of technical construction:

- quality control of the demilitarised areas
- on-site quality control of the de-armed area using a search and detection instrument
- preparation of final reports, findings and tasks related to quality assurance

De-armament planning

Almost the whole of Europe was a theatre of war by land and air during World War II. Today, its influence still poses a significant threat. During operations, battles and battles fought, the combatants deployed the full arsenal of combat equipment. However, military explosive devices (bombs, mines, projectiles, ammunition, grenades, etc.) were only partially effective. As a consequence, dangerous devices were placed below the surface and have been detected, deactivated and disposed of, including by means of munitions disposal.

In order to avoid accidents and to ensure the safety of construction and work in the area, it is necessary to assess, evaluate and minimise these risks. The assessment should be made during the planning of the technical – preparatory works. When carrying out a de-armourisation study, an answer must be given to the general principles of de-armourisation of the project site.

General conclusions are drawn from combat operations for the performance of subsequent tasks. Evaluate and characterise the combat, the military explosive devices likely to be encountered and their risks. The expected technical preparation tasks, demilitarisation costs, basic demilitarisation standards, methods, times and expected demilitarisation risks are discussed.

De-armament impact assessment

The purpose of a de-ammunition or bomb disposal impact assessment is to identify and assess the likelihood of unexploded ordnance or explosive remnants being found during urban development projects, and includes a detailed description of the bomb disposal technology, bomb disposal contractor fees, lead times and regulatory environment.

The events encountered during the preliminary examination and subsequent de-ammunition phase, the recovered explosive devices and the actions taken in relation to them are also documented to provide a realistic picture for experts and military historians.

Without the preparation of a BIA, explosive devices, explosive remnants or ammunition discovered during the execution of a planned construction project within the municipality may pose a risk or require unexpected, unforeseen firefighting response, which may seriously affect the cost and feasibility of the planned project.

In this study, conclusions are drawn on the preparation and execution of a fire investigation, instrumented ground investigation and the fire risks associated with the above processes.

Field measurements and excavations are carried out to identify the explosive devices likely to be encountered and to assess the metal contamination data.

De-ammunition plan

The summary name of the specific de-ammunition, ordnance and instrumented ground investigation plan for the project area. The plan shall specify the expected technical preparation tasks and their duration, the cost of the demilitarisation, the demilitarisation baseline standards, methods, times and the expected demilitarisation risks associated with their implementation.

Conclusions

Regardless of the type of investment, bringing different areas under cultivation is always a task that requires a great deal of attention and care. I have shown that unexploded ordnance from wars can still pose a serious threat today, and that a historical check of the site is therefore recommended before any investment is made. If any documents or the memories of the local population suggest that the area has been the scene of fighting or military action, it is necessary to contact a specialist company and ask for a preliminary investigation. In the lucky event that no explosives are found, the project can proceed as planned. If an explosive device or its remnants is found, it is recommended that a full munitions clearance is carried out and the project is continued. In most cases, the top layer of topsoil, which can be a few metres, must be removed when a mine is being constructed and then the hard rock is accessible. In many cases, it is possible to find contamination (municipal waste) when removing topsoil. In this case, one should be suspicious that other objects, which may also be dangerous for the workers on site, may be found together with the rubbish. Of course, we should not forget explosive devices that are loaded with some kind of chemical charge, so in the event of an explosion, they could contaminate the area, which could cause further problems.[18]

Most of the mines are often located far from towns and other built-up areas, so it is unlikely that large quantities of munitions would be found when excavating them. It is therefore essential to check the history of the area, and if there is the slightest chance that there may have been fighting or a military presence, to carry out the necessary investigations. I would also like to point out that explosive devices left behind during the world wars may now be in such a state that even the slightest movement could be life-threatening, so I would ask everyone to notify the authorities if they find such a device and keep a safe distance from them. Many people think that, from an economic point of view, they would rather not carry out the necessary tests, saying "there's nothing there anyway", but when an explosive device turns up and the investment process is halted for weeks or months, they realise that this was not such a good idea.

[18] Berek–Ember 2023: 32–37.

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