Two Mortar Bombs from June 1664

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Sampling and material analysis

In the spring of 2008, four cannonballs were discovered during earthmoving in the area. The finders handed them over to Lajos Jancsecz, Mayor of Belezna, who sent them to the Museum of Military History. Based on the types and finding places of the projectiles, it is supposed that they got there during the siege of Zrínyi-Újvár in 1664. Based on their size, the two balls with a diameter of 26 cm were identified as mortar bombs. Additionally, they both had a well-recognisable ignition hole, one of which was opened up by the finders. When moved, the remains of gunpowder fell out of the ball in the form of black lumps. The sample thus obtained was subjected to a material analysis. According to the analysis, this material could no longer be regarded as gunpowder, since saltpetre and sulphur had completely transformed over the centuries, so there was no danger of explosion. The second bomb was completely intact, so we tried to find a testing method that would provide the most information for science. The nearly 6 cm thick wall of the bomb made X-ray examination impracticable. First, we designed a tubular drill probe with which we wanted to remove the fuse together with a sample of gunpowder beneath. This solution would have left the iron bullet intact, but would have made only partial examination possible. Finally, we chose the easiest method and cut the bomb in half. The size of the ball did not allow laser cutting. We also ruled out cutting with plasma and water jet because it could have damaged the fine powder. Eventually, the easiest solution remained; namely, cutting the bomb in half with a disc, which was carried out by researchers of the Bay Zoltán Institute of Materials Science and Technology. The extremely hard wall was cut in half and then split in two. In this way, crystalline inclusions that developed in the iron shell structure while the cast was cooling became visible. The section of the bomb showed clearly that moisture seeping through the ignition hole had dissolved the particles of gunpowder. Afterwards, various substances were concentrated at certain parts of the interior of the bomb. This was suggested by the coloured stripes visible on the cross-section and precipitation that appeared a few days later.

We were pleased to discover that the gunpowder was preserved in its original granulated state on one side of the ignition tube. The sample taken from there made possible the material analysis of the gunpowder.

The marks seen on the cross-section proved that it was the right decision to cut the ball in two. The sample taken with the originally designed probe tube would not have given representative results for the original filling due to the uneven distribution of the material.

Besides the two mortar bombs, two balls with a diameter of 17 cm were also taken to the museum. It was not until May 2009 that they were cleaned, because they were first believed to be solid iron balls used with siege cannons. Their diameter was the same, but the weighting caused a surprise, as one of them was 6 kg lighter. A closer examination revealed the outlines

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of the casting spine and the ignition hole, which was indicative of another mortar bomb. Due to our previous results, there was no doubt that we should cut this one in two, as well. In the meantime, our institution acquired the necessary equipment, so the work was carried out by József Prím, a restorer at the Museum of Military History. We were surprised to find that the fossilised powder had perfectly preserved the internal structure of the smaller projectile. However, after cutting the iron shell, the gunpowder filling also had to be cut with an iron saw.

The section clearly showed the wooden part of the ignition tube and the fine powder inside. In a layer of about 3 cm around the ignition tube, the grains of the originally filled-in gunpowder were preserved.

The cross sections of the bombs revealed that the crystallised incrustations got thicker towards the inner side of the iron shell. Additionally, there was an iron spike in the cast opposite the ignition hole.

Mortar cannons are the forerunners of today's rocket launchers. Their bombs fired at a steep trajectory were able to kill enemies hiding behind fortress walls and obstacles, or in ditches. Their firing range was not large. They were usually fired at targets within 300 steps, but it was this special firing mode that allowed the guns to be brought close to the enemy hiding from them behind a rampart or in a firing station dug into the ground. Their orientation was completely different from that of the cannons. While in the latter case, the barrel was aimed directly at the visible target and the projectile was fired at the target, the gunner of the mortar did not need to see the target directly, but set the barrel at a certain angle and drop the ball onto the target.

The projectiles of mortar cannons included stone balls and bombs with an iron shell. The stone balls were usually made of limestone and used during the sieges of fortresses. The steeply shot and then falling stone ball had significant kinetic energy. It was able to break through protective roofs. In case of multi-storey buildings, it could also break through every ceiling in its way to the basement. It was useful against live force, especially when it hit a hard surface on which it exploded into pieces causing terrible wounds. The most effective ones were the solid marble balls with a homogeneous structure.

The bomb has three main parts: the hollow iron ball, the powder filling and the ignition tube. The iron shell of the projectile was cast from a material with a high silicon content, which made it hard like glass, and, at the same time, burst into shrapnel more easily. The inner cavity of the ball was formed by casting around the spherical core put in the centre of the mould, which was held in place by a wooden rod led through the ignition hole. An iron tip was attached to the termination of this, which extended beyond the core and fixed it to the metal poured in during casting. After the cast had cooled, the inner sand core was removed from the sphere through the ignition hole. However, the iron tip of the fixing wooden rod was left in it melted into the cast. In practice, as a result of the forces exerted during casting, the wooden rod moved slightly, which often resulted in a lateral asymmetry in the thickness of the sidewall. In the vertical direction, there is a more marked difference in the thickness of the shell, as the side facing the ignition hole was deliberately cast thicker. The purpose of this was to keep the ignition hole upwards to prevent the ignition tube from getting damaged during the impact.

The gunpowder filling consisted of gunpowder pellets with a diameter of 2–4 mm, which indicates a high level of knowledge of the burning properties of gunpowder. Gunpowder burns in layers, that is, on its surface that was in contact with air. If the projectile body was filled with fine powder, after firing, it would flare up in a huge flame through the fuse hole like a rocket. Conversely, in the air between the powder pellets, the fire spreads quickly and the entire surface of the pellets starts to burn. The ignition proceeds gradually towards the centre of the pellet. The duration of the ignition depends on the size of the pellet: the larger its diameter, the longer the burn. From the perspective of the explosion, the quantity of the gases produced during combustion and the duration of gas formation are relevant. One litre of gunpowder produces approximately 500 litres of gas. Fine gunpowder burns up in a very short period of time producing a lot of gas quickly, so the process takes place in the form of an explosion. This explains why the projectile was filled with finely granulated gunpowder. In contrast, in case of gunpowder used for firearms, the objective is to keep gas formation continuous, at least until the projectile leaves the barrel.

The ignition tube made possible the timed burning of the gunpowder filling. Gunpowder was pressed into the borehole of the wooden tube in the same diameter as that of the tube. After setting the powder on fire, it burnt at an even speed, usually one centimetre per second. Before firing, the master gunner cut the ignition tube to a length relevant to the flying time of the projectile and then pressed it into the ignition hole using a tool dedicated to this purpose. It could not be hammered because the gunpowder pressed into it would have broken.

Before shooting, the gunpowder chamber of the mortar cannon was filled with powder, and then the bomb was placed on the powder with its ignition tube facing outwards. At the time of shooting, the ignition tube of the bomb was first lit through the mouth of the barrel, and the mortar was fired.

In truth, after several years of research, the discovery of the bombs came as no surprise. In the area of the Ottoman siege trenches the shrapnel of numerous large mortar bombs were discovered, so I secretly hoped that we would also find an unexploded projectile sooner or later. During the examination of the finds we bent a soft tin solder wire over the curved wall of the cleaned pieces of shrapnel, and with the help of the curved wire we drew the cross-section of the projectile. According to this, the armoury of the defenders comprised mortars that could fire thin- and thick-walled bombs with a diameter of 35, 30, 27, 25, 19 and 16 mm. During the investigations, we discovered 16 pieces of bomb shrapnel in one place at a depth of half a metre, which belonged to the same projectile. One part of the burst shell must have got pressed into the soil when the projectile hit the ground. Measurements have shown that the discovered pieces formed 30% of a 30 cm diameter bomb, suggesting that about 45–47 pieces of shrapnel weighing 1.2 kg on average flew apart.

No shrapnel belonging to a bomb with a 17 cm diameter was discovered in the territory of the Ottoman siege trenches, so it probably belonged to a projectile used by the Ottomans. Large bombs were found outside the fortress, but in the territory of the Ottoman siege trenches we found a piece of shrapnel with a size of this. Based on this, it is certain that the Christian army possessed and used such bombs. There are two possible answers to the question of how the two bombs came to the Ottoman siege area. They could have been booty belonging to the Christian guns left behind at Kanizsa, but the Ottomans could also take them from Zrínyivár once they seized the fortress. Pál Esterházy's diary reveals that during the days before the fall of the fortress, all the cannons were moved to the other side of the Mura. However, a part of the ammunition may have been left behind and captured by the Ottomans, who removed the usable war material before blasting the trenches. Eventually, because they did not have any mortar cannon in the size of the bombs, they left the bombs behind.

Based on the finding place of the pieces of shrapnel, their actual range was 150 m. The piece of shrapnel of the large mortar bomb was found about 200 m from the courtyard of the fortress, which corresponds to the data of 300 steps found in contemporary military books.

The data of the bombs

The larger projectile has a flattened spherical shape. It is 26.5 cm wide and 26 cm high. The thickness of the wall is 4 cm at the ignition hole, 5.5 cm at the bottom and varies between 5 and 5.5 cm at the sides. The inner chamber is a sphere with a diameter of 17 cm, into which theoretically about 4.8 kg, that is, 2.572 litres of gunpowder could be filled. It weighs about 58.5 kg. The diameter of the ignition hole is 5 cm, and the wooden plug is about 4 cm thick. The length of ignition tube is approximately 8 cm.

Figure 1.
The cross-section of a 26 cm diameter mortar shell
Source: picture made by the author

Figure 2.
The cutting of the 17 cm diameter shell
Source: picture made by the author

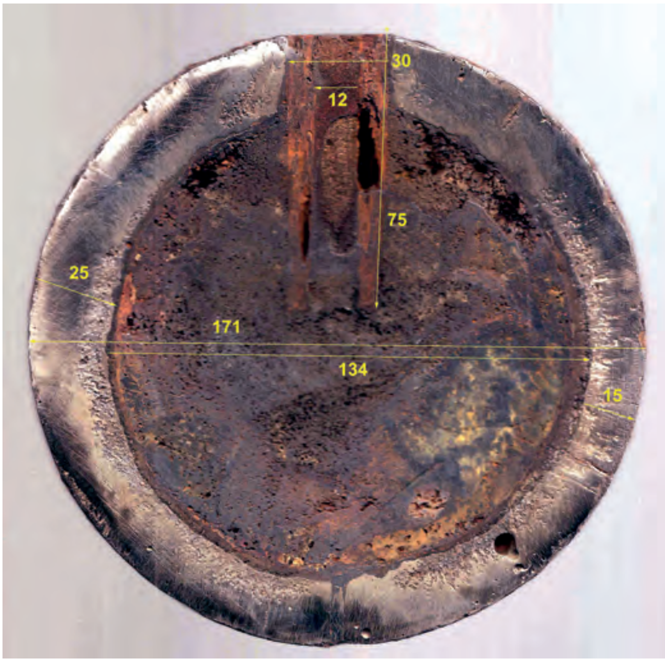


Figure 3.
The cross-section of a 17 cm diameter mortar shell with the remains of the ignition tube
Source: picture made by the author

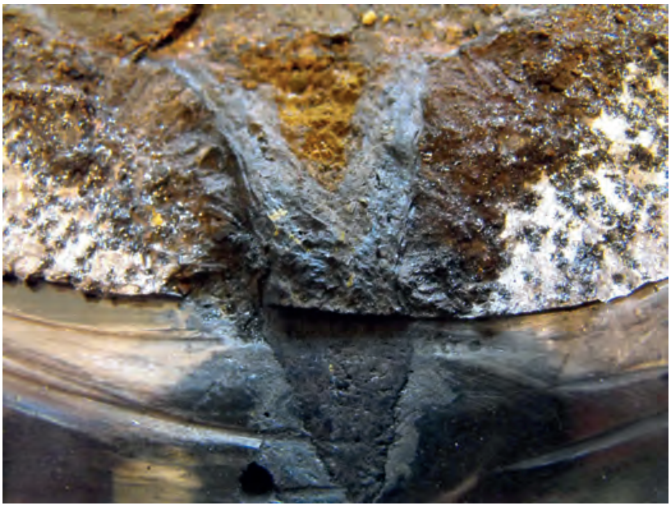
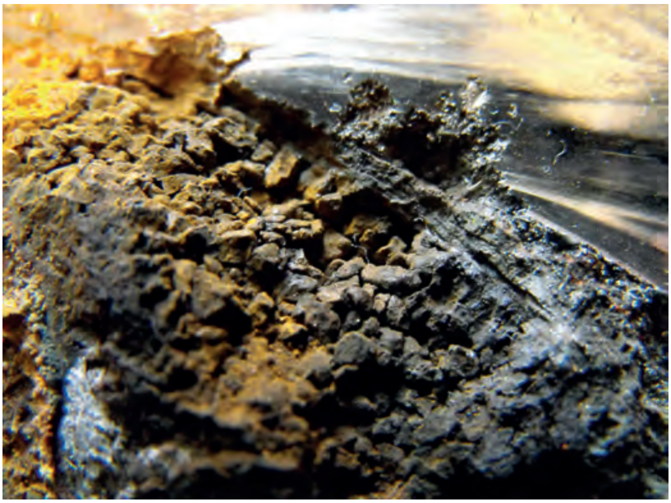
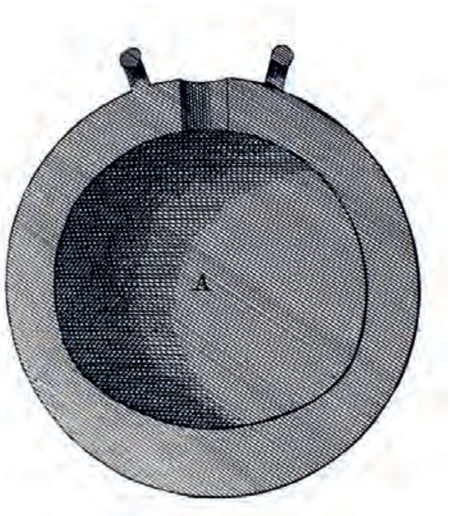


Figure 4.
The remains of the iron spike fixing the core
Source: picture made by the author

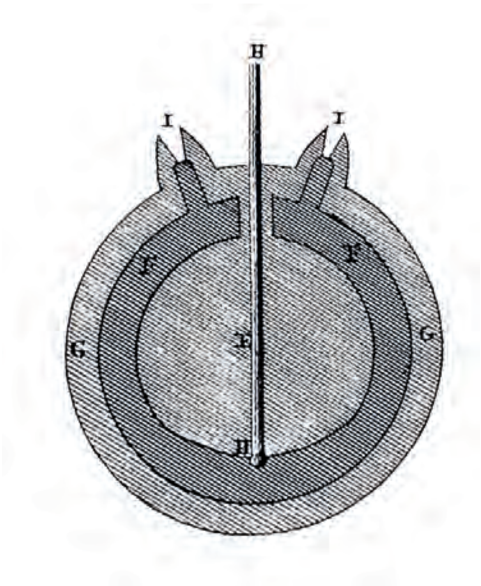
Picture 5.
The fuse hole of the 17 cm diameter shell
Source: picture made by the author



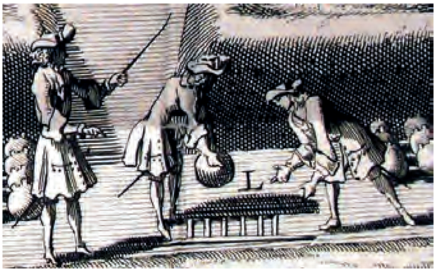
Picture 6.
The remains of gunpowder pellets on one side of the ignition tube
Source: picture made by the author



Picture 7.
The representation of a projectile in a contemporary artillery manual
Source: Surirey de Saint Remy 1702. 245.



Picture 8.
The moulding of a mortar shell, the iron spike fixing the core marked H
Source: Surirey de Saint Remy 1702. 300.



Picture 9.
Inserting the ignition tube

Source: Surirey de Saint Remy 1702. 254.

Picture 10.
Filling the mortar

Source: Surirey de Saint Remy 1702. 254.

Picture 11.
Firing the mortar

Source: Surirey de Saint Remy 1702. 254.