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Application of analysis of aerial photographs in search of burial sites of victims of war and totalitarian crimes

Summary

The search for invisible and clandestine burial places of victims of wars and totalitarian crimes is a very difficult task. Research and exhumation teams use various methods to help locate burial places. According to the experience of our team, one of the best sources of information about burials are archival and contemporary aerial photographs. During World War II, aerial photography became one of the most important tools for warfare reconnaissance. For this reason, huge numbers of aerial photographs are currently available, in which the victim's burial sites have been accidentally recorded. Aerial photographs are often helpful not in the direct identification of graves, but in the reconstruction of topographies of individual objects within a defined period of time, and thus, indirectly, in the location of graves. The aim of the study was to demonstrate the usefulness of historical aerial, satellite and drone photographs in the process of searching for the remains of victims of armed conflicts and totalitarian crimes. The paper presents the experience gained in the course of research projects carried out.

Key words: aerial photography, drone, exhumation

Introduction

The search for hidden burial places of victims of wars and totalitarian crimes poses a major challenge. Exploration and exhumation teams use various methods to help them locate burial places, such as georadar- or electrical resistance-based methods, drillings and survey excavations. In the event of a number of armed conflicts, the search is hampered by the passage of time between the victims' death and the commencement of field work. Research is complicated by the fact that the perpetrators had often attempted to conceal the burials of their victims. In addition, the memory of living witnesses is often unreliable and their testimonies tend to be vague. Data from historical documents very rarely accurately specify the location of graves. All this makes it necessary to use methods that help to reveal the places sought. Increasingly, search and identification teams are made up of experts in the fields of forensics and forensic medicine, supported by other scientists. The experience gained by specialists in the course this research provides an opportunity to apply the same methods in contemporary matters. In the opinion of our team, one of the best sources of information are archival and contemporary aerial photographs. During World War II, aerial photography became one of the most important tools for warfare reconnaissance. The effectiveness of bombardments was photographed, targets were identified and occupied areas were inventoried after the end of hostilities. Thus, today we have a huge number of aerial photographs available, in which the victim's burial sites have been accidentally recorded. Aerial photography is often helpful not in the direct location of the burial, but in determining what the site under investigation looked like at a the time, which, in an indirect way, contributes to finding burial places. When analyzing the site, we often use aerial photographs taken by different parties to the conflict at different times. In our work, we often encounter a situation when at one and the same location we find the victims of communist, Soviet or Nazi crimes. The possibility of finding burial places in aerial or satellite photography is determined by several elements. Burial mounds are well visible, especially in sunny weather, as the mound casts a shadow on one side, while being lit on the other side (Fig. 1). Additionally, both the mounds and secret burial sites grow differently in vegetation

than the area around them. The very disturbance and mixing of the soil structure results in the grave absorbing and releasing heat and moisture in a different way. As a result, such places at different times of the year look different than the surrounding areas, e.g. they overlap with frost, get covered in snow and freeze in a different way. Often, around the burial site, vegetation is not regenerated for some time, because of infertile soil, which has been displaced from a greater depth. This soil is often of a different colour. For over 15 years, our team has been engaged in searching, exhumation and identification of victims of wars and totalitarian crimes. During this period time, the team exhumed about 10,000 bodies and led to the identification of more than a thousand of them. The team operates in Poland, as well as in Germany, Russian Federation, Belarus, Lithuania, Ukraine, Hungary, Norway, France, Belgium and Latvia.

Objective

The aim of the study was to demonstrate the usefulness of historical aerial, satellite and drone photographs in the process of searching for the remains of victims of armed conflicts and totalitarian crimes. The authors relied on their own experience gained in the course of research projects carried out.

Test sites

This chapter presents selected examples of research conducted by the team.

Burial plot Ł" of the Powązki Military Cemetery in Warsaw

In the years 1948-1956, in this burial plot several hundred people murdered by communists were buried, mostly members of the Polish underground movement. In the years 2012-2014, exhumations were carried out, finding the remains of 196 people. Analyzing aerial photographs from the Central Military Archives, one could observe objects which, as the exhumation has shown, constituted rows of irregular grave chambers. These graves were not in the form of burial mounds, and the place where burials were carried out served at that time as a cemetery rubbish dump, located at the end of the newly established part of the necropolis. Although the graves were leveled out and masked immediately after the burial, anomalies arranged in clear rows were noticeable. These anomalies resulted from the disturbance of the original soil structure, leading to changes in permeability and cohesiveness, which, in turn, causes an uneven growth of such areas by vegetation. Another factor that makes such areas visible is surface exposure of soil of a different colour. Additionally, these sites are exhibiting different snow cover and the ground around them freezes differently. Very often, such anomalies are not visible from the position of the person standing on ground level, but can only be observed from a height.

The first photograph (Fig. 2, Area A), dating back to 1945, does not show any anomalies which could be considered as burial sites, except for a fragment of

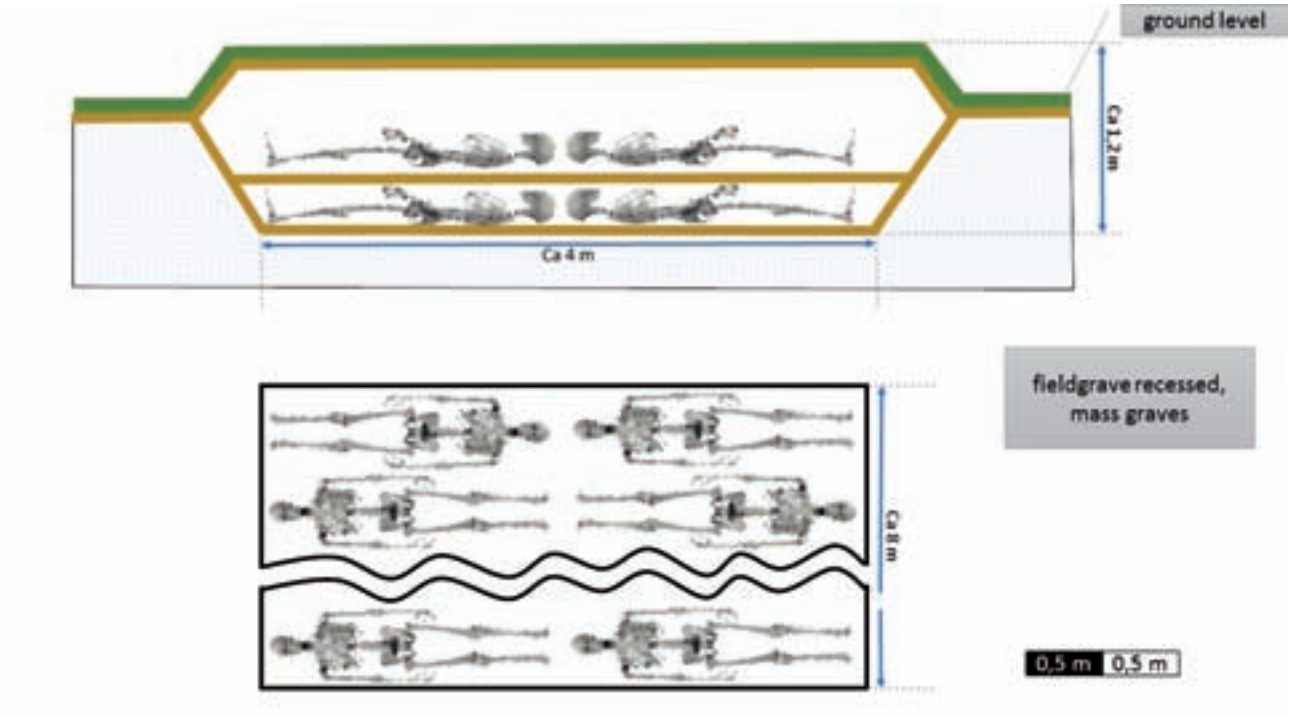

Fig. 1. Sketch showing the positioning of the bodies in the field mass grave embedded in the ground.

the burial plot from the World War I visible in the upper left corner of the photograph. In the photograph taken in 1951 (Fig. 2, area B), several groups of objects are clearly visible: anomalies numbered from 1 to 4 are rows of graves, at the north end of row 3 light sand spots are visible, indicating that burials have recently been carried out there, no. 1 designates a row of graves located along the cemetery wall. In groups 2, 3, 4, burial sites of victims of communist crimes, while in group 1 sanitary burial sites (remains buried in coffins, complete skeletons, fragments of bodies and medical waste) were found.

In the photograph taken in 1953 (Fig. 3, area C), another group of objects are visible. The row of sanitary graves is clearly noticeable (object group 1). Objects 5, 6 are successive rows of graves of victims of communist crimes.

In the photograph taken in 1955 (Fig. 3, area D), one can see additional groups of objects. The objects from the previous photographs are less pronounced, but the row of sanitary graves is conspicuous (object group 1). Objects 5, 6, 7, 8, 9 and 10 are further concentrations of graves of victims of communist crimes. For reasons of transparency, only selected visible anomalies were indicated on the photographs.

Thanks to the analysis of the photographs, the data obtained in the course of research were used to perform exhumation works, during which it was possible to explain the origin of the objects. The works were carried out in the years 2012-2014 within the framework of the project of the Institute of National Remembrance in cooperation with the Council for the Protection of Struggle and Martyrdom Sites, the Ministry of Justice and the Pomeranian Medical University in Szczecin. As a result, the graves of 196 people buried within the so-called "Ł" burial plot were discovered (Fig. 4). The remains found were subjected to the process of individual identification within the framework of the project of the Polish Genetic Base of Victims of Totalitarianism; research is carried out by the Pomeranian Medical University in Szczecin in cooperation with the Institute of Forensic Research in Krakow.

About 60 victims of communist crimes were identified during the six years of research (www.pbgot.pl).

Machliny – field cemetery

In the case of field graveyards, a simple analysis of aerial photography is sufficient to locate the burial plot. Whole burial plots are often visible many years after their establishment. An example could be two burial plots located in Machliny in the West Pomeranian Voivodeship (Fig. 5). The aerial photograph from 1949 shows two burial plots filled with war graves of Polish Army and German soldiers. On the basis of present terrain features, compared to the aerial image taken years ago, it is possible to locate larger objects, such as field cemeteries, prisoner-of-war and

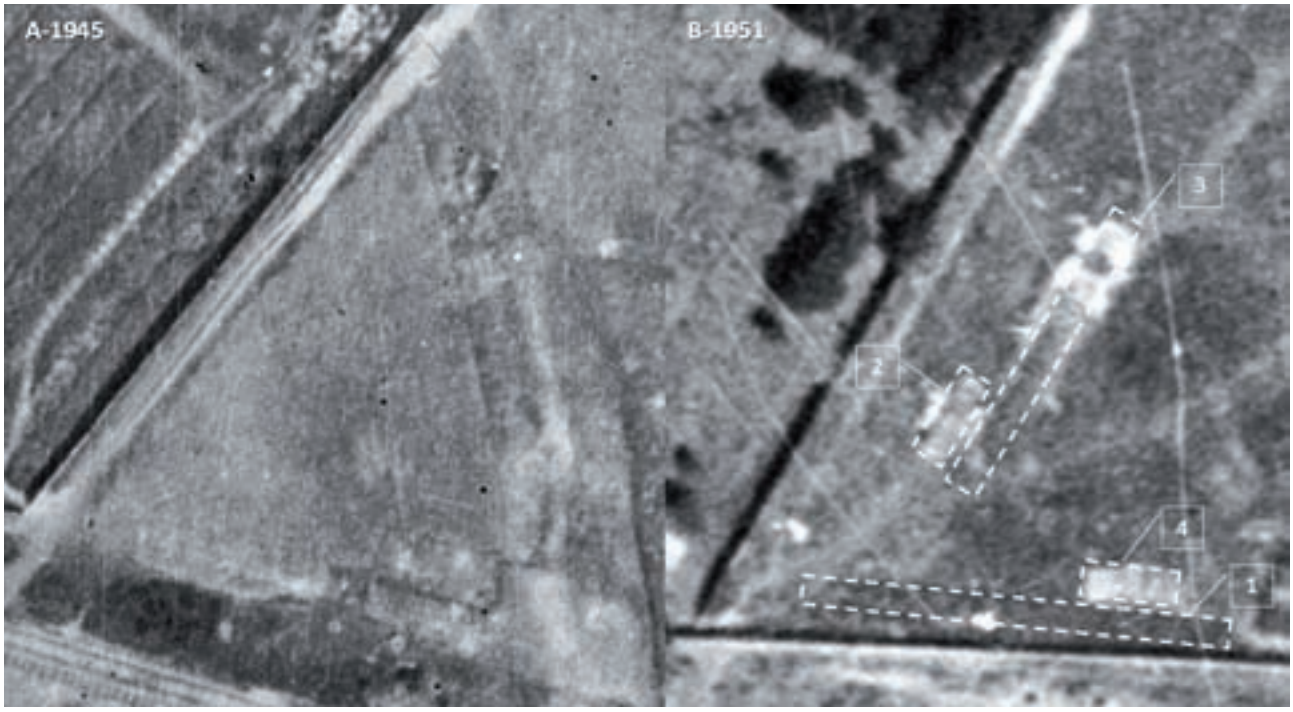

Fig. 2. Aerial photographs taken over the "Ł" burial plot of the Powązki Military Cemetery in Warsaw in 1945 and 1951.
Aerial photograph from the CAW collection, N-34-138-44-379-1945 (A).
Aerial photograph from the CAW collection, N-34-138-03-5394-1951 (B).

Fig. 3. Aerial photographs taken over the "Ł" burial plot of the Powązki Military Cemetery in Warsaw in 1953 and 1955.
Aerial photograph from the CAW collection, N-34-138-04-2043-1953 (C).
Aerial photograph from the CAW collection, N-34-138-09-0104-1955 (D).

Fig. 4. A person's corpse discovered in a burial plot "Ł", a body thrown inert into a trench, face down with hands tied behind the back.

forced labor camps, anti-aircraft batteries, buildings and others. The analysis allows to estimate the war damage, verify the hypotheses concerning the location of buildings, etc.

Information about the existence of a burial plot with several dozen graves of Polish and German soldiers who died during the fighting in February 1945 in the area of Iłowiec, Wielboki and Świerczyna was received by our team at the end of the 1990s from former German villagers. However, they were unable to determine, in which part of the municipal cemetery were the soldiers who died in the fighting buried. Similarly, the military graves did not engrave in memories of the first Polish settlers. Due to the large size of the cemetery and knowledge about post-war burials, survey searches throughout the entire necropolis area were not an option. However, a burial plot of Polish Army soldiers was mentioned.

It was not until obtaining access to a relevant aerial photograph from 1949 that it was possible to indicate the place where the German war cemetery was most likely located (Fig. 5, Field 1) and to confirm the location of the Polish war cemetery within the same necropolis (Fig. 5, Field 2).

The survey and subsequent exhumation works revealed the burial sites of 71 German soldiers. The bodies of Polish Army soldiers were exhumed in the 1950s and transferred to the war cemetery in Wałcz.

Police – prisoner-of-war camp

Works based on the analysis of aerial photography were also conducted in order to verify the shape, size and location of the former German prisoner-of-war camp "Tobruklager" operating at the synthetic petrol

Fig. 5. Aerial photograph from 1949 showing the village of Machliny in Western Pomerania, in the area of which heavy fighting took place in 1945. Soldiers of the Polish and German armies were buried in the cemetery.
Aerial photograph from the CAW collection, N-33-01-3254-1949.

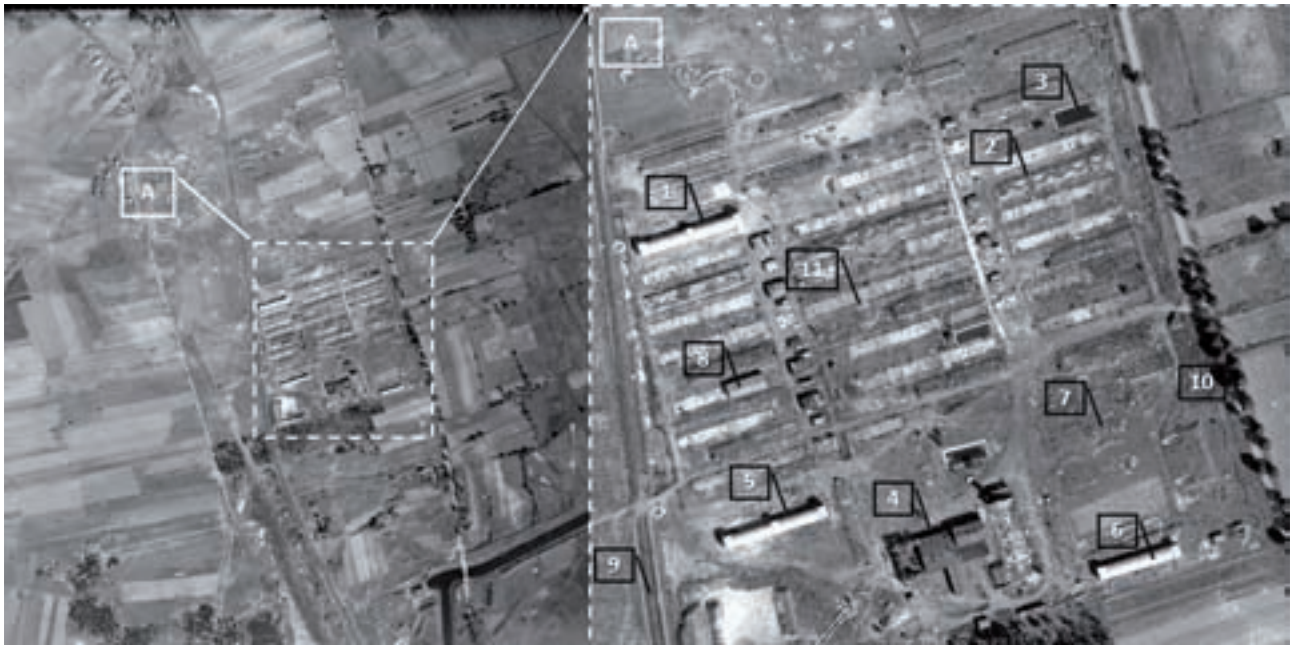

Fig. 6. Aerial photograph showing the "Tobruklager" camp located at the synthetic petrol factory in Police (Hydriewerke Pölitz).
Aerial photograph from the CAW collection, N-33-90-18-9037-1948.

factory in Police (Hydriewerke Pölitz). For many years now, a burial plot has been sought, in which workers and prisoners of war – the victims of Nazi crimes – were buried. The analysis of the aerial photograph allowed to determine the location of the camp and its individual elements, while the cemetery itself was not identified within the camp area. Therefore, it is unlikely that it has ever been present there. The camp was completely

destroyed during the construction of a chemical factory in Police in the 1970s. On the basis of an analysis of the aerial photograph from 1948 (Fig. 6) it was possible to reconstruct its appearance and verify the location and presence of individual objects. Recognized objects visible in the aerial photograph include: 1, 5, 6 – ground shelters of the "Salzgitter" type; 2 – ground shelters; 3 – fire basin; 4 – canteen; 7 – pitch; 8 – utility barracks; 9 – Police-Trzebież railway line; 10 – Police-Jasienica road; 11 – residential barracks.

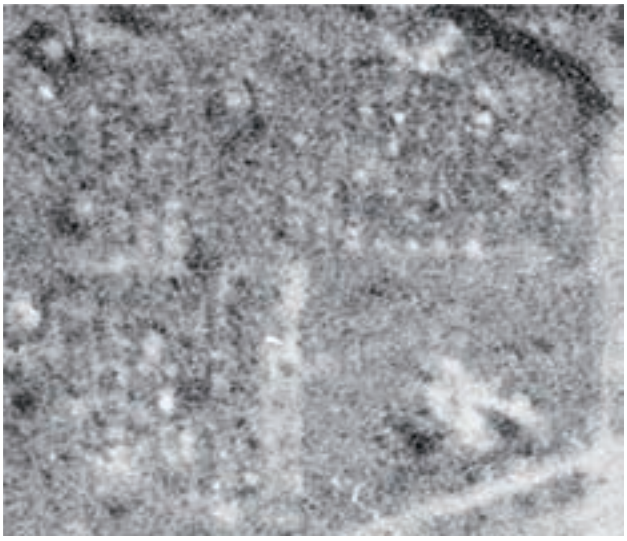

Fig. 7. Burial plot with individual burial sites. Aerial photograph from the CAW collection, N-33-90-18-9037-1948.

Another area selected for exploration was the one south of the synthetic gasoline plant in Police. Analyzing aerial photographs from 1948 found in the resources of the Central Military Archives, a group of characteristic objects were identified that could correspond to the burial plot sought (Fig. 7). In this case, fragments of a satellite photograph were superimposed onto the 1948 aerial photograph in order to find the site location (Fig. 8).

Subsequent analysis of archival documents and the field verification showed that it was indeed a burial plot, but it contained the bodies of soldiers of the Red Army, who died in field hospitals at the end of World War II and afterwards. This burial plot was exhumed in the 1950s. To date, the precise location of the cemetery of forced laborers and prisoners of war working in the production of synthetic gasoline in Police has not been determined.

Szczecin – Central Cemetery

Aaerial photograph from 1948, showing the area of the Central Cemetery in Szczecin, was used for research purposes (Fig. 9). The image shows a German war cemetery where soldiers who died in field hospitals in Szczecin or were brought from the front line were buried

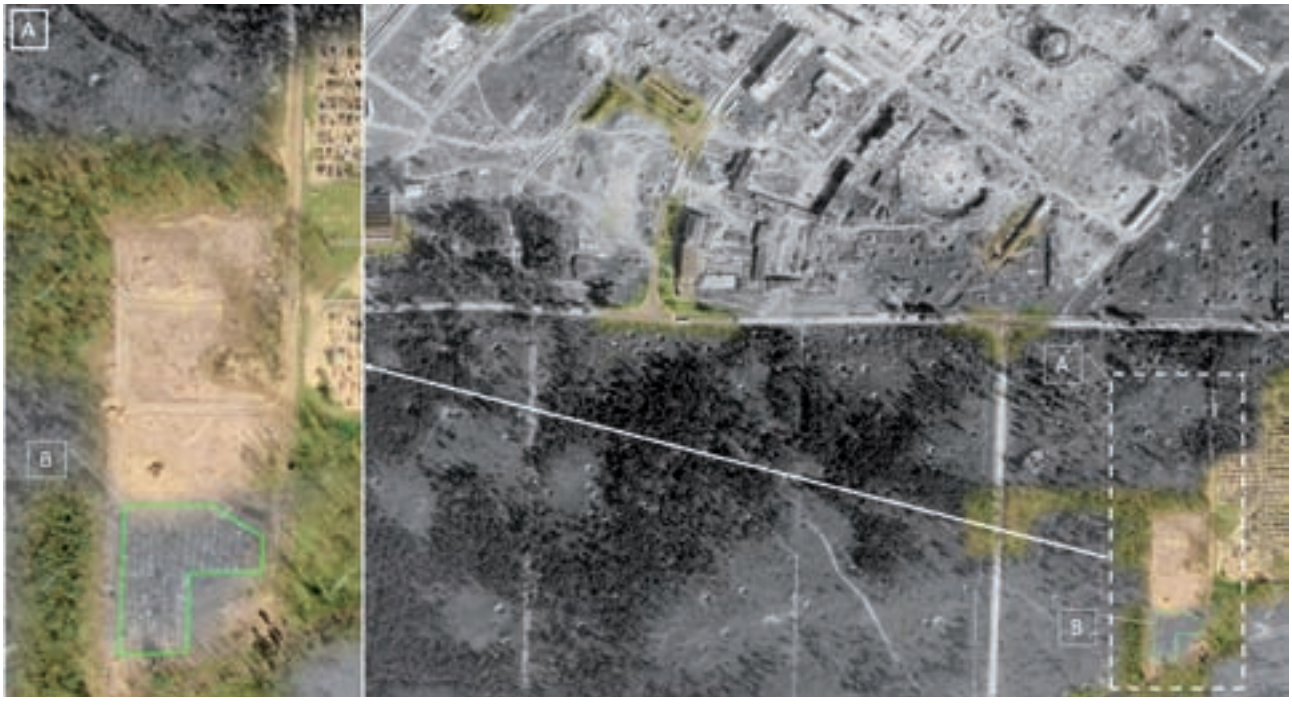

Fig. 8. Processed aerial photograph from 1948 with superimposed fragments of a contemporary satellite photograph showing a burial plot with individual burial sites of Red Army soldiers.
Aerial photograph from the CAW collection, N-33-90-18-9037-1948, superimposed onto contemporary satellite images.

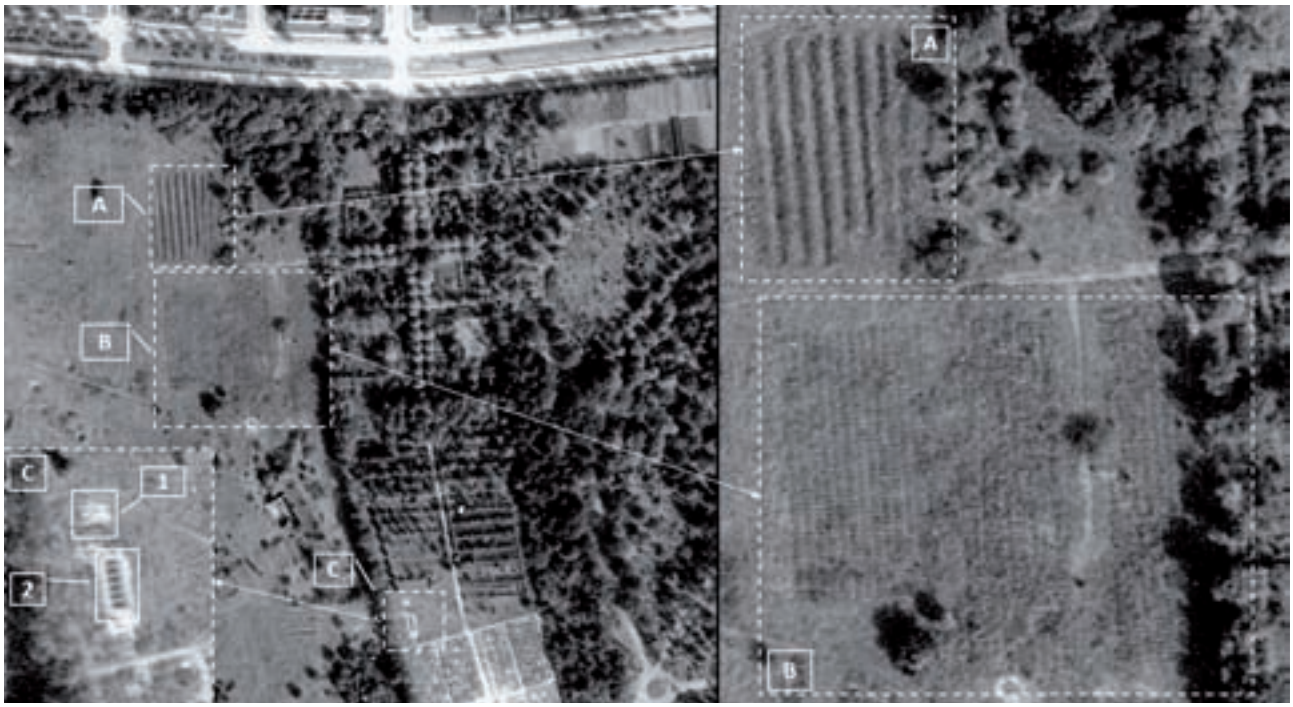

Fig. 9. Aerial photograph taken in 1948 showing a fragment of the Central Cemetery in Szczecin. Aerial photograph from the CAW collection, N-33-90_1-07-8219-1948.

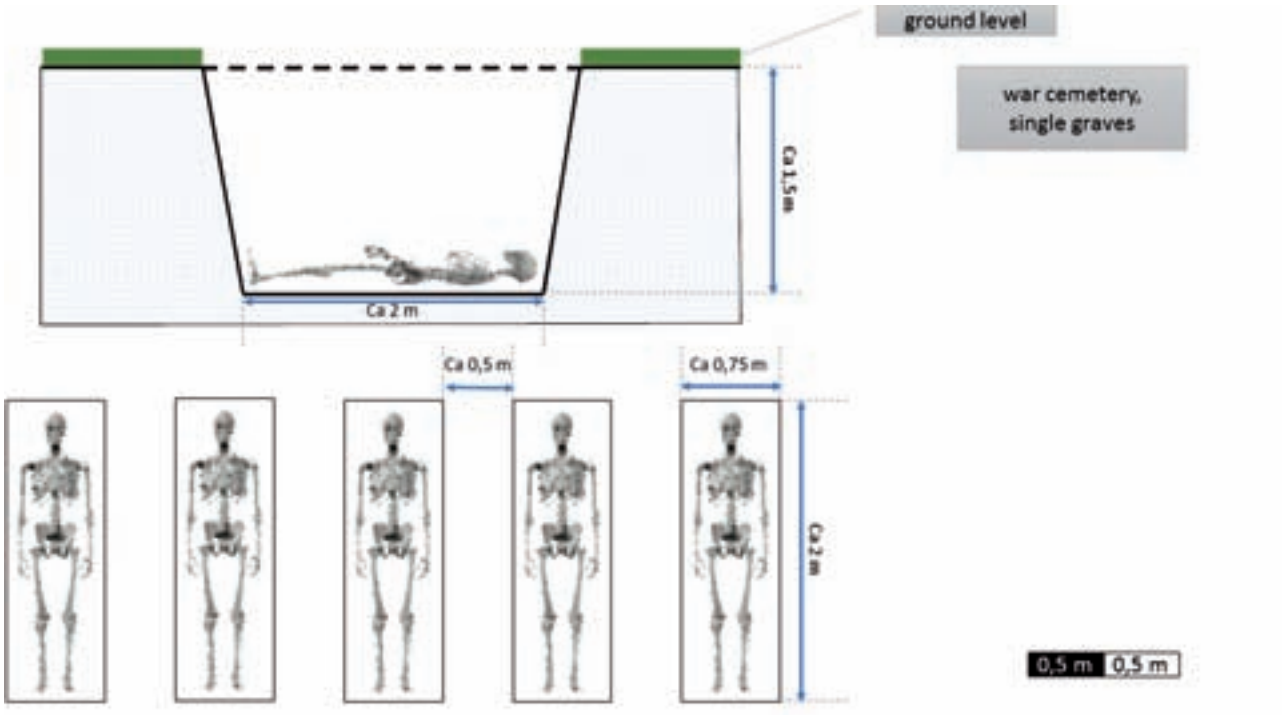

Fig. 10. Sketch showing the positioning of the bodies in the row of individual graves in the regular war cemetery.

(Fig. 9, objects A and B). When zoomed in, the burial plot shows individual graves arranged in rows within object B (Fig. 10). In the area of object A, burial mounds called "comrade graves" are visible, i.e. graves formed by digging a long ditch, in which bodies were laid side by side and covered by a common mound (Fig. 11). These burial plots were exhumed by the Germans in the years 2000-2001, and the remains of German soldiers found were transferred to the war cemetery in Glinna.

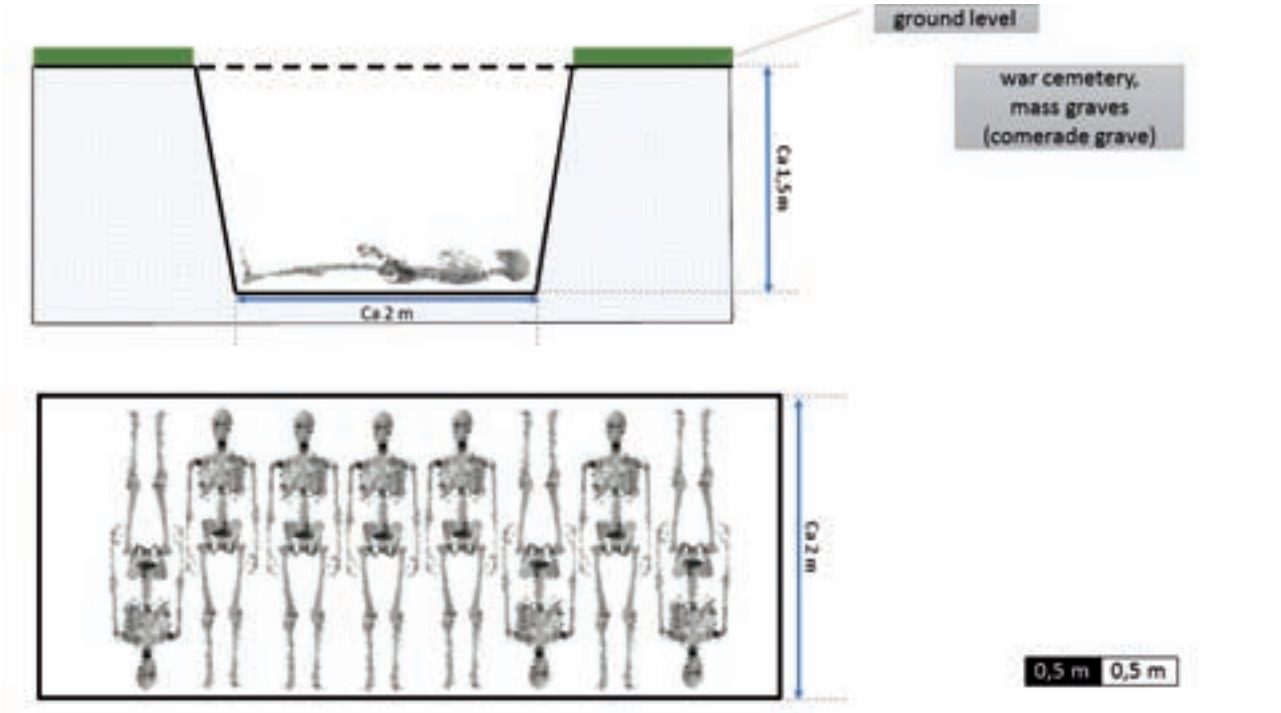

Fig. 11. Sketch showing the positioning of the bodies in the row of mass graves (comerade grave) in the regular war cemetery.

Object C, visible in the same photograph, is a burial plot established in 1945, after the city was taken over by the Polish administration. It contains the remains of the first deceased Polish settlers from Szczecin and others. This burial plot was also used for the victims of communist crimes. The enlarged fragment shows new graves (object 1) in which, among others, soldiers of the Army Combat Unit executed in 1948 were buried. These graves were exhumed in 2009. Three out of five buried bodies were found and identified. Additionally, open grave chambers prepared for burials, indicated as object 2, are visible in the photograph.

Szczecin – Kasprowicz Park

Another example of an image that allowed for the location of burial sites is an aerial photograph taken in 1948 over Szczecin (Fig. 12). In this image, fragment A, one can see long ditches dug up with coffins prepared for backfill. This photograph shows sanitary burials – in 1948, hundreds of bodies were found in the ruins of buildings bombed during the war and in wrecks of ships and barges removed from the Oder River. The victims' bodies were buried in unknown places, and the photograph reveals one of them. In the photograph, five ditches dug out (square A, objects marked 1-5), about 30 m long and 2 m wide are visible with soil embankments around them (object 6). Object 1, filled with coffins spaced apart, is ready for backfill. In ditches 2, 3, 5 single coffins can be seen. The quality of the photograph allows to count them. Five coffins are placed in grave 5, while grave 4 is empty. At a distance of about 60 m from the graves (square B), ten rows of coffins placed near the access road and prepared for burials can be seen. The coffins in the rows can also be counted accurately.

Drawno

The location of a burial site can also be determined by comparing aerial photographs with archival sketches. Based on the location of the objects that have survived to this day (e.g. buildings), the location of the points of interest can be estimated with great accuracy.

An example of the application of this method was determining the location of the mass grave of Soviet soldiers of the 146th Rifle Division killed in the fighting in February 1945 in the Drawno area. A sketch of the location of this grave was published on the www.obd-memorial.ru website by the Russian Ministry of Defense in the division documents (Fig. 13) (www.obd-memorial.ru). The names of soldiers buried here were not recorded in the book of the Soviet war cemetery in Choszczno, which gave rise to the suspicion that the grave was not exhumed in the post-war years. Comparing the outline of the building in the aerial photograph from 1948 (Fig. 14, area B-1948) with the current outline of the foundation (Fig. 14, area A-2014), the location of the grave visible in 1949 (Fig. 14, area A-2014, object 1) was determined with relative precision. North-west of the sheepfold (object 2), a grey rectangular shape casts a shadow (object 1). The nature

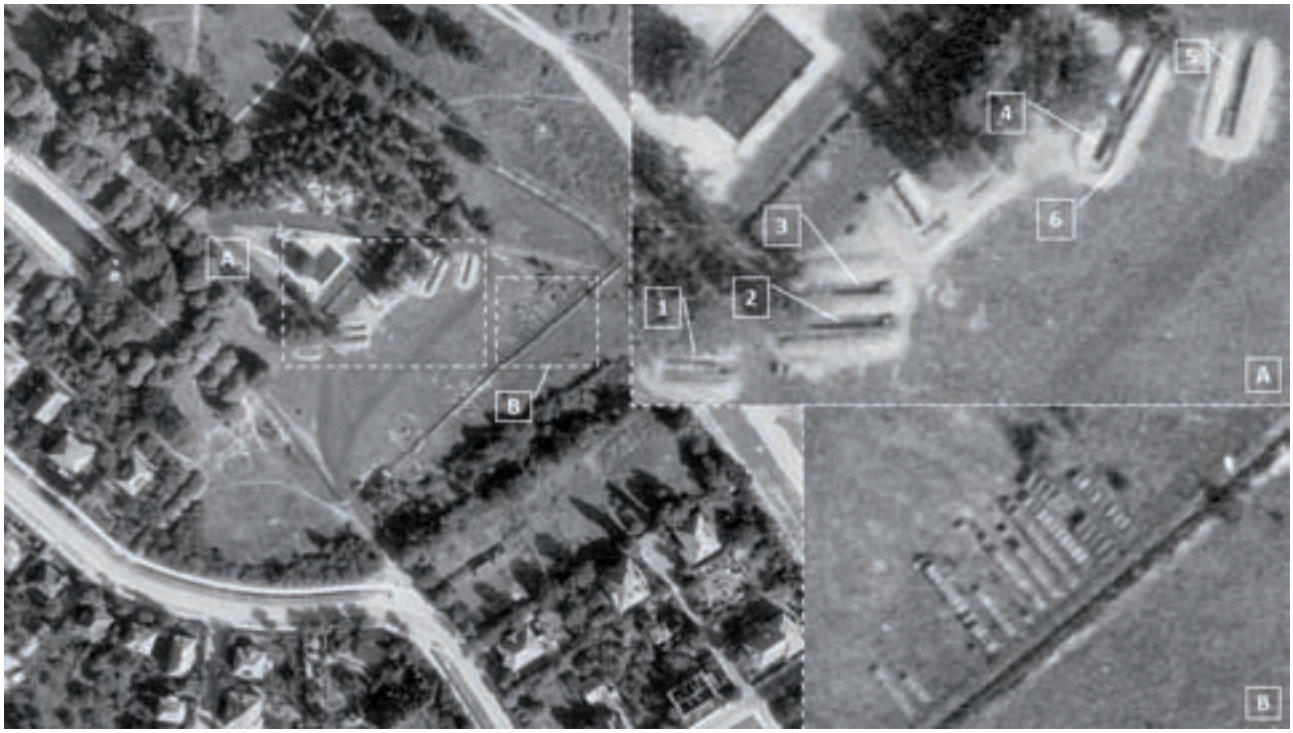

Fig. 12. Aerial photograph taken in 1948 over Szczecin showing the coffins being laid in mass graves. Aerial photograph from the CAW collection, N-33-90_1-05-8107-1948.

of the anomaly indicated that it could be a sought-after mass grave. In 2014, photographs were taken using the Vision 2 drone with the GOPro3 camera. Even though several decades had passed since the burial, the place where the grave was located was still visible (Fig. 14). Object 3 is a residential house and object 4 corresponds to a utility building (pigpen).

A survey carried out in 2014 revealed the existence of a post-exhumation pit, which leads to the conclusion that the corpses of soldiers were transferred to the war cemetery, while the documentation of the exhumation works carried out in the 1940s or 1950s has not been preserved. Soldiers were probably transferred to the war cemetery in Choszczno.

Nętkowo

An example of the use of photo calibration is the area where the German front line of the 5th Rifle Division was broken by the Soviet 3rd Army on March 1, 1945 in Pomerania Calibration consists in superimposing a photograph onto a contemporary map, in line with characteristic points, and then importing the created photomap into the GPS device Both Soviet relations and German reports indicated large losses suffered by German infantry on the front line as a result of mass artillery fire[1]. Post-war relations claimed that the fallen German and Soviet soldiers were buried temporarily on the battlefield within field fortifications or inside explosion craters.

The location of the German defensive positions on the basis of archival documents was not possible due to the vast area without distinctive characteristic points (hills, faults, streams). It was not until the calibrated archival photographs from the Central Military Archives, taken in 1949, were used, that the first line of German defence was discovered and the first exhumation works carried out (Fig. 15). In the photograph analyzed, a broken line of fortifications can be seen. Two objects were listed: A and B. In area A, a broken trench is visible, marked with numbers 2 and 3, and a heavy machine gun nest (Fig. 1, area A, object 1). Field inspection has made it possible to find fortifications visible on the photograph. Using a GPS device, the remains of two German soldiers were discovered within the machine gun nest. In object B, a trench marked with the number 6 as well as three positions of 20 mm cannons marked with the number 5 can be seen. Number 4 symbolizes the blackout, which turned out to be the place where the Russian Il-2 assault aircraft had collapsed. The type of aircraft was determined on the basis of the construction elements found. In building A, a fragment of the Il-2 assault aircraft's wing is visible, marked with the number 7.

Żółwino

The last example presented are the mass graves revealed near Żółwino, in the area where the German

[1] CAW Archives, repository 2. of the Lusatian Artillery Division of the Polish Army: III-153, III-154, III-157-161.

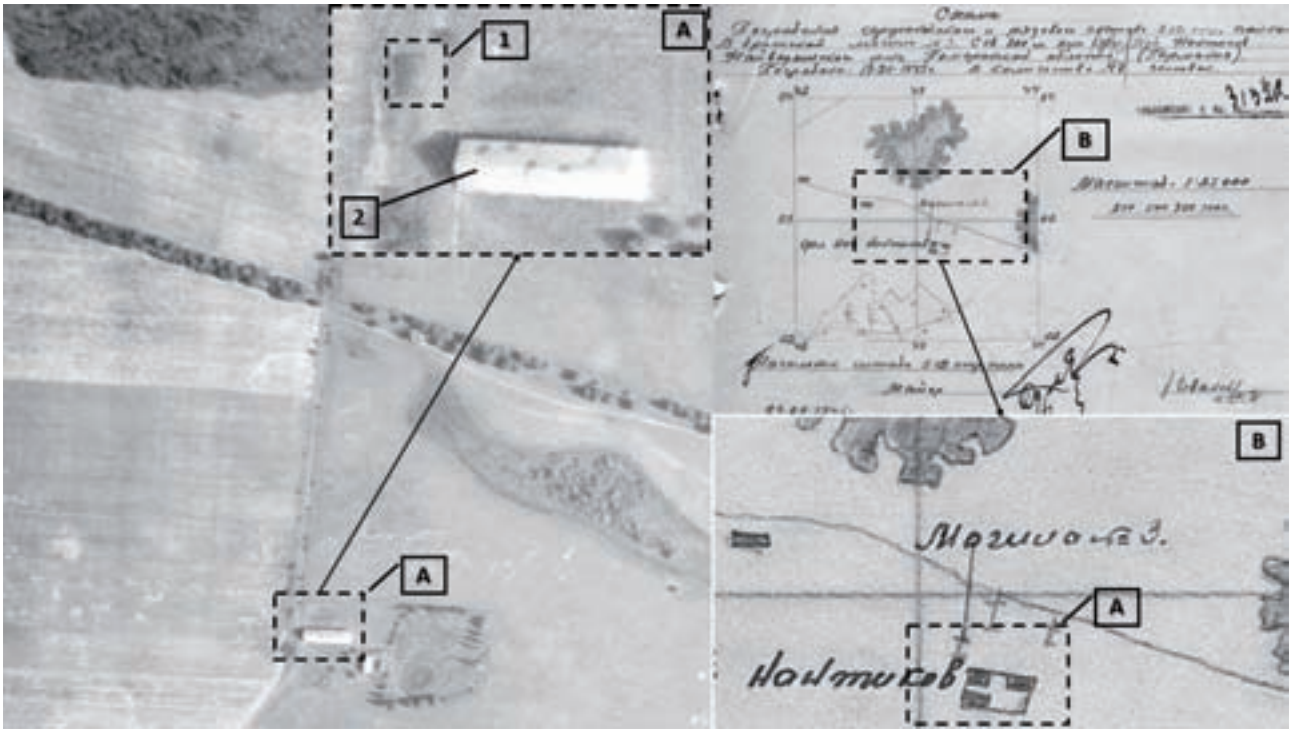

Fig. 13. Aerial photo collated with the image taken in 1948, showing the location of the mass grave of Red Army soldiers.

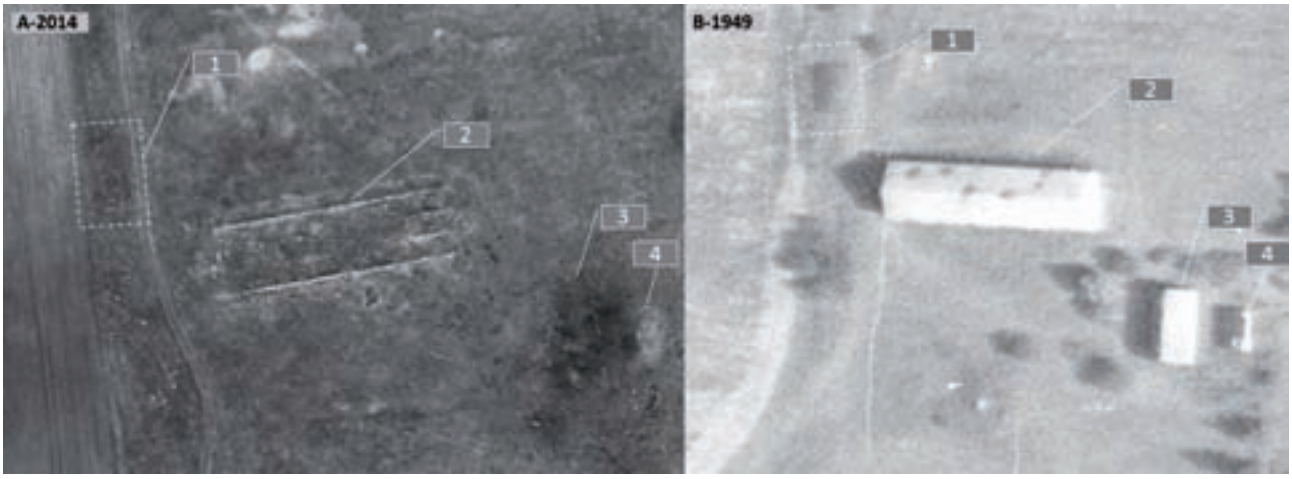

Fig. 14. Drone photograph from 2014 collated with the 1949 aerial image. Both images show the same objects.
Photograph taken with a drone (A).
Aerial photograph from the CAW collection, N-33-104-14-4228-1949 (B).

front line of the 5th Rifle Division was broken by the Soviet 3rd Army (Fig. 16). The analysis of the photographs from 1949 made it possible to locate large mass graves in the vicinity of the village. The image shows two marked objects. Object no. 1 represents a row of six mass graves. Object no. 2 is a single mass grave. After the calibration of the photograph, a field reconnaissance was carried out and the objects were found thanks to the GPS device – it turned out that the burial sites had already been exhumed. In this region, such graves have been created by laying the bodies in layers on top of each other and covering them with soil, which resulted in very clear mounds (Fig. 17). In such a case, the graves have not been dug up, but the bodies have been laid directly on the surface of the ground (Fig. 17).

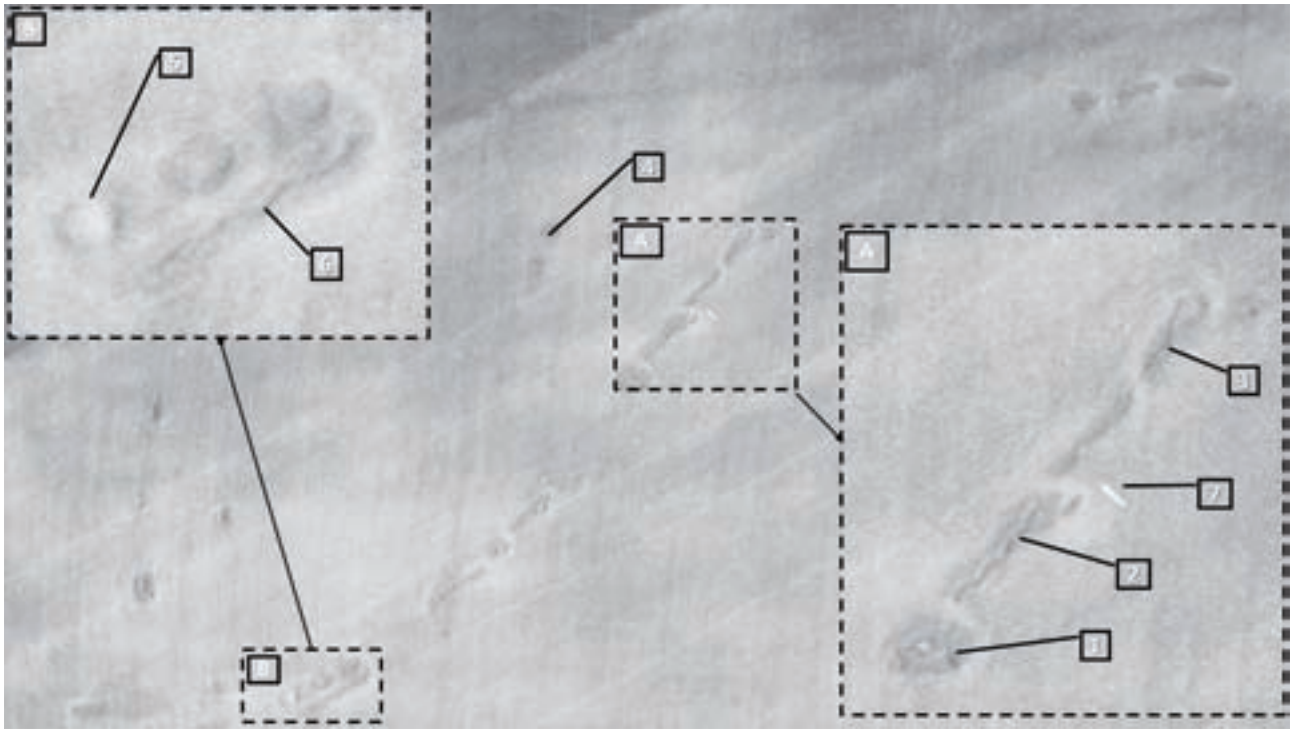

Fig. 15. Aerial photograph from 1949 showing field fortifications and other objects. Aerial photograph from the CAW collection, N-33-104-14-4229-1949.

Discussion

Based on our and other research teams' many years of experience, it can be concluded that the use of historical aerial photography to search for burial sites is a very effective method (Poirier, 1981; Mycke-Dominko, 1992). As regards the sites for which aerial photographs taken up to 10 years after the burial were found, they were helpful in locating the burial sites in almost all cases. The major problem that can be encountered is the availability of such materials. Unfortunately, it turns out that most of this type of collections had not been processed or even have been kept as classified material to this day, which involves a very high cost of archival queries.

Other authors most frequently write reports about large surface areas (grave fields), such as the Katyn Forest, where the Soviets murdered and buried about 4400 Polish prisoners of war from the Kozielsk camp (Mycke-Dominko, 1992; Chlebowski, 1990; Łojek, 1991; Rurarz, 1988). Such areas usually do not pose a major problem in terms of interpretation and recognition. The experience gained by our team also shows that large grave sites (fields) are much easier to recognize in aerial photographs than single burial sites, even containing multiple graves.

Highly specialized exploration methods such as the analysis of aerial photographs as well as the use of georadars, help in the location of burial sites and accelerate field works, and, as a result, significantly reduce the cost of exploration works. Similar conclusions were reached by other research teams (Pringle et al., 2012; Fiedler et al., 2009).

Our experience shows that an exhaustive archival query resulting in the acquisition of appropriate historical materials specifying the location of burial sites, gives much better results than limiting the analysis to field inspection only. The costs of exploration works are disproportionately higher than those of archival research. Similar conclusions were formulated by scientists conducting research on the battlefield of the First World War at Fromelles in France. In this case the 1916 aerial photographs proved to be of key importance (Pollard, Barton, 2013).

A similar situation applies to magnetometric and metal detector tests. The best results are obtained with the use of multiple exploration methods – starting from obtaining good aerial photographs, followed by georadar and magnetometric (non-invasive) tests, and finally survey excavations. The above sequence makes up an ideal approach; of course, it does not guarantee success, but it significantly increases the probability of finding a burial site.

Our experience shows that finding individual burial sites is incomparably more difficult than searching for large mass graves. The same conclusions can be found in Melissa Connor's work (Connor, 2007). In case of single burial sites, it is the single concealed bodies that are most difficult to discover. However, when dealing with grave fields, their location is much easier. Similar observations were made by other teams working on

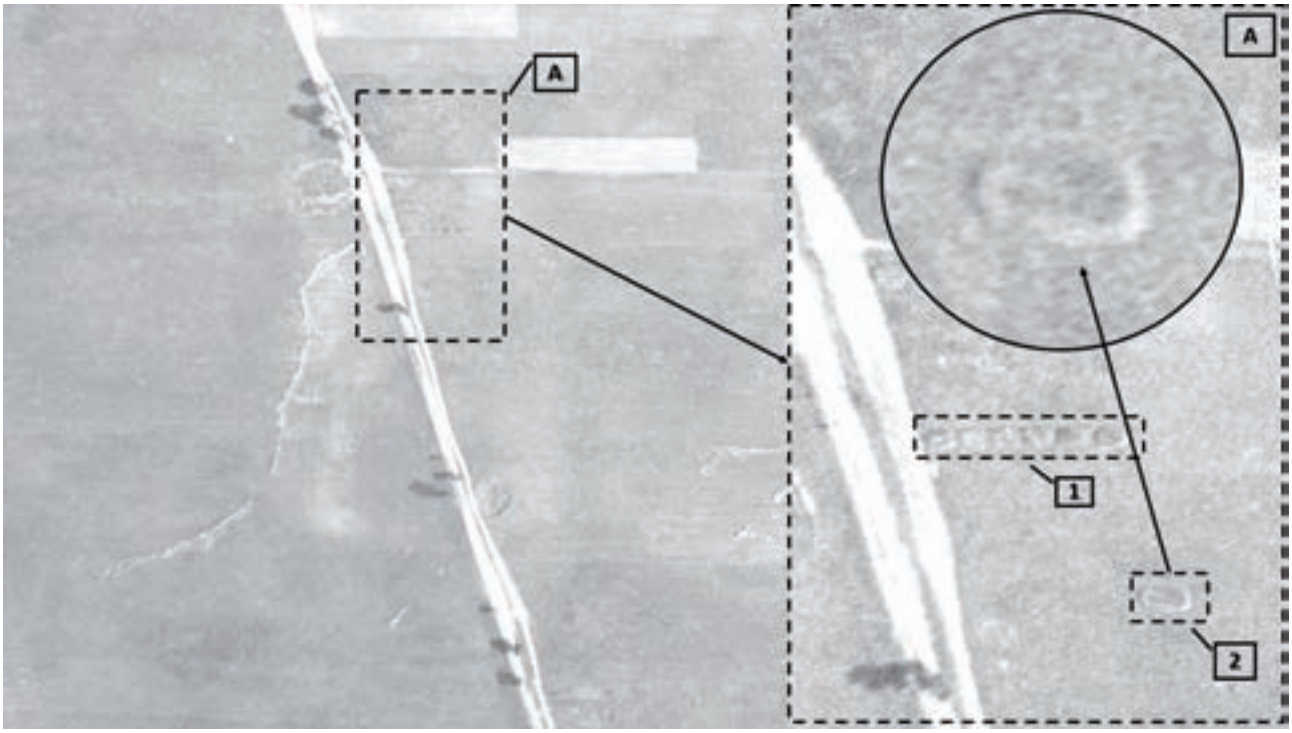

Fig. 16. Aerial photograph showing field fortifications and mass graves.
Aerial photograph from the CAW collection, N-33-104-13-4163-1949.

this subject (Hunter et al., 2001; Pringle et al., 2012). The study by Pollard and Barton (Pollard, Barton, 2013) presents photographs in which mass graves of about 400 "British" were identified (the term used by the Germans in reference to British and Australian soldiers they buried). Although the aerial photographs analyzed in the present study were taken in 1916 and at high altitude, they were suitable for analysis and finding burial sites. Our experience shows that the grave fields that had been camouflaged – e.g. not covered with mounds – can be well visible in aerial photographs.

The analysis of historical aerial photographs, contemporary satellite images or photographs taken with the use of drones greatly facilitates exploration work. Our experience, as well as that of other teams, shows that one aerial historical photograph can make up for years of field and historical research. This type of analysis is suitable not only for searching for visible burial sites (mounds), but, above all, for secret and unmarked ones, etc. This method can be freely applied also in contemporary cases (Pollard, Barton, 2013; Pringle et al., 2012; Ruffell, McKinley, 2008; Equitas, 2010; Fiedler et al., 2009).

As other authors emphasize, gathering an interdisciplinary team of specialists from various fields (experts in aerial photography and georadar surveys, dog squads, geophysicists, botanists and archaeologists), who could collectively search for concealed burial sites, is a rare and often impossible situation (Caccianiga et al., 2012). Therefore, it seems reasonable to select and train specialists in the broadly understood field of burial explorations, who would have practical knowledge of the basics of most of the above mentioned methods and, if any problems arise, would seek support from specialists in the relevant field. This is all the more important given that the majority of experts in the aforementioned fields do not specialize in the search for burial sites, but only incidentally participate in such activities. Setting up a crisis team made up of coordinators of particular types of exploration methods, supported by specialists trained in mutual cooperation, would make it possible to significantly improve exploration work in the future. The analysis of aerial photographs can be freely applied in contemporary activities consisting in searching for concealed bodies or material evidence. The use of this method may be of particular interest with regard to older unexplained cases handled by the police X-Files teams.

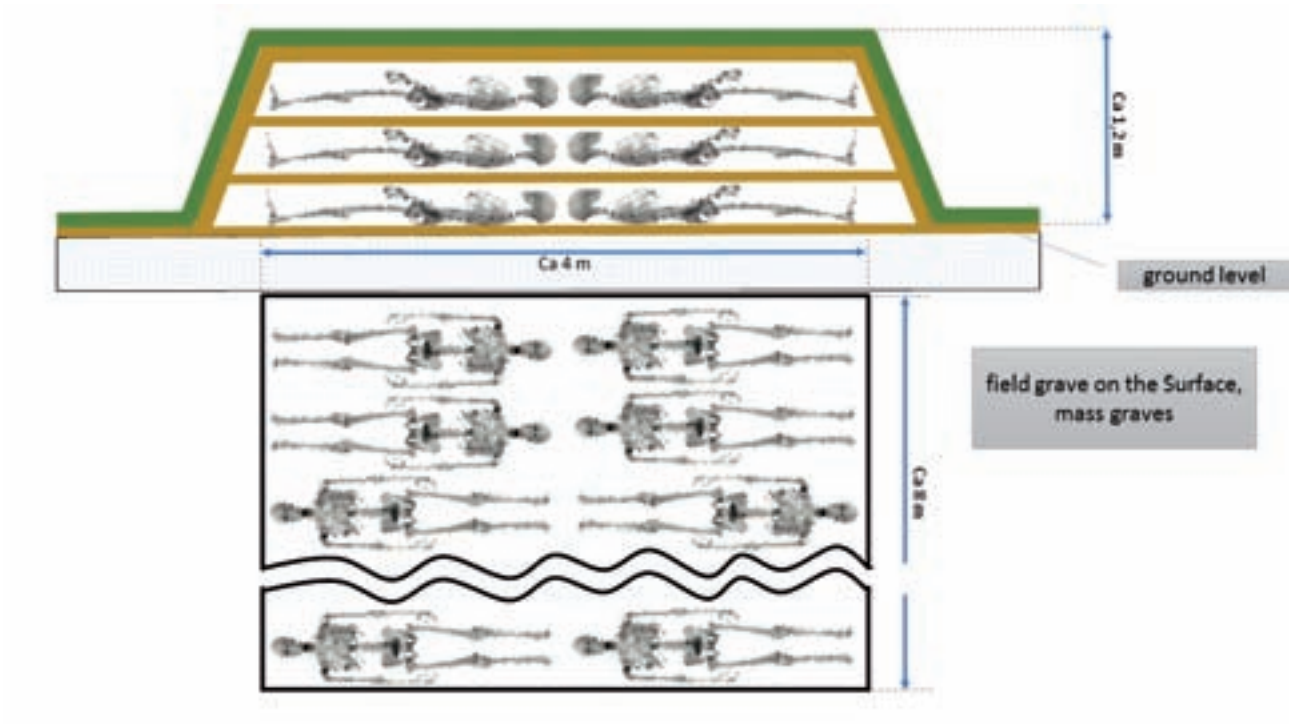

Fig. 17. Sketch showing a special example of mass graves in which bodies were merely laid on the surface of the ground and covered with soil.

Sources of figures:

Figure 1: *Andrzej Ossowski*
Figure 2: *Aerial photograph from the CAW collection, N-34-138-44-379-1945 (A).*
Aerial photograph from the CAW collection, N-34-138-03-5394-1951 (B).
Figure 3: *Aerial photograph from the CAW collection, N-34-138-04-2043-1953 (C)*
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Figure 17: *Andrzej Ossowski*

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