

IDENTIFICATION POSSIBILITIES OF FORMER SETTLEMENT AREAS BASED ON AERIAL IMAGES

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Abstract

The actual state of the Earth surface is often presented with use of remote-sensing and photogrammetric techniques. In many cases photo images are being used for acquiring information about human-made objects that cannot be directly identified or are underground such as civil or engineering structures and buildings, tracks or fortifications.

Analysis has been made to proof usefulness of aerial images for identification of destroyed or lost settlements placed on, mostly desolated, hills. For this purpose digitalized, panchromatic, aerial images were used from time span of last 30 years with different scale characteristics. Topographic maps, new and old cadastral maps and even aerial images placed on postcards has been used for localization of lost settlements fragments.

The research was conducted for few objects placed in the Kłodzka valley. The developed methodology allows tracking and detecting settlement remains based on changes in high vegetation structure or soil structure. This was proofed by detection with use of aerial images of some objects that were not noted in cartographic archives.

Keywords

remote-sensing, aerial images, settlement areas

1 INTRODUCTION

The need to collect reliable and objective information about the environment, which man has evolved and developed, is one of the subject of research. An important part of the process of acquiring these information are scientific tools involving taking and analyzing images with space-information. These are the basis of creating a variety of developments, mostly cartographical in traditional as well as digital GIS version.

Images of the planet's surface, made of different caps, different techniques and different ranges of the spectrum are performed mostly for present the current state of the earth's surface. However, more and more begin to recognize the possibility of using images (photographs, scanning images, etc.) to obtain information about anthropogenic objects not visible directly, located beneath the Earth's surface, often mutilated, buried and missing, such as structures, buildings, routes, equipment and engineering fortification.

A new branch of science - aerial archeology, using aerial photographs to find relics of the past. It uses achievements of imaging techniques and image processing, among other things, the experience of remote sensing.

2 REVIEW OF TECHNIQUES TO IDENTIFY SETTLEMENT AREAS

Looking from deck of an aircraft, we will see huge areas of land from nearly right angle, which gives a completely different point of view. Namely, for the pedestrian walking through the field, variable colors and outline areas of the field will not be noticeable and he will not perceive anything surprising. Experienced observer flying the airplane, looking at huge areas, is able to identify objects that are beneath the surface of the ground. Ongoing research in this scientific area has problems with lands covered by forests, buildings and roads. Aerial archeology is not applicable to the built-up areas due to the inability to read information from the ground through the building.[1,2,3]

In a situation when there are no visible traces of the building it becomes an underground monument including a moat, the burial cavity, mining shafts and foundations. Often these are the only evidence of civilization existing thousands of years BC. Most of them are discovered by chance during construction work, causing great damages to the valuable relics of history.

Subsurface remains reveal through shadow marked sites, soil marked sites and crop marked sites. Sites which are still more or less cut into the soil or rise above it, like castles, ruins, fortifications (banks and ditches still preserved) or tumuli. They can be seen by their light-and-shadow contrast. That is why they are called "shadow marked" sites. Sites that have been levelled completely (mostly) by agriculture. They are still leaving traces at the surface, which are only visible under certain conditions. Depending from the type of the traces, they can show up as "soil marked" and as "crop marked" sites.

- Shadow marked sites

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They can be seen more or less easily depending on several factors like preserved height, color and vegetation of the objects, and time, date, flying height, angle of view and direction of view while you are photographing them. Almost flat sites need very slanting sunlight to produce a visible shadow. Therefore, the flying time should be early morning or late evening.[1,2,3]

A determining factor for the visibility of a shadow marked site is the orientation of linear features towards the sunrises. If they are at right angles, they will throw distinct shadows. If the alignment is more parallel, the shadows will be weak and hard to discern.

- Crop marked sites

Crop marks appear due the principle of differential growth. One of the factors controlling the growth of vegetation is the condition of the soil. A buried stone wall for example will affect crop growth above it, as its presence channels water away from its area and occupies the space of the more fertile soil. Conversely, a buried ditch, with a fill containing more organic matter than the natural earth, provides much more conducive conditions and water will naturally collect there, nourishing the plants growing above.[4]

The differences in conditions will cause some plants to grow more strongly and therefore taller, and others less strongly and therefore shorter. Some species will also react through differential ripening of their fruits or their overall colour.

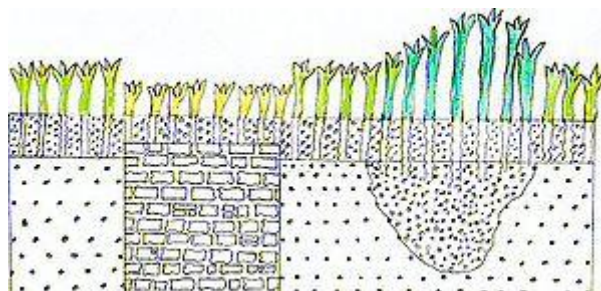


Fig. 1 Sketched diagram of a negative cropmark above a wall and a positive cropmark above a ditch

- Soil marked sites

When a ditch or a pit is dug, the local soil-profile gets disturbed. In most cases, the refilled material is different from the undisturbed soil. The differences are twofold:

First, the material itself is different. Refilled material is in most cases not so compact, and it contains more humous components, making it look darker.[4] Secondly, the grain size distribution differs from the undisturbed soil. Refillings have mostly a larger number of smaller grain sizes. Both cases lead to a better water-storage, which makes the refillment look darker than the surrounding soil, which can be seen very well from a higher viewpoint. The opposite happens in cases of buried walls. Here, the compact stones and mortar cannot store any water, and so, the soil gets very easily dry.

3 INTERPRETATIONS OF THE NETWORK SETTLEMENT TRACES AT DIFFERENT RESEARCH FACILITIES

3.1 Research facilities

The history of objects that were selected for study demonstrates that there are opportunities to find evidence of historical groundwater in their areas. As a choice they were selected objects from Kłodzka Valley, for the reason of introducing results of work it was chosen one of researched objects called Zimne Wody.

3.1.1 Zimne Wody

Zimne Wody Country was founded in 1684, it is located on the south shore community of Lewin Kłodzki, now administratively assigned to the neighboring Jawornica. At the peak of development in the mid-nineteenth century the village had 21 houses. Most residents were weaving in their houses. After World War II the village was gradually depopulating, and from 21 houses hasn't left anyone. It is a mountainous area.

3.2 Source materials

For the analysis it was used a variety of cartographic materials and aerial photographs. Cartographic materials were:

- German archival topographic maps
- Map from the measurement of possession from 1947
- Archival cadastral maps
- Actual cadastral maps
- Digital cadastral maps
- Topographic maps

The study used also high-resolution scanned aerial photos from the periods:

- 1975 – 1:19 000, 1: 23 000 (black & white)
- 1982 – 1:16 000 (black & white)
- 1985 – 1 : 25 000 (black & white)
- 1994 – 1 : 30 000 (color images)
- 2004 - Orthophotomaps

3.3 Applied different types of marks for identification

Marks which are used were divided into two groups, each of them contains several specific identification keys:

- marks related to the transformation of the soil structure

Negative cropmarks can be seen on the basis of plant growth and appearance of the place of the foundation of the missing objects. Assumption that the identification works only with the growing negative marks is not supported by unambiguous evidence, therefore, in this work the existence of the positive feature of the vegetation, may show the existence of traces of building's foundations. This choice was made because of the possibility of moving the masses of earth, collapsing better quality land in pits with the foundation, which may cause the existence of the above parameters. [1]

Another subtypes of the marks of soil structure, is mark which shows minimal changes in surface features. Mostly the characteristic form of relief can specify the location of underground facility along with pre-defined outlines and shapes. From the air, such phenomena are seen as objects with different colors, or appear convex or concave.

Marks which shows signs of non-existing building in most obvious way are those which have visible features of those buildings.

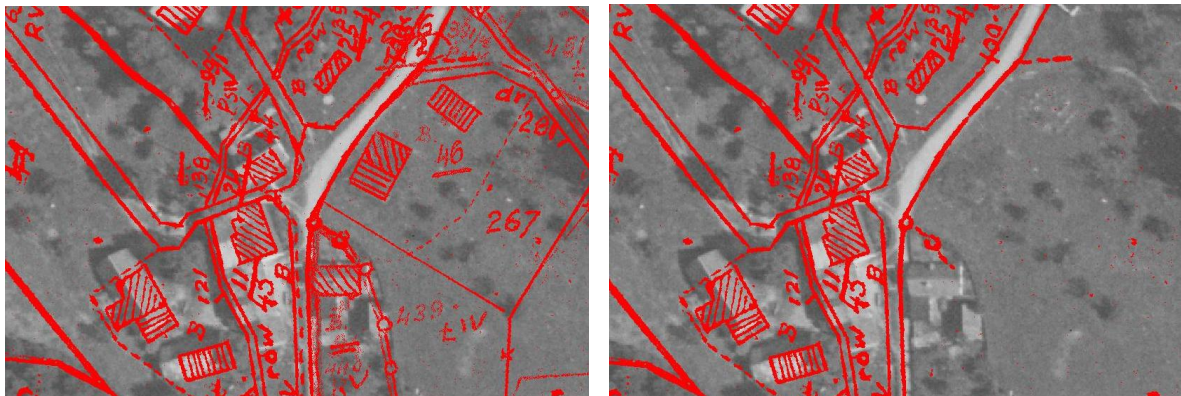


Fig. 2 Diagram of soil structure marks

- Marks with changes in high vegetation structure:

Group of parameters associated with the transformation of high vegetation was divided into two parts. The first is related to the change of tree species occurring in areas of the object existence, mainly from conifers to deciduous. On the whole areas of coniferous forest are visible the characteristic elements of the regular leaf shapes. Aerial photo was imposed on the cadastral map and it compared the location of buildings on the map with the locations of places of occurrence of deciduous trees including conifers. These characteristic place is taken as another mark.

There are many cases in which on huge fields are visible well formed groups of trees corresponding with the shape of the object we are looking for. Based on analysis of aerial photographs and first map from measurement of possession it is found that in many cases it is the proof of existence of facilities damaged or missing. In view of the above analysis that phenomenon was adopted as a mark, allowing the identification of objects in the picture carrier.

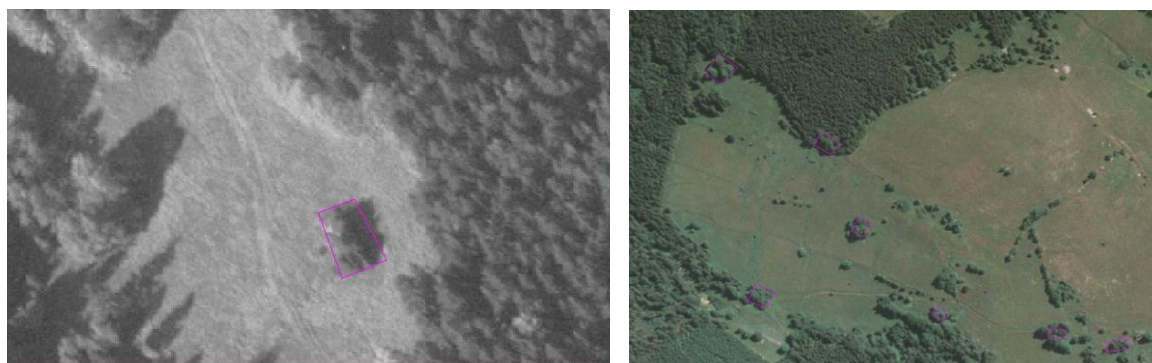


Fig.3 Sketched diagram of high-vegetation structure marks (Zimne Wody- picture on the right)

4 ANALYSIS WITH SPECIFIED MARKS ON THE RESEARCH AREAS

During running research on subsequent aerial photos it was found that only one building is existing on them.

Object	Type of raster	Number of buildings
Zimne Wody	Map from measurement of possession	32
	Archival cadastral map	1
	Actual cadastral map	0

Tab. 1 Summary of number of building on each of individual maps

In order to determine a trend of disappearance of objects launched from an analysis of aerial photographs starting from the oldest from 1975. The process of interpretation consisted of a precised viewing the material in search of marks, so that was possible to identify traces of the missing buildings. These marks included: marks related to the transformation of the soil structure, marks with changes in high-vegetation structure.

Combining these data about the number of existing objects on aerial photographs and the number of objects on different source material, number of buildings decrease in 60's after to the complete disappearance of the network of settlements from the land. The data showed that in 20 years between the creation of map from measurement possessions, and the implementation of the cadastral maps from the Zimne Wody 95% of the buildings is gone. Until the mid-90's, according to the interpretation of air photographs is left only one building, which is not reflected in the current cadastral maps. The reason for this is probably incorrect identification resulting from the inability of distinguish from the air if the building which exists the ruins.

Research object	Zimne Wody	Type of applied mark	Number of buildings visible on the aerial photos		
			Photo taken in a year:		
			1975	1984	1994
		PSG	17	14	9
		ZSRW	13	7	13
		$\sum (PSG + ZSRW)$	30	21	22

Tab. 2 Summary of number of visible rests of building on each of aerial photo

where:

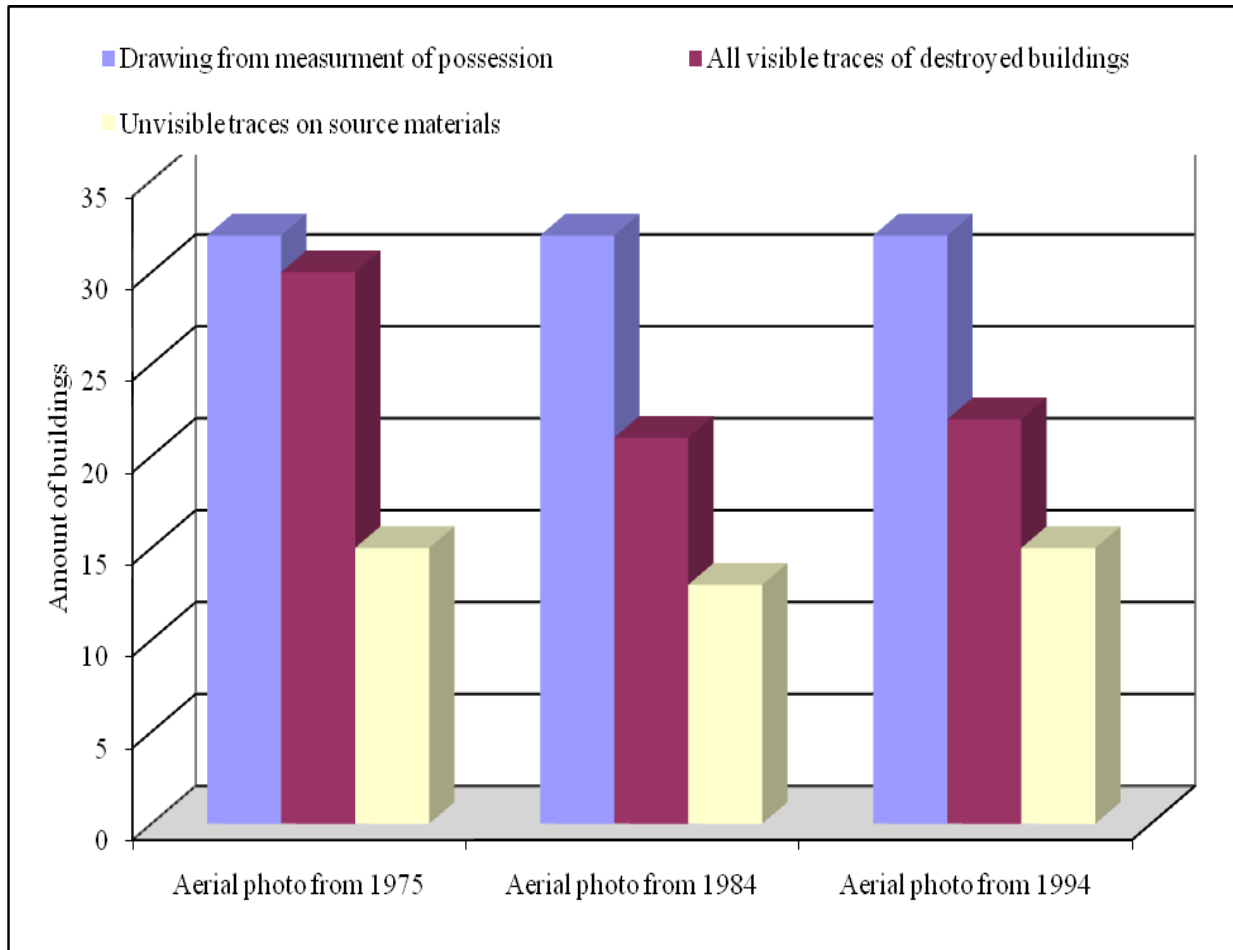
PSG – marks with changes of soil structure

ZSRW- marks with changes of high-vegetation structure

Analyzing the collected data, it was possible to identify 95% of the objects from the map of possessions on the aerial photo from 1975. In subsequent periods, this number is estimated at about 60%, which may be due to the quality,

performance and scale of images. Pictures are not vertical, what is performed by the geometrical distortion, which may affect on the interpretation of the results with use of marks related to high vegetation changes. Therefore, the low level of identified buildings in the photograph of 1984 is the result of shadows cast by trees under the sun's height above the Earth's surface and the direction flights with the camera. In about 10% of the identification of missing objects in Zimne Wody correspond to the second feature of this group, showing the change in species of the trees. Well formed shapes of trees in areas covered with deciduous prove the existence of underground traces of settlements.

The rest of identified objects are the results of changes in soil structure. Zimne Wody as a terrain is covered in 80% of the meadows, where the most visible change is the one in structure of the soil.



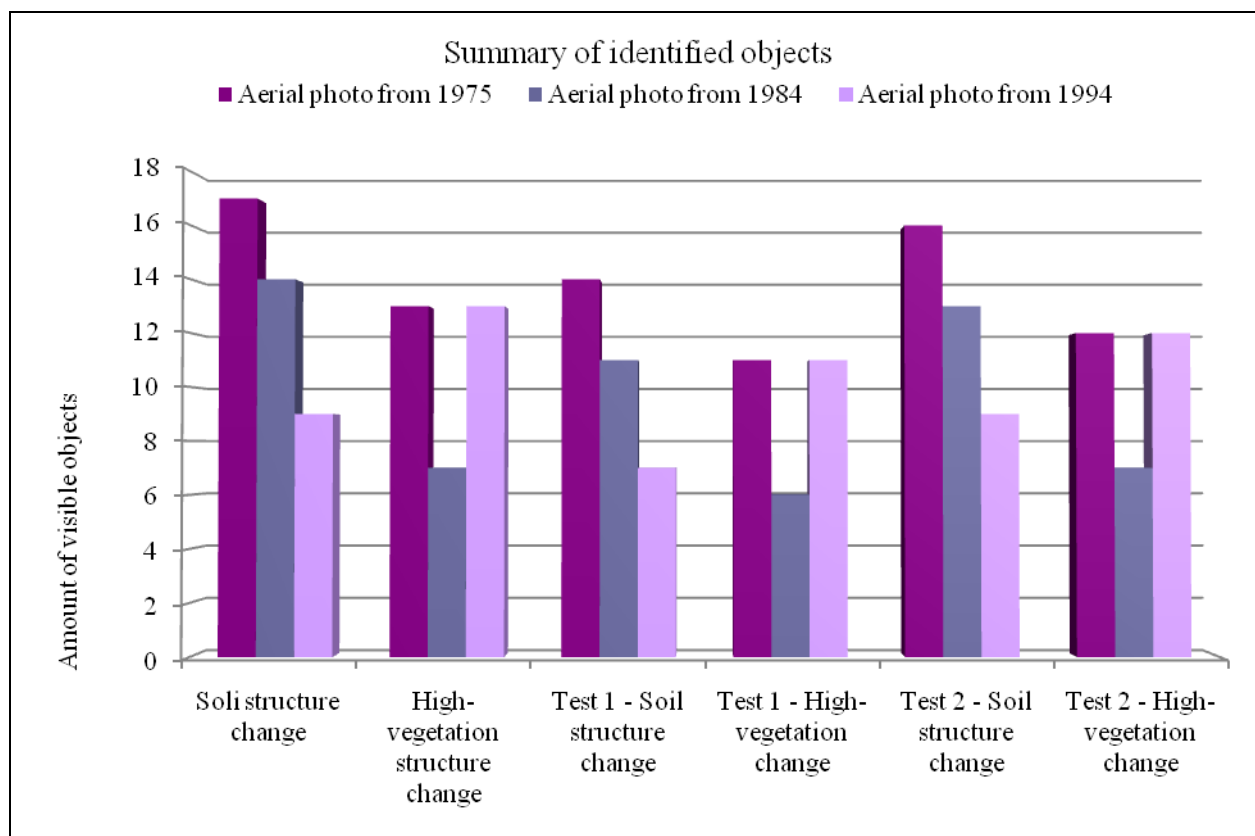
Graph 1 Visible and invisible traces of settlements

Zimne Wody completely disappeared from the earth's surface, leaving behind only traces of the revised structure of the ground and the high-vegetation, which provide evidence that the settlement ever existed there.

In order to test the possibilities of interpretation of the observer, they were conducted two tests, whose task was to determine the number of buildings identified in the analysis of images before covering images with raster, and after analyzing all of research facilities. Both the first and second test sought on the images soil and high-vegetation marks, responsible for the existence of damaged or demolished buildings. Each test was vitiated by errors of mistakable identification. Verification of the correctness of the selections made by the covering with raster, of map from possession measurement, aerial photos

Erroneous observations were subtracted from the total number of identified objects. The difference between the number of found objects in the first and second test is about 20-25% for both marks. Test review of aerial photos shows the evidence, that it is possible to identify traces without any control of raster using but the results in searching objects are much lower. The first test carried out that 70% of traces in request was found, in relation to the interpretation of the images in conjunction with map of possessions measurement. In the second test level of identification increased to 95% of level of connected interpretation(aerial photo and raster).

According to the obtained results, it was found that a man as an observer during time span and the quantity of aerial photos gains experience, which allows to execute faster and better interpretations.



Graph 2 Summary of identified objects with use of applied marks

5 CONCLUSIONS

It was found that the well formed shapes of trees, in most cases are responsible for the existence of the settlement traces. Sudden change of tree's species indicates a change in the structure below ground, indicating the presence of missing or hidden objects. Change of the color of the vegetation in areas of regular shapes are the results of the existence of objects beneath the surface of the ground. On the effect of identification influence season of taking a picture, it was found that the periods of spring and summer encourage interpretations of detection for buildings.

On the effect of identification major influence has direction of plane movements, direction from which pictures are made. The shortest shadow the better picture to analyze. Tests were carried out in mountain, what made whole process of identification more complicated. On the basis of examinations it was found that in areas with small differences in altitude, the effectiveness of identification increases.

It was established that it is not clear that on oldest aerial photos there are more possibilities to identify some settlements traces. Color photographs of 1994 gave a slightly higher percentage of identified objects and it is said that color version of photo gives better results of interpretation.

Although it is possible to interpret aerial photographs of archaeological purposes, without covering aerial photos with raster of possessions. For inexperienced observer it is better to recourse to archival cartographic materials. During using the mark of changing structure of the soil in some cases it is possible to determine the exact shape of the previously existing building.

There is the possibility of errors of interpretation, the observer could be confused with the buildings, once part of the existing ditches, dikes.

It is proposed to continue research on the basis of High resolution satellite material in different spectral ranges in order to verify the possibility of identifying the network of former settlement on theirs basis.

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