

Aerial photography can indicate the presence of sub-surface features: discuss the nature of the evidence that might be revealed, and outline the care that should be taken when interpreting this medium.

“Anyone studying [natural or man made features] is likely to want to know, and to demonstrate, not only the distribution of the features, including their relation to others whether natural or artificial, but also in more detail and with more accuracy their individual shapes and structures. For all this work aerial photographs are likely to be far the simplest, most powerful and often the most revealing tool.”
(Wright J, 1932)

Aerial photography is a non-invasive technique utilised by archaeologists to assist them in discovering and interpreting sites of archaeological interest. The results of an aerial photographic survey can also be used to plan future investigation and conservation of these sites. When using aerial photographs as survey tools, great care must be taken to interpret them correctly. Archaeological remains can be displayed in these photographs in many different ways depending on the time of day, weather conditions and techniques that are available at the time of the photographic survey. Geological features, local topography, existing and current features can all interfere with actual archaeological evidence. Although an invaluable tool, many sites that cannot be assessed from ground level due to their scale can be clearly identified from the sky. Some writers (Reeves D, 1936) describe this as a cat (or a fly) viewing a rug from a low viewpoint – they are aware of the pattern but cannot discern its actual design – and a human viewing it from a higher viewpoint – they are able to see the pattern in its entirety and context and can therefore understand what they are looking at as a whole.

Aerial photography was first used in the late 19th century but the camera and aviation technology was in its infancy. Hot air balloons were initially used, but these didn't provide the manoeuvrability that is required to take accurate and useful aerial photographs. Military advancements that began in World War I and continued through World War II and beyond, improved the aircraft and also the camera technology and techniques, enabling the RAF to utilise their skills to facilitate military reconnaissance. One of the most beneficial uses of aerial photography was to allow precise mapping of areas, and the discovery of the presence of sites of archaeological interest was an added bonus. OGS Crawford began to request photographs from the RAF of sites of interest and

it was his interpretation of these photographs that seems to have sparked the birth of aerial photography for archaeology (Reeves 1936).

There are a number of techniques that can be used in aerial photography, each with their own benefits and problems. Vertical photography is often cited as the best technique for accuracy as they do not distort the dimensions and angles of the surface objects. To correctly display a site, photographs must be taken with the camera perpendicular to the ground in an overlapping series providing at least 2 frames of every position on the ground. This allows accurate and precise mapping and can assist in viewing the photographs stereoscopically (Wright 1973). There are factors that can distort the photographs and potentially cause misinterpretation. Surface objects can become skewed when they appear in the extremities of the photograph, possibly causing errors in scale, distance or height. Miller (1957) describes this as relief error (when elevated features are displayed radially outwards and appear to lean). Tilt error is caused if the camera is tilted in any way so the earth's plane and the film are not parallel causing errors in distance and scale. Oblique photography is when the camera is used at any angle to the ground which, whilst displaying shadow sites to their best advantage, again distorts the angles and scale of the site.

Wilson (1982) expands on the theory that there are four main types of evidence that can be discovered using aerial photography. These are buildings, earthworks (or shadow sites), soilmarks and cropmarks. Wilson practically discounts the importance of using aerial photography to define buildings as they are usually visible above ground therefore should be able to be interpreted at that level. This may be so for complete or near complete smaller structures, but an aerial photograph of a larger or partially ruined site can allow the building to be interpreted and assessed as a whole and within the larger context of its environment and neighbouring features.

Crop marks are created by the effects of different types of soil on the vegetation planted within it, but this only works for above-surface crops. Soil that contains filled pits or ditches is more likely to retain moisture which in turn provides more nutrients to the crop enabling it to flourish. Buried stonework is likely to drain quicker therefore be drier which may cause the crop to be stunted or to fail. From the air these differences in height and colour can be easily seen.

Care must be taken in the timing of the photographic expedition as crops may ripen at differing times of the year and not every crop will display the same characteristics due to fluctuations in the weather and seasons. To interpret these photographs correctly, the interpreter needs to be aware of the differing characteristics of and weather conditions during the crop's lifecycle, the current weather conditions and the type of soil the crop is planted in, so any supposed indicators are not incorrectly interpreted as archaeological remains. The best crops to provide cropmarks are cereal crops, especially wheat and barley (AARG website).

Geological features and agricultural methods can also affect the growth of crops (AARG website) and it is imperative that the interpreter is aware of any external factors that can influence the evidence. If an archaeologist is expecting to see some evidence of crop marks, it is advisable (if it is affordable) to take a series of aerial photographs of the same site at different times of the year or season and in different weather conditions.

Archaeological remains such as walls and ditches can cause fluctuations in the surface of the ground. Remains that are above ground can clearly cause shadows at certain times of the day, when the sun is low in the sky and accentuates the shadows thrown by these sites. Features that are below the ground and have been filled or covered with looser soil can cause depressions in the ground which again throw noticeable shadows. Snow or frost accentuates these shadow sites by covering the ground with a uniform colour and concealing any extraneous information, for example bushes, paths or trees. Evidence is also affected by the position of the site in relation to the sun and therefore may not cast shadows effectively enough to be observed. The topography

of the land may also affect the shadows thrown, for example if an archaeologically interesting site is covered by a natural slope above and beyond its own (Wilson 1982) or if there is substantial tree cover. Earthworks are often the easiest to identify as they can be additionally surveyed from the ground with ease and the combination of aerial and ground surveying can make interpretation more accurate.

From the sky, the archaeologist can also determine soilmark sites, especially in areas that have been ploughed. Archaeological remains can change the colour of the soil in a number of ways. Sub surface manmade structures that have been fragmented by ploughing can be discovered by the fragments being mixed with the soil and changing its colour. Ditches, for example, are often filled with darker organic material and when this is disturbed its colour contrasts with the existing soil. Again, one must be aware of existing geological features and the type of soil that is prevalent in the area being surveyed to ensure that true archaeological features are being displayed.

Soil and crop marks are often difficult to interpret from aerial photography alone. Although any previous archaeological surveys can provide similar evidence and interpretation, care must be taken when interpreting to ensure that the evidence suggests actual archaeological features and not natural or man-made features. These non-archaeological features can interfere with analysis but they can also be useful to allow the surveyor to assess the environmental evidence around the potential site providing a larger context for the feature (Wilson 1982).

Wilson (1982) provides a number of examples of man-made and natural features that can mislead the archaeological surveyor into believing that there is a feature of interest on the ground below them. He cites the example of the remains of a football field, which, with its lines of dark grass where the chalk lines used to be and the build up of the chalk in the ground can change the consistency of the soil and, when viewed from the sky, can simulate the remains of enclosures or ditches. Geological features such as stratification or jointing of the rock under the surface can change the soil and even effect crops grown over the soil. Agricultural practices such as

ploughing, fertilisation or irrigation can cause lush or poorer areas of growth or disturb or change the colour of the soil, again simulating archaeological features.

An additional predicament with interpreting aerial photographs is the problems that can occur with the mechanics of taking photographs. Apart from the positioning of the camera which has been discussed above, there are physical features that can be interpreted as archaeology by the inexperienced interpreter. Dust can resemble features on the landscape, smears and fingerprints can suggest crop marks, scratches on the film can bear a resemblance to lines on the landscape and electrostatic damage can proffer substantial tonal differences in the landscape that could imply soil marks (Wilson 1982).

Traditional aerial photography is a valuable part of the suite of survey tools available to archaeologists. Photographs enable a site to be surveyed without interference from ground level features, provide evidence of remains that are below ground and enable the site to be seen as a plan, without any invasive techniques being undertaken. But photographic evidence is not infallible, mainly for the reasons above, and all these factors have to be taken into consideration when examining a photograph for archaeological evidence. Developments in techniques and technology are taking place that compliment and emphasize the results from archaeological aerial photography.

Computer and camera technology is developing constantly and can only increase the validity of aerial photography and improve the results that can be displayed. The English Heritage website discusses the new technology of LIDAR (Light Detection and Ranging) which uses a pulsed laser beam to scan the ground from side to side as the airplane flies around the survey area. LIDAR can measure between 20,000 and 100,000 points per second allowing the production of a high resolution image of the landscape. This image can be a very precise model of the ground and its features and can define any hidden earthworks or other archaeological site that causes change in the surface layer, even with the slightest of physical evidence.

Global Positioning Satellite (GPS) units are also being used for surveying sites and the data collected can be manipulated to give three dimensional computer models, maps and plans. GPS works by measuring the distance between GPS satellites and the user's receiver, where a number of satellites are used to triangulate the position of the user and to provide accurate measurements – depending on the surrounding environment, as tree cover can interfere with the sensitive equipment. Although still in its infancy for archaeological use, and involving potentially expensive equipment GPS can provide a more accurate picture of a site in comparison with aerial photography (English Heritage 2003).

Geographic Information Systems (GIS) is a new tool which allows sites to be visualised in three dimensions. The data provided from collecting data from maps and digital aerial photographs can be collated and disassembled and reassembled to provide spatial analysis to assess how archaeological sites relate to the topography and potentially imply evidence about the significance, use and date of suggested archaeological features. GIS can emphasise aerial photographic surveys, providing greater accuracy of mapping which in turn facilitates interpretation (Harris 2002).

Aerial photography is a very useful tool to the archaeologist. It offers the opportunity of large scale mapping of areas, of precise depictions of potential investigative sites, of clues to interpretation of sites and the ability to record of sites that may be in danger of being lost. Although potentially and expensive technique, aerial photography can accurately pinpoint a site, enabling excavation or other investigative techniques to be specifically focussed. Alternative and complementary techniques are being developed that can provide a more accurate and informative site survey, but these are still in their infancy and unproven or expensive to be commonly used. More research on these burgeoning techniques and the results they provide needs to be undertaken before aerial photography becomes obsolete.

Interpretation must be undertaken with care, considering the topography, geology and land use of the site being surveyed to ensure that the archaeologically interesting features displayed in the photographs isn't naturally caused or contemporary. No archaeologist should embark on excavating a site based on aerial photographic evidence alone, but when used in conjunction with field work and desk research, aerial photography can save time and money when further investigation – either geophysical or excavational – finally takes place.

Bibliography

Estes J E, Jensen JR, Tinney LR, The Uses of Historical Photography for Mapping Archaeological Sites, *Journal of Field Archaeology*, Vol 4 No 4 (Winter 1977) 441-447

Harris T M, GIS in Archaeology in Knowles A K (ed) (2002), Part Time, Past Place: GIS for History, Redlands, CA: ESRI Press

Miller W C, Uses of Aerial Photographs in Archaeological Field Work, *American Antiquity*, Vol 23 No 1 (July 1957) 46-62

Reeves D, Aerial Photography and Archaeology, *American Antiquity*, Vol 2 No 2 (Oct 1936) 102-107

St Joseph J K, Air Photo and Archaeology, *The Geographic Journal*, Vol 105 No 1/2 (Jan – Feb 1945) 47-59

Wilson D (1982) Air Photo Interpretation for Archaeologist, Batsford

Wright J, Air Photography for Small Expeditions, *The Geographic Journal*, Vol 139, No 2 (June 1973), 311-322

Where on earth are we? The Global Positioning System (GPS) in archaeological field survey. English Heritage, 2003

http://www.english-heritage.org.uk/upload/pdf/where_on_earth_are_we.pdf
Accessed 21st February 2006

English Heritage : Aerial Survey
www.english-heritage.org.uk/server/show/nav.1158
Accessed 13th February 2006

AARG : Short Introduction to Aerial Archaeology
Aarg.univie.ac.at/aerarch/aerarch.htm
Accessed 9th February 2006

MacLeod D (October 2002) Aerial Archaeology
www.bbc.co.uk/history/archaeology/time-flyers_01.html
Accessed 10th February 2006