Archaeologists use a wide range of reconnaissance techniques to locate archaeological sites and to investigate sites without excavating them. Some archaeologists predict that future advances in non-invasive, and non-destructive, methods will see them emerge as an alternative to excavation. Reconnaissance techniques are also used to map evidence of human activity in the archaeological record.

**Figure 1.1** Factors influencing the choice of reconnaissance methods

**YOUR GOALS**

You need to be able to

- understand the key methods used by archaeologists to locate and define sites
- identify some strengths and limitations of the most important techniques
- suggest appropriate methods for locating and exploring sites in particular circumstances.
landscape. The appropriate methods in each case will relate to the time and resources available as well as to the particular case being investigated.

Every year hundreds of new sites are located. Some are spotted from the air or even from satellites in space, others through the discovery of artefacts by metal detectorists. Quarrying, dredging and peat cutting all regularly produce unexpected finds while some of the most important have come about completely by chance.

The discoveries of the body of Ötzi the Ice Man by skiers and of the Altamira cave art by children are classic examples. So too was the discovery of the Neolithic tomb at Crantit in Orkney, which was found when a digger fell through the roof!

Equally, some sites were never ‘lost’ to begin with. Stonehenge and the Pyramids were well known before the development of archaeology and many of the buildings of the last 200 years are still in use. Other named sites were documented by historians and located by using written sources. Schliemann’s discovery of Troy is the classic example but many historic battlefields also fall into this category. In addition, a considerable number of new discoveries are made during the exploration of known sites.

To locate or explore sites through research or ahead of development there are four broad and complementary categories of methods that are commonly used:

- desktop study
- surface survey
- geophysical or geochemical survey
- aerial survey

In addition there is a range of newer techniques, most of which can be labelled remote sensing.

Reconnaissance should not be seen simply as the precursor to the real business of digging. In some cases it can provide all or most of the evidence needed to answer questions. The pioneering Shapwick project which investigated the development of an estate owned by Glastonbury Abbey used a battery of reconnaissance methods alongside limited sampling of deposits through shovel pit testing, geochemical survey and excavation. The results when combined with evidence from maps, historical sources, and environmental data enabled the production of regression maps showing the development of settlement in the area.

**DESKTOP STUDY**

As its name suggests, this is an office-based investigation using existing records. Some archaeologists, usually concerned with shipwrecks, aircraft or the investigation of historical individuals, continue to use written sources to track down or identify particular sites. More generally, most excavations and all research in Britain today begins with a search of information that has already been recorded. The majority of these investigations are part of the planning process. Their purpose is to determine whether there are likely to be archaeological remains which might be threatened by development (p. 341).

Desktop study involves researching maps and historical or archaeological documents including aerial photographs about the area under investigation. If they are not in private hands, these are most likely to be held in planning departments, county records offices, historic environment record, local Sites and Monuments Record (SMRs) or the National Monuments Record (NMR) offices.

**Historical documents**

A diverse assortment of documents may be of value to the archaeologist. These will vary by county, area and period. In much of the country known documents are archived or recorded in the County Records Office. In many areas, useful sources have also been catalogued in a volume...
of the Victoria County History (VCR). This is often the first resource researchers turn to. Only a fraction of early records have survived and those that have need translation and interpretation. Amongst the potential range available, the following categories are important.

Legal documents. Records of ownership such as Anglo-Saxon charters or court records of disputes often included physical description of boundaries and occasionally land use. Wills and inventories which can be linked to particular buildings may provide lists of contents. These can provide clues to that building’s use.

Tax records. These are particularly valuable in helping to identify landowning units and their economic uses. The Domesday Book is the best known but later tax surveys and tithe awards are often of more direct use.

Economic records. Order and sales books are invaluable to industrial archaeologists while nineteenth-century directories are useful in exploring functions of buildings. Estate agents’ bills are increasingly being preserved to record changes in important buildings.

Pictorial records. Paintings, engravings and photographs can be of value both in identification and in tracing changes. They are particularly valuable when studying standing buildings. Archives of aerial photographs (APs) such as the RAF ‘or Luftwaffe’ surveys of Britain in the 1940s are key documents in tracing landscape change in the last sixty years. They are often the only record of many sites.

Written accounts. Descriptions of places in books, diaries and travelogues are of use in identifying the function, construction methods and identity of many sites. The work of early antiquarians such as Stukeley is particularly valuable for descriptions of monuments as they were before the modern period.

Archaeological records. There are three main sources here. If there are early excavation or
NOTTINGHAMSHIRE SITES AND MONUMENTS RECORD  

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<td>General BA</td>
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<td>Form</td>
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</tr>
<tr>
<td>Description</td>
<td>Circular enclosures, linear features. (1)</td>
<td>Ring ditch, through to be a barrow, excavated 1975 in advance of development. Situated on a slight knoll on the flood plain terrace, it survived only as a cropmark. The circle is 25.0m in diameter, the flat bottomed ditch 2.0m wide and 70cm deep. 12 sections were made. In the infill, there were layers of iron panning and traces of iron stain in the deposits of natural silts. The only finds were 4 flint waste flakes, and a small fragment of handmade pottery, possible a fragment of an early BA collared urn or food vessel. No burials were found (destroyed by ploughing?)</td>
<td>Looks like a BA barrow (2) See 03055a for adjacent cropmark.</td>
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Compiled/Revised  
24/08/1987 VB

**Figure 1.3 How to read an SMR printout**
survey results they can often be accessed through libraries or local museums. Local collections of finds and reports will also be held in local museums. Details of previous archaeological work and stray finds for much of Britain are held in local SMRs. These records are increasingly computerised and a national version is being built up at the various NMR offices. Printouts which include lists of earlier research can be made by inputting grid references.

**Oral accounts.** While living people may provide clues to the use and location of recent buildings, farmers and others who work on the land or the built environment may have valuable knowledge for archaeologists. Farmers, for example, may be able to identify areas where building rubble has been ploughed up or where dressed stones have been removed. Sometimes estate management records may hold this information for earlier periods.

**Maps**
Maps are amongst the most basic tools and sources used by archaeologists. They are used to locate and explore sites and to answer questions about previous use of the landscape. They are of particular value in tracking changes through time (settlement shape and location, boundaries, land units, fields and hedges). They can also be used to relate sites to geology and topography. Medieval archaeologists are often able to produce their own maps for periods before mapping began. They do this by working back from the oldest available map and cross-referencing historical sources and fieldnames. This technique is known as regression.

A wide variety of maps are used by archaeologists, including the following.

**Early maps**
Maps from the sixteenth century tend to show the properties of the rich. They are not always to scale but may provide visual information such as illustrations of specific buildings. From the seventeenth century there are also route maps such as Ogilvy’s Road Book, which is a series of linear strips. Maps were produced to show the proposed routes of turnpikes, canals and railways in order to gain permission from parliament for building to take place.

Changes in rural landownership from the eighteenth century onwards were recorded on enclosure award maps, while taxes owed to the church by landowners were sometimes written on tithe award maps. Occasionally these can be cross-referenced and both can provide information about fieldnames, routes and boundaries, which are vital for landscape archaeology. Other maps show landscaped gardens, battlefields or provide plans of factories and mines.

These early maps are often held in county record offices. Some may be in private hands or belong to churches.

**Ordnance Survey (OS) maps**
During the early nineteenth century the OS mapped each county at 1 inch to 1 mile. From the 1880s OS 6 inch to 1 mile maps provided more detail of individual buildings and even hedge species. OS maps established a new standard in accuracy and a comprehensive system of coding and keys for features. A grid system was used which covered the whole country and enabled precise references to be given. By examining a succession of maps for any area, changes in land use and the built environment can be easily seen.

- [www.ordsvy.gov.uk](http://www.ordsvy.gov.uk)

**Maps used in archaeological**
The OS 1:25000 Pathfinder or Leisure series show the location of some archaeological sites but planning maps that use the OS grid system are needed for investigations. 1:10000 (old 6 inch) maps are sometimes the most detailed available for mountainous, remote and some rural areas but 1:2500 (old 25 inch 1 mile) rural or 1:1250
urban planning maps are normally used. For field walking 1:10000 or 1:2500 is used and for excavation the 1:2500 or 1:1250 provides a base. A 1:2500 map allows you to identify individual metre squares with a 10-figure grid reference. These maps are held in county or district planning offices.

Other maps sometimes used include the Geological Survey series, street maps, factory plans, vegetation and climatic maps, land use and classification, soil surveys and specialist archaeological maps. Increasingly archaeologists are using computerised mapping systems based around Geographical Information Systems (GIS).

As an archaeology student you need some basic map skills including the ability to:

- identify and interpret common archaeological features from maps
- ‘read’ contours and hachures
- use scales and at least 6-figure grid references
- produce basic cross-sectional sketches from maps
- interpret simple archaeological plans and diagrams
- use other evidence such as photographs and written accounts to interpret maps and plans.

SURFACE SURVEYS

This term can be used to encompass field-walking, surveying and even planned aerial photography. We will use it to describe non-destructive visual surveys at ground level. These can range from slow, painstaking searches on foot to quite rapid examinations of a landscape by Landrover, looking for upstanding earthworks. Since most sites lack visible features, the former is more common. Fieldwalking is largely concerned with finding traces of unrecorded sites. Scatters of building rubble or artefacts or slight undulations in the surface can reveal where there are buried walls or house platforms. Differences in soil or vegetation may also be indicative of past human activity. For studies of the Mesolithic and Neolithic in Britain, scatters of flint and

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**KEY TERM**

**Geographic Information Systems (GIS)**

This refers to powerful databases which can store many layers of data against individual map grid references. This can include details of topography, geology and vegetation as well as archaeological data. GIS can integrate data from satellites with field recordings. It can produce topographic maps and site plans in three dimensions and perform complex statistical analysis. It is revolutionising the presentation and interrogation of archaeological data. It can even be used to predict site locations based on known patterns.


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**KEY TASK**

**Sourcing information**

Take each of the following examples and list the types of source you might find useful in investigating it.

Next take a real example of one of them and find out what actual sources exist. You may be surprised.

A round barrow or cairn
A Roman villa or Saxon church
A deserted medieval village or abbey
An eighteenth-century farm or canal
A nineteenth-century railway line or factory
A twentieth-century pillbox or airfield
animal bone are often the only traces of human activity visible in the landscape. To study the activities of these mobile populations, careful identification and plotting of these scatters is essential. A variation on this is the study of hedges and woodlands for traces of past economic activities and to help locate settlement areas (p. 202). Surface surveys can cover large areas such as Webster and Sanders’ work in the Copan Valley of Mexico or woods such as the Thetford Forest project in East Anglia.

Surface investigations of known sites include **micro-contour surveys** of the topography. These involve detailed and precise use of surveying tools to build up a picture of variations in height and levels. Data is increasingly being entered on databases to enable computer enhancement of the landscape. These surveys can often reveal hidden features that could not be detected with the naked eye.

In most studies, the areas to be surveyed are measured using surveying equipment or Global Positioning Systems (GPS) and set out with rows or squares of pegs, cane or marker poles. This is to enable accurate sampling and recording.

**Recording standing buildings**

One specialised area of archaeological surveying focuses on the built environment and links archaeology to architectural science. Detailed studies of the material and construction techniques of structures are made both to enhance knowledge of the development of buildings and...
Sampling

Whatever is deposited is a fragment of past material culture. Dependent upon the material, a variable portion of these deposits will survive. Archaeologists will recover a sample of these. Not every site can be fieldwalked, let alone excavated. Choices have to be made. If these choices are arbitrary (non-probabilistic) they could lead to bias in the archaeological record with certain types of evidence being neglected and others over-represented. For example, if archaeologists chose only to study hill forts from the Iron Age or, as often happens, if development only permitted excavation in one part of a town, it might create an unrepresentative picture of life in the past.

When archaeologists design research strategies they use some form of probabilistic sampling to reduce bias in recovery. This means that the chance of anything being recovered is known. Rigorous sampling is used in most aspects of archaeological reconnaissance and excavation.

Firstly the plan of the total area or site to be surveyed is divided up either into a grid pattern of numbered squares or a series of equidistant parallel lines or transects (p. 12). Both are usually aligned north–south to link into the national survey grid although sometimes grids in fields are aligned on a particular boundary. With large areas it is common to select a sample of grids and then use transects within them. The scale varies according to the task. An initial surface survey of a whole landscape might start with 100 metre or kilometre squares and then have transects between 10 and 50 metres apart depending on terrain and resources. For test pitting on a known site the initial grid might be 1 metre square. You need to understand four basic approaches to sampling. Our illustration is for grids but the principles are the same for transects.

A simple random sample works like a lottery. The numbered units are selected by computer or number table. This is fair as each unit has an equal chance of being selected, but it can also lead to clustering and thus miss features.

Stratified sampling overcomes clustering bias by first dividing the sample universe into sections. For example, if the site has natural zones such as hills, valley and plain then numbers are selected randomly for each zone in proportion to its area.

Figure 1.5 Models of different approaches to sampling
to provide a record against future destruction or decay. For example laser scanning is used in some buildings which are covered with lichen to see how they are constructed. Records will range from written description to CAD (computer-aided design) based recording of every brick or stone. Most recording of buildings occurs as part of the planning process (p. 347) or during conservation work. A recent example is the Defence of Britain project, which collected records on surviving defensive monuments of the Second World War.

- www.britarch.ac.uk/projects/dob/index.html

Fieldwalking

Fieldwalking, or surface collection, involves systematic collection of artefacts from the ploughsoil which might be indicative of human settlement. This is based on the reasoning that material on the surface reflects buried remains. Sometimes high density scatters of particular materials such as building rubble or broken pottery enable specific sites such as buildings or kilns to be identified. More typically, the method helps identify areas of settlement or activities such as hunting. Ceramics and worked stone are the most commonly gathered but metal, bone and burnt stone are often also collected. The method is destructive in that archaeological material is removed, but as it has been disturbed by ploughing, it is not in its original context anyway.

Decisions about sampling have to be made when planning fieldwalking. Not everything will be collected, particularly when building rubble is involved. For instance, will all ceramics be collected or just diagnostic pieces? Decisions also have to be taken about the width of transects or size of grids.

Timing is important. Ideally ploughed soil should have been broken down by weathering and recent rain will have cleared dust from the surface. Walkers either proceed along a transect in a series of stints or search a grid. These have been carefully set out with marker flags or poles. Grids tend to be used when total coverage of a field is required. The material collected is bagged and tagged with the number of the grid or stint for processing and analysis.

Once washed and identified, finds are counted for each grid or stint. This can then be plotted on a distribution map to show patterns and concentrations. There are many ways of displaying this information. Phase maps or a series of clear plastic overlays for each period or type of find are commonly used. Computer displays using GIS have an edge here since several types of data can be linked to any point and comparisons easily made.

Fieldwalking is a well established method because it has many strengths. It is a relatively
cheap way of surveying large areas since volunteer labour can be used to collect and wash finds. It can help establish the function and period of a site without excavation and provide insights into location and exchange. Fieldwalking can indicate the spread and foci of evidence. It does, however, have important limitations too. It is only really useful on arable land where access has been granted and then only at certain times in the agricultural cycle. In addition, its results cannot be taken at face value. For example, medieval manuring practices transferred much domestic refuse to the plough-soil, creating a doughnut shape pattern of pottery distribution. Chris Gerrard’s work on the Shapwick Project has explored two other major limitations.

Different materials behave differently in the same soil. In Shapwick, rewalking the same fields

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**KEY TERMS**

**Transects, traverses and stints.**

A transect is a sampling line which could be across a single site or an entire landscape. It is usually aligned north–south and tied into the national grid. In fieldwalking transects are usually divided up into manageable chunks or stints of 10 to 50 metres where one walker will use one collecting bag. ‘Traverse’ is a term used largely in geophysics and sometimes aerial photography to describe the straight, parallel paths passed over by the surveyor. So a magnetometer survey might use traverses set at 0.5 metres apart.

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**Figure 1.6 A Level students fieldwalking**

The experience and training of fieldwalkers and the conditions on the day are factors affecting what is recovered (p. 117).
Figure 1.7 A planned fieldwalk which has been linked to the national grid system. Transects are 10m apart with 50m stints.

Figure 1.8 The density of one category of finds plotted in relation to each fieldwalker's stint. Amounts of selected materials can also be shown with shapes or dots where the size and colour or shading represent the numbers of finds.
and monitoring ceramics in them showed that some material migrates further than others. Patterns for pottery from different periods were also very different. It was not always a good indication of settlement. A second variable was the differential collection by different fieldwalkers. Analysis of their finds showed that some were good at recognising and collecting one type of material but poor with another. This applied to experienced walkers as well as novices. Their performance varied according to weather and slope. Taken together it means that what is recovered is a sample of what was in the topsoil and the topsoil holds a sample of what lies below. In both cases the sample varies for each type of find. Fieldwalking results therefore need to be cross-checked with other data before conclusions can be drawn.

There are a number of other prospection methods which provide alternatives to fieldwalking although all are more destructive. Shovel pit testing can take place in woods, pasture and gardens where fieldwalking is impossible.

Coring and augering are also used to sample the subsoil. This can provide a snapshot of the stratigraphy and the sample can be examined for artefactual or environmental evidence. Probing, which involves driving a rod into the ground, is more useful for tracing shallow buried features such as walls on known sites ➤ p. 253.

GEOCHEMICAL PROSPECTION

These relatively new methods and expensive techniques attempt to locate areas of past human activity by detecting differences in the chemical properties of the soil. All living things produce organic phosphate as waste or through decay. Unlike phosphate in fertiliser, this remains in the soil where it was deposited. Samples of soil

Figure 1.9 An excellent example of a flint arrowhead recovered during fieldwalking at Thetford

Figure 1.10 A total station

The total station combines the functions of theodolite, EDM and data logger. It is highly accurate in calculating heights, angles and distances and can be used to rapidly set out grids or to record the position of hundreds of points. These can later be downloaded and with the right software, used to produce 3D maps of the survey area.
are taken and levels of phosphate measured in a laboratory. Once plotted, concentrations of organic phosphate may indicate settlements or animal enclosures. Similar principles apply to heavy minerals such as lead and cadmium and to lipids (fats). These may become increasingly important in the future. One possibility is that different chemical combinations could identify ‘signatures’ (p. 125) for different activities.

**GEOPHYSICAL SURVEYS**

This term covers techniques that detect features through their physical differences with the surrounding soil. The most common techniques detect magnetic and electrical anomalies and require considerable skill to interpret. With the increasing involvement of archaeology in planning development and a shift in emphasis amongst archaeologists in favour of preservation rather than excavation, these techniques are now commonplace. The manufacture of increasingly reliable instruments for archaeology has seen magnetometry become a standard technique.

- **http://www.geoscan-research.co.uk**
- **www.brad.ac.uk/acad/archsci/sbject/archpros.htm**

**Resistivity survey**

There are differences in the ability of different soils to conduct electricity. This can be detected by passing an electric current through the ground and comparing readings. Electricity is conducted through the soil by mineral salts contained in water. The more moisture there is the better the conductivity of the soil. A buried ditch or grave will generally retain water better than the surrounding soil. A buried wall or road will conduct poorly and therefore resist the current more than the surrounding soil. Electrical current flows close to the surface so it can be measured using shallow probes. The method works better with some soils than others. Clay retains moisture
well, so differences in resistance between the soil and buried ditches or pits may be impossible to detect. This also applies to many soils if they become waterlogged in wintertime. Plants, rocks and variations in the depths of soils can also create misleading readings.

Resistivity can also be used to create pseudo-sections of buried features. This involves taking a series of readings from a line of probes placed across a buried feature such as a ditch. Wider spacing produces data on deeper parts of the feature than narrowly spaced probes. The depth to which this technology penetrates the soil is limited and readings require considerable interpretation, as the sensitivity of the meters is not great. At Hindwell in Wales, a 4-metre wide ditch identified by resistivity turned out after excavation to be a series of massive postholes with construction ramps.

**Figure 1.13 Resistivity surveying**

Meters are usually mounted on a ‘zimmer-like’ frame and have a data logger on board to record results. While relatively easy to use they are not fast and are best suited to detailed exploration of a site rather than initial prospecting.

**Magnetometer surveying**

The earth’s magnetic field is generally uniform in any one place. However, local magnetic distortions can be caused by past human activity. Topsoil contains haematite (Fe₂O₃), an iron

**Figure 1.14 A simplified diagram illustrating the principles of resistivity**
oxide. In some forms its crystals are magnetic. A ditch which has filled up with topsoil will contain more haematite than the surrounding area. Its fill will therefore be slightly different magnetically and may be detected by sensitive, modern magnetometers.

A second type of distortion is caused where topsoil has been subject to considerable heat. This erases the magnetic properties of the iron oxides. For Haematite 675 °C is required. When the soil cools the iron oxides become permanently magnetised according to the polarity of the earth’s magnetic field at that time. Since this field changes over time the sites of kilns and hearths appear as magnetic anomalies.

The earliest magnetometers were cumbersome and slow to use. The development of hand-held fluxgate gradiometers has enabled the technique to be used to rapidly scan quite large areas to highlight anomalies. Magnetometers are also used in detailed site investigations where they can detect small features up to 1 metre down and provide images of some buried features. For very detailed work traverses are set 0.5 metres apart with samples every 0.5 metres. 1 metre gaps and sample intervals are more common.

**Figure 1.15** Magnetometer survey

Magnetometers are either hand-held or as in this example, mounted on a frame. The twin fluxgate gradiometer shown here has two vertically mounted sensors a metre apart to maximise speed and sensitivity on large searches.

**Figure 1.16** Resistance and Magnetometer plots compared

The essential complementary nature of these techniques can be seen in these plots from English Heritage’s survey of White Barrow.
To be able to detect anomalies, the magnetic background of the soil has to be measured and magnetometers calibrated against it. The measuring of this magnetic susceptibility of the topsoil can also be used as a crude but rapid survey technique in its own right. Magnetic hotspots suggest areas of past settlement or industrial activity, which could be surveyed using other methods.

Sensitive magnetic instruments are easily disturbed by iron, including nails, pipes and wire fences as well as the zips and piercings of the archaeologist. A further limitation can be background interference from magnetic bedrock or where a long period of occupation has left a magnetic layer over a wide area. Sandy and clay soils often do not provide sufficient contrast. Fluctuations in the earth’s magnetic field also have to be taken into account. It requires considerable skill and experience to interpret the results.

**Caesium vapour (CV) magnetometers**

These are many times more sensitive than conventional magnetometers and are more commonly used in Germany and Austria. Typically several machines are used close together on a large wooden handcart. They work by pumping caesium vapour and taking rapid measurements at around 25cm intervals. This alkali is so sensitive to minute variations in magnetism that it can detect and define the edges of buried features formed by traces of magnetite. This iron oxide (Fe$_3$O$_4$) is concentrated in the remains of the bacteria which consumed the wooden structures such as posts which once stood there. It is being used at a number of well-documented sites to reveal more of their secrets. Recent work at Stanton Drew stone circle revealed the ‘ghosts’ of hundreds of postholes in concentric circles. Caesium magnetometers suffer less from the background ‘noise’ which occurs with handheld devices but at £40,000 per machine and perhaps four machines on a cart, this technique is expensive.

**Other methods**

Metal detectors are useful for metal objects down to about 15 cm. Some archaeologists use them on site to provide information in advance of digging such as the position of burial deposits. Skill is required to avoid time being wasted exploring buried slag or modern metal debris. Similarly they can sweep areas in advance of detailed geophysics to identify concentrations of metal that might distort readings.

Ground penetrating radar (GPR) which was developed for defence and engineering is starting to be used in archaeology. Aerial versions can highlight buried landscapes and rivers. GPR works by transmitting pulses of energy into the ground and recording the time taken and strength of the return signal. This can indicate the density and depth of buried deposits. Data based on different energy wavelengths can be plotted as a series of ‘time slices’ to build up a 3D picture of buried remains.

Sonar, which was developed to detect submarines is a form of acoustic sensing. Side scan sonar measures sound waves as they ‘bounce back’ and can map the sea bed and reveal the

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**KEY TASK**

**Test your understanding of geophysics**

Which of the two main geophysical methods would normally be effective in detecting these buried features? Answers on p. 429.

1. Hearths
2. Cobbled floors
3. Stone walls
4. Graves
5. Kilns
6. Large pits
7. Stakeholes
8. Building platforms
9. Small pits
10. Ditches
Bosing is a crude form of acoustic sensing used on land. It involves hitting the ground with a mallet and listening for variations in resonant sounds. These may indicate buried ditches or walls.

Finally there is dowsing. This is a traditional method by which skilled dowsers use wooden rods to detect water or archaeology underground.

All of these geophysical techniques are limited in the type of work they can do and they should therefore be seen as complementary. None of them are particularly useful on waterlogged sites. Their value is often in pinpointing or exploring features rather than finding new sites.

AERIAL PHOTOGRAPHY

The first aerial photographs (APs) were taken from balloons. Today, most photographs are taken from light aircraft although even kites or balloons are used on occasions. APs are used for mapping, finding new sites rapidly over large areas and illustrating and exploring known sites. Substantial archives of aerial photographs are available publicly and commercially so new pictures may not always be needed.

- http://aarg.univie.ac.at/
- http://www.nmia.com/~jaybird/AANewsletter/

Figure 1.17 Handcart mounted GPR

Ground versions of GPR are useful for detecting buried floors, voids and walls. It has been particularly effective in revealing the internal structures of buildings and exploring burials. It is the only effective geophysics technique in city centres where it can even penetrate tarmac. Due to its cost and the availability of quicker methods it has not been used widely outside urban areas in the UK although this is starting to change. It also works poorly on clay soils.
Verticals and obliques

Aerial photographs used for mapping are taken with the camera pointing straight down at the ground (verticals) with the aircraft flying along grid lines. Often these are taken from high altitude. This is the case with the RAF archives dating from the 1940s which are now housed at the NMR. These also provide an excellent desktop source for initial study of landscape developments. Overlapping vertical photographs can be viewed through a stereoscope to see the landscape in 3D. Their main value is in planning and illustrating sites. Where some dimensions in the photograph are known, reasonably accurate plans can be drawn of sites, including their contours. This is known as photogrammetric mapping.

Oblique photographs are the most widely used in archaeology to locate sites and illustrate features. These are taken from low-flying aircraft with the picture taken at an angle to the ground. Aerial reconnaissance usually precedes field survey. While this is fast and gives good coverage, it can be expensive and can miss features if their signatures are not visible from the air. Equally, there may be features which are invisible at ground level and this provides the only means of recording them. There are three main ways in which archaeological sites show up from the air.

Shadow sites

In low light, either at the start or end of the day, shadows are at their longest and even quite minor variations in ground level cast shadows, for instance ploughed out barrows or the remains of early field systems.

APs taken from a low-flying aircraft and recorded with a camera pointed into the sun have a distorted perspective which emphasises shadows. The technique is best used for illustrating existing sites and locating details within them, for example features inside a hill fort. However, shadows are also created where crops are at different heights (\ref{p.23}) and occasionally new sites can be detected. Winter is the best season for photography as the sun is low and vegetation which might mask sites has often died down. Snowfall and flooding can accentuate the appearance of hollows and earthworks and create some of the most dramatic images of shadow sites.

Cropmarks

The ripening and growth rate of crops is related to the amount of moisture their root systems can access. Plants with better access to moisture will often grow taller and turn a different tone or

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*Figure 1.18* Side scan sonar image of a submerged aircraft

This scan of a US Navy PB4Y-2 Bomber was recorded by sonar mounted in a towfish device. The aircraft is at the bottom of Lake Washington in the USA under 164 feet of water. http://www.marinesonic.com/

Other information on marine surveys is at http://www.url.edu/artsci/his/mua/MUA.htm
Figure 1.19 An excellent view of the deserted medieval village (DMV) of Bingham’s Melcombe, which shows up because of shadows cast by low sunlight. Traces of houses, enclosures and trackways are all visible.

Note how features at right angles to the sun show up best.

Figure 1.20 Why earthworks are visible as ‘shadow sites’
colour than those plants around them. If there are buried archaeological features under a field this can result in patterns showing in the crop. A buried ditch with its infill of humus and topsoil will often hold moisture, creating a dark green line in the crop above. This ‘positive’ cropmark is visible from the air. The opposite occurs in plants over a buried wall. They are likely to be stunted and produce a yellowish, ‘negative’ cropmark. ‘Parch marks’ show on grass for the same reason.

Cropmarks sometimes only show for a few days a year. Repeatedly flying over areas over time can pick up new and different features. Some only show up in drought conditions when crops with access to moisture have the greatest advantage and colour contrast is exaggerated. The technique works best on quickly draining soils such as river gravels but is less good on clay or areas of deeper topsoil, where the soil retains moisture well. Cropmarks show up best in cereal crops such as wheat and particularly barley. They do not show up in many crops, for example peas and beans, and the effect of differential moisture can be overcome or masked by irrigation or fertiliser. Care has to be taken with interpretation, as geological features such as periglacial cracks and modern field drainage and underground pipelines also create cropmarks. Trial excavation is often the only way to firmly identify many sites. Cropmarks are the most prolific source of new sites, particularly for the late Neolithic to early medieval periods, and are also used to investigate existing sites such as the extent of the harbour at Fishbourne Palace.

Figure 1.21  An Iron Age ‘banjo’ enclosure on Cranborne Chase showing as a dark cropmark

The crops growing over the ditches of the feature are darker because their roots have better access to moisture than the surrounding crops. Crown Copyright 1955 & 1959/MOD.
Soil marks

On soils where there is a marked contrast between the colour of the topsoil and subsoil, evidence of ploughed-out monuments can occur as soil marks. On chalk, the dark brown of ditch infill will contrast with the chalk rubble of a bank and the lighter brown of the plough soil. At Flag Fen a Roman road appeared as an orangey stripe against the black peat soil. Soil

Figure 1.22 Three-dimensional cross section of cropmarks

Figure 1.23 Winterbourne Stoke round barrow cemetery showing as soil marks

The difference in tone between the top soil and the material used for the barrow provides a clear contrast. The monuments would not be easily detected on the ground.
marks are sharpest in winter when vegetation is low.

**Remote sensing**

This can be a rather confusing term. Usually it is used to distinguish between the imaging techniques used from planes and satellites and those of ground based prospection. Sometimes it is used to describe all techniques that don’t remove material. When you come across it, be sure to check which sense it is being used in. We are using it in the first sense. The results of all these techniques need to be checked at ground level.

A variety of airborne and satellite techniques, including thermal imaging and infrared photography, are able to record temperature, dew and frost dispersal variations invisible to light-sensitive film. They all work on the principle that anomalies such as disturbed earth or buried walls will absorb and retain heat or moisture at different rates to the surrounding ground. Commercial equipment is really only suitable for large features although military developments to increase sensitivity will no doubt filter through to archaeology. Currently such equipment is too expensive for most archaeological surveys.

![Figure 1.24 Loughcrew](http://www.arcl.ed.ac.uk/arch/remotesense/)

The area around Loughcrew in Ireland is packed with neolithic monuments, however, little is known about other use of the landscape. Current research is using a technique called airborne Lidar (Light Detection and Ranging) to map all the earthworks within 3km of the site. The Lidar device is mounted in a light aircraft and transmits a scanning laser beam which is reflected back from the ground surface and recorded on sensors. The time taken determines the precise distance from the aircraft. This method is more sensitive than conventional photographs of shadows and is revealing early field systems within the modern landscape which survive as slight earthworks.