UNIVERSITY OF SOUTHAMPTON

AIR ARCHAEOLOGY

IN THE VALLEY OF THE RIVER SEVERN

VOLUME 1 of 3

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ABSTRACT

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AIR ARCHAEOLOGY IN THE VALLEY OF THE RIVER SEVERN

by William Arnold Baker

This work constitutes part of a programme of aerial reconnaissance in the West Midlands over the period 1952 to 1978, an area previously regarded as inhospitable and devoid of prehistoric settlement. The application of flying disciplines and photographic techniques in light aircraft are discussed. Comment is also made on the technique of air archaeology, with particular reference to the recognition and recording of archaeological features revealed through changes in the growth of vegetation, including the effects of weather and seasonal variations. Consideration is given to the various soil types in the region and associated crop-mark distribution, together with detailed plans of the settlement sites recovered. Emphasis has been placed on the evidence for Roman remains in the area, including military installations and the recording of Roman road alignments. Apart from the conduct of aerial reconnaissance in general, attention is drawn to the advantages of a project oriented aerial survey, in this instance over the Romano-British town of Viroconium Cornoviorum in Shropshire, culminating in the interpretation and analysis of the complex features revealed; from this work a research excavation was initiated to determine the nature of the 4th century defences, in terms of a bastion form of defence with the use of artillery.

The illustrations throughout are interpreted and reflect the opinions of the writer, with sufficient detail to facilitate future excavation planning. The technique of aerial thermal mapping in the far infra-red region is also included, as an aid to archaeological research.

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ACKNOWLEDGEMENTS

In the preparation of this thesis it has been necessary to draw on the findings and conclusions of scholars and excavators who have worked in the valley of the river Severn. The contribution of Birmingham University Department of Extramural Studies is also acknowledged, in supporting aerial reconnaissance in the west Midlands as a whole, and reflected in the encouragement given by Dr G Webster and the late Professor D R Dudley. I am also grateful to the Birmingham University Field Archaeology Unit for a preview of the results from rescue excavations in the Severn valley, prior to external publication, and particularly in accepting responsibility for the conduct of the research excavation initiated by the writer on the site of the Romano-British town of Viroconium: and to the National Trust and English Heritage for access on the site of Viroconium and the granting of Scheduled Monument Consent. To the University of Southampton, Department of Archaeology, my appreciation of the recommendation and acceptance of postgraduate studies, and to my supervisors, David Peacock and Tim Champion for their advice and guidance in the preparation of this thesis. I am especially grateful to the Royal Commission for Historical Monuments (England), for their support in providing the university fees involved.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

The purpose of this thesis is to present the results of aerial reconnaissance in the valley of the River Severn and its watershed; it will also reflect the writer's experience and problem areas in the conduct of air archaeology in the West Midlands over the period 1952 to 1978. It is not intended to include the results of other practitioner's observations over the area concerned, except by reference where relevant.

With the exception of the items acknowledged, all the aerial photographs and drawings contained in the thesis are the work of the writer, and sites of archaeological interest recorded in the valley, are presented in the form of sketch plans on 1:2500 series ordnance survey maps. The argument is solely the opinion of the writer, and is based to a large extent on the photographic evidence, illustrations and maps. On initiating this work in 1952, the writer had no previous experience in this discipline other than the ability to fly an aeroplane. At that time the area of the West Midlands, in which the River Severn and the Warwickshire Avon are the predominant features, was considered to be heavily wooded where prehistoric occupation of any kind is likely to have been scanty or transient. Against this background, the Jurassic ridge along the Cotswolds was presented as the demarcation line between the well developed areas to the East and the relatively undeveloped landscape to the West. It was not a question of treading where man had never trodden before, but rather where it had never been considered profitable to do so. Also in 1952 there was little information published on the technique of aerial reconnaissance and its archaeological potential; it was necessary therefore to develop flying and photographic-disciplines, combined with a study of the problems involved in landscape interpretation. Comment will be made on these aspects together with the technique of air archaeology; although the latter is now well documented, it is not the intention to duplicate unnecessarily what has already been published, but it is considered that a more comprehensive treatment of particular aspects of the discipline would not be out of place, in that it would be of some practical value and compliment the main theme of the thesis. In this context the technique of Infra-Red Linescan is introduced.

In view of the wealth of information revealed through aerial reconnaissance in the Severn valley, the research data is presented in three volumes which will, in addition to the analysis and discussion of the results, also provide an opportunity to examine fundamental differences in applied reconnaissance techniques.

Volume I is devoted to the text and presents the flying and photographic disciplines as developed by the writer, including the technique of air archaeology and the results achieved in the Severn valley. A more specialised viewpoint is also introduced in the recovery of Roman roads and Military installations, in conjunction with the merits and results of a dedicated research project over the Romano-British town of VIROCONIUM CORNOVIORUM at Wroxeter.

For ease of reference, all the aerial photographs, maps and illustrations appertaining to the text are designated as figures and contained in Volume 2. Because of the number of sites involved, only a representative selection of figures have been included, and the remainder is contained in Volume 3. For the purpose of illustrating some aspects of the technique of air archaeology, aerial photographs from the writers collection, other than in the Severn valley, have been used.

1.2 Landscape Archaeology

In the writer's experience, one of the most compelling views of the landscape is from the air, following the passage of a cold front, when visibility appears to be infinite and the patterns of agriculture, roads and dwellings, are revealed with extraordinary clarity in the clear polar air. A landscape which constitutes a mosaic, created by continuous occupation and changes in land use down through the ages. In most cultures, progress is invariably dictated by events which have a profound influence on their development, either directly through conflict, or the advent of trade introducing new techniques, innovation is a much slower process. So it is that archaeology has found it convenient to classify the various periods of occupation accordingly. Although the circumstances may be dramatic, as in the invasion of Britain by the legions of Imperial Rome, it does not necessarily have an immediate effect on an established culture. It may influence the structure in terms of government and administration due to the introduction of new skills and demands on its resources, together with the need to suppress insurrection or afford protection against further intrusion; but the basic lifestyle and ritual must to a certain extent be maintained to accommodate such a change. Inevitably, the result will be a gradual integration with the influx of new ideas, which may also reflect significant changes in land use. This is of relevance when considering the interpretation of the results from aerial reconnaissance. It must also be borne in mind, that the advent of new cultures does not necessarily result in continuous progression in a particular standard of living, but may eventually lead to regression as is evidenced by the collapse of Roman administration in Britain, to be followed by the Dark Ages.

The outcome is a dynamic landscape in which areas of settlement may disperse or cease to exist, to be subsequently reoccupied over a period of time. The complexity of the evidence in some areas as revealed by aerial photography, does not therefore imply continuity of occupation, although some communities may indeed readjust to external pressures and others develop into more intensive areas of occupation. The evidence for early settlement, integral with the landscape of today, is clearly visible in the form of burial mounds, hillforts, enclosures, boundaries and other remains, but the reorganisation and acquisition of land in terms of field systems for pasture or cultivation, which may extend over considerable areas, is more difficult to assess. There is very little of the present landscape that has not been influenced to some extent by human activity in the past, and the evidence for it is reflected in extant remains and casual finds together with such settlement patterns as may survive concealed beneath the surface soil. Aerial photography can enhance the detail and extent of visible remains, by providing a broad canvas of features which may otherwise be difficult to resolve at ground level. It has no contribution to make in respect of casual finds alone, except perhaps to observe and record the area in which they occur. The most important contribution leading to an understanding of the evolution of past landscapes, is the evidence for occupation which lies under the topsoil and may be revealed by changes in the growth of vegetation. It is a paradox in that, although intensive agricultural processes are responsible for the destruction of surface features, it is the most productive medium through which concealed remains are revealed.

Over the last six decades aerial reconnaissance has produced an embarrassing wealth of evidence for early settlement, previously unsuspected, presenting archaeology with a new challenge, for it has become necessary to address the development of the landscape as a whole and not solely by the investigation and assessment of individual sites in isolation which may, or may not, elucidate the problem. This situation is quite apart from the demands of rescue excavation prompted by the unprecedented extent of site destruction due to present day land exploitation, although it may compliment the prospect of landscape evaluation in that sites are also revealed which have not responded in the form of changes in the growth of vegetation and have therefore remained undetected. To further complicate the situation, the evidence for occupation confined to the land surface has in many instances been swept away by the plough, leaving no trace of its existence except perhaps through the incidence of casual finds. The discipline of aerial reconnaissance can no longer be relegated to a useful tool in archaeological research, and in the light of present land utilisation constitutes a specialised contribution, the results of which excavation alone cannot possibly hope to elucidate. The impact of such an embarrassing wealth of information has necessitated a restructuring in archaeological thinking, skills and assessment. The problems in landscape archaeology may be summarised under three headings.

i The retrieval of information through aerial surveillance.

ii Archival storage and data reduction in terms of interpretation, mapping, classification and presentation.

iii Archaeological evaluation, research and excavation.

The issue is compounded by the speed and extent of present day land exploitation in terms of gravel extraction, urban development, road systems, quarrying and industrial activity. This has emphasised the need for the preservation and scheduling of specific monuments in an endeavour to protect some aspects of the landscape for future assessment.

From the available evidence, the difficulties in attempting to evaluate and present the information in a comprehensible and manageable form are formidable. The sheer volume of accumulated data has resulted in the introduction of a new concept based on non-destructive archaeology, where selected areas are subjected to a detailed investigation, including field walking, geophysical exploration, analysis of casual finds and place names together with the results of aerial reconnaissance; in the context of landscape evaluation some limited research excavation within the resources available is an essential prerequisite, if the sites which have now been destroyed are to be understood through comparative analysis with those that remain.

Over the last four decades, the opportunities for the acquisition of data through aerial reconnaissance have been unique, due to the changes in land use arising from World War II, where land hitherto undisturbed was ploughed and cultivated in the interests of food production. The situation is now being reversed, in that it is proposed to take one million acres out of agricultural production. To a certain extent this is an advantage in archaeological research, for although repeated ploughing may have eroded or destroyed any surface remains, at least the features preserved at lower levels will be afforded some degree of protection. On the other hand, aerial reconnaissance is denied any further opportunity to recover additional information over the area arising from exceptionally dry weather conditions, which may reflect more intensive variations in the overlaying vegetation. It may be that archaeology has never had it so good in terms of reconnaissance, but there is no room for complacency for there is still a pressing need to intensify exploration, particularly on a regional basis. It is encouraging that since the writer first attempted work in the West Midlands, when there was a paucity of information and practitioners, the number of air observers has substantially increased, especially in the private sector. Although it may appear that information of archaeological interest in the landscape is easily recovered, there are many limitations in the process of acquisition which will form the basis of discussion in later chapters.

1.3 Historical background

Prior to the 19th century, the study of visible remains and casual finds was the prerogative of the antiquarian, relying for the most part on individuals of private means with a concern and interest in the evidence for early cultures which formed an integral part of the landscape; a situation which exists today in the private sector contribution to aerial reconnaissance. In the absence of photography, their illustrations and plans were detailed and informative although the narrative may be embellished in some instances with superstition and folklore. Nevertheless, their findings constitute a valuable source of information, indeed perhaps the only record of features which have since been eroded away, or subsequently destroyed through land exploitation. By the mid 19th century, excavation supported by private funding and subscription was becoming more fashionable, together with a change in attitudes. To quote (Corbett Anderson, 1867) on the Roman city of Uriconium "The truth is if we would ascertain the nature and degree of the civilisation imported to Britain by the Romans, we must seek for it under the soil, and in such archaeological enquiries as those of which Uriconium has recently been the field. The time is past when works relating to ancient historical monuments failed to attract attention; every year the science of antiquity becomes more comprehensible and acceptable". Such was the situation prior to the advent of aerial photography.

In an historical context, the first important discovery was made in 1841 through the work of William Fox Talbot which produced the latent image, the foundation of present day photography, where the image recorded on a film emulsion is invisible until subjected to chemical development. The second most important event was that of powered flight achieved by the Wright brothers; the two inventions came together for the first time in 1908 when L P Bonvillain, a Pathe cameraman, flew as a passenger on a demonstration flight near Le Mans, the pilot being Wilbur Wright. The occasion of World War I resulted in significant advances in the design of aircraft and photographic equipment. The historical background to the progress of aerial reconnaissance in archaeology has been well documented (Crawford & Keiller, 1928; St Joseph, 1951; Deuel, 1971; Downey, 1980). It is not proposed to repeat what has already been written, but it would not be out of place to review the events in so far as they influenced the writer in undertaking aerial reconnaissance in the West Midlands, an area in which the river Severn is a predominant feature. The first significant milestone was reached through the work of O G S Crawford a professional archaeologist, appointed as archaeological officer to the Ordnance Survey in 1920, who realised the potential of powered flight and air photography in archaeological research from his service as an air observer with the Royal Flying Corps during the war. His initial experimental work in association with A Keiller, an experienced pilot and navigator, resulted in the vertical coverage of a wealth of extant archaeological features in Wiltshire, recorded mainly as shadow sites; this investigation culminated in the publication of

"Wessex from the Air" in 1928, which still stands today as an excellent reference work, particularly since the aerial photographs were coupled with maps, field walking and the results of excavation.

The method employed to achieve this was remarkable in its simplicity. A captured German plate camera was fitted with a suitable lens and installed initially in an Avro 504K; because of limitations in aircraft performance and slipstream effects a difficulty experienced in the initial experimental work by the writer, the camera was subsequently fitted in a DH9 to overcome the problems, and accommodated in the observers position which also improved the sighting prospects. The aircraft was a single engined biplane with cockpits open to the elements. The quality of the results is even more remarkable, in that there was no degree of sophistication in the installation to correct the problems introduced by pitch, yaw, drift and vibration. This constituted initial experimental work using a simple equipment installation, together with a dedicated enthusiasm for the venture. In addition to the recording of features as shadow sites and soil marks, Crawford also realised the significance of changes in the growth of vegetation, in the form of marks in cereal crops revealing patterns of settlement concealed beneath the surface soil; he also recognised the possibility of misinterpretation introduced by the presence of non-archaeological features. The medium of recovering archaeological remains through cropmarks was not unknown, but the expedition represented the first systematic approach to aerial survey from an archaeological point of view.

The next milestone occurred with the contribution by G W G Allen in the upper Thames valley during the period 1932-1939. An engineer and private pilot he became aware of the work in Wiltshire through Crawford's Ordnance Survey publication and realised the possibilities in the

Thames valley, an area rich in early settlement. Allen's aircraft was an enclosed cabin Puss Moth, a high wing monoplane into which he installed a vertical camera supplemented by a hand held plate camera of his own design. The results were astonishing, not only in the evidence from shadow sites and soil marks, but more significantly from crop-marks revealing a veritable Alladin's cave of evidence for early settlement on the shallow soils overlaying the river gravels. The aircraft was equipped with only the basic instruments and flown solo; under these circumstances the difficulties of storage and replacing plates in the cameras together with the problems inherent in navigation and weather conditions can be imagined. Unlike Crawford, Allen was able to continue flying throughout all the seasons and study the cycle of crop development coupled with ground investigations; the result formed the foundation of present day techniques in aerial reconnaissance and archaeology. It is ironic in that although his family business was involved in gravel extraction implying site destruction, it was through his contribution that the archaeological potential which existed in the form of remains concealed under the surface soil was to be fully recognised. Prior to his untimely death in 1940 Allen had prepared a detailed manuscript of some 12,000 words on the technique of air archaeology, including illustrations from his collection of over 5,000 plates presently housed in the Ashmolean museum in Oxford. O G S Crawford and J S P Bradford were aware of his intentions and continued with the formidable task of editing the work, but sadly it remained unpublished until 1983, (Allen, 1940). During World War II, Flt Lt D N Riley in his capacity of flying instructor based on an airfield near Oxford was able to observe and extend Allen's contribution in the Thames valley, (Riley, 1943-44). More importantly he saw the latent possibilities and appreciated the need to promulgate the information, which resulted in the first interim detailed statement of the basic principles in the technique of air archaeology. (Riley. 1946): this remained the sole reference document on the subject for many years. It is noteworthy that the work of Allen and Crawford was for the most part contained in a regional survey of some of the most productive areas of settlement. It was J K S St Joseph who after World War II, became the instigator of a systematic exploration in terms of landscape archaeology. His initial work using a hand held camera was carried out in training aircraft through the offices of the Royal Air Force. Although the survey was mainly oriented toward Roman military installations, the widespread evidence for early settlement, previously unsuspected, began to emerge. During 1948-49 he became curator for the Cambridge University Committee for Aerial Photography, organised to encourage the application of this discipline in research. It was against this background that the writer first became involved in the subject in 1952. Subsequently in 1965 a twin engined Cessna 337 Super Skymaster was purchased by Cambridge and equipped with a Wild RC8 vertical survey camera, using a hand held F24 for the purpose of oblique photography.

1.4 Aerial reconnaissance in the West Midlands

In 1948 it became necessary to undertake pilot training in the interests of the writer's profession, to facilitate the conduct of experimental equipment flight trials. This was accomplished at the Royal Air Force No 24 Reserve Flying Training School at Rochester airfield in Kent. Subsequently, in order to keep in flying practice without the need to travel elsewhere, the writer initiated the formation of Defford Aero Club in Worcestershire during 1949. To this end, four dismantled DH82A (Tiger Moth) biplanes were purchased from disposal stores in south Wales for the princely sum of £25 each, including spares. Together with a number of colleagues, the first aircraft was assembled and test flown in 1949. It was not until 1952 that the prospect of aerial photography became a reality. The first introduction to the possibility of aerial reconnaissance occurred through an interest in the local archaeological society, following initial attempts to record the remains of Iron Age hillforts on Bredon hill and the Malverns. This came about during a series of lectures given by Graham Webster, at that time a research fellow in the Department of Extramural Studies at Birmingham University; his enthusiastic approach to initiate flying in the West Midlands for archaeological purposes proved irresistible, and thus began a close association with the department and Graham Webster, who subsequently supported the venture over a period of some 25 years. In the beginning the learning process was slow, for the subjects involved covered a wide range of disciplines (Fig.1.1). The initial requirement was focussed on Roman military installations, including the Romano-British town of Viroconium at Wroxeter. At this point it would be appropriate to also record a particular debt of gratitude to the late D R Dudley, professor of Latin at Birmingham University, for his guidance and encouragement during this early phase of investigation.

In response to a selection of rather dubious aerial photographs J S P Bradford at Oxford offered useful advice and information. However, in the opinion of O G S Crawford, the outlook in the West Midlands was less optimistic in terms of prehistoric settlement. The search for Roman military sites involved reconnaissance in the valleys of the river Severn, Warwickshire Avon and to a lesser extent the river Wye, relying on the only information available on the technique as published by D N Riley; with regard to the discipline of aerial reconnaissance and photography, there were no references. As a consequence, the discoveries of G W G Allen in the Thames valley became a focal point. Photographic illustrations at that time had limitations in terms of applying the technique and in order to further assist in the problem of site recognition and interpretation, sorties were eventually planned and flown in the upper Thames valley; these were to yield information not only in the acquisition of new features, but in observing and recording the type of site which may be anticipated elsewhere, (Benson & Miles, 1974). The subsequent recovery of similar sites on the gravels of the river terraces in the West Midlands were to prove of equal importance, perhaps not reflecting the same degree of intensive occupation as in the Thames valley, but nevertheless revealing a complex spread of evidence indicative of occupation from Neolithic to Saxon.

From this work, a pattern of early settlement had emerged, representing a new and important addition to archaeological knowledge in the West Midlands. A similar situation was to be reflected throughout Britain in the contribution from other practitioners, notably that of J K S St Joseph at Cambridge. It must be borne in mind that there is a distinction between the professional and private sector in terms of facilities and opportunities to fly. Because of increasing concern in the extent of site destruction resulting from gravel extraction along the river terraces, a comprehensive assessment of the situation was published by the Royal Commission on Historical Monuments in 1960. In order to coordinate and accommodate the increasing volume of information from aerial reconnaissance, in addition to the archives already in existence from other sources and quite apart from the Cambridge collection, the Royal Commission set up an Air Photographs Unit in 1965 as part of the National Monuments Record. As an initial contribution, the writer's collection was substantial enough to deposit the negatives in the care of the Unit where the information could be made more readily available for the purpose of archaeological studies, field work, excavation and publication.

Through the auspices of Birmingham University the writer was encouraged to organise and conduct courses on the technique of air archaeology for interested groups in the West Midlands. Weekend schools were also held on behalf of Oxford University Department for External Studies and undertaken in conjunction with J Pickering, whose contribution to landscape archaeology in the East Midlands is without parallel (Pickering & Hartley, 1985). In 1958 it was found possible to arrange a weekend school on archaeology from the air at Preston Montford Field Centre near Shrewsbury, this included flying and photography in association with the Shropshire Flying Club. But it was not until 1972, when the writer initiated the first international symposium in Britain on aerial reconnaissance for archaeology, that the subject received the impetus it merited. The organisation of this event was under the chairmanship of Graham Webster and involved the Royal Commission on Historical Monuments (England), the Council for British Archaeology and the Extramural Department of the University of Birmingham. The proceedings were recorded and published. (CBA, Research Report No 12, 1975).

By 1979 there were over 50 practitioners involved in flying for Archaeological purposes. This has resulted from a concern in the early years that the private sector contribution should be encouraged on a regional basis, provided that the skills in reconnaissance and photography could be demonstrated. To this end in 1974 the writer was involved in the formation of a Research Committee in Air Archaeology, under the auspices of the Council for British Archaeology, to assess current trends and advise on policy regarding the private sector contribution. Subsequently, limited funding to support the conduct of aerial reconnaissance was made available by the Department of the Environment, to be allocated on a regional basis through recognised groups or committees responsible for the requirement.

CHAPTER 2

AIRCRAFT AND FLYING DISCIPLINES

2.1 Flight Details

The DH82A (Tiger Moth) shown in Fig. 2.1, was the mainstay of the writers reconnaissance work in the West Midlands, but in later years other types were to become available, more compatible with the requirement. The aircraft is a single engined biplane with metal framed fuselage, fabric covered, including two open cockpits in tandem equipped for dual control, and served the purpose well as a training aircraft with the Royal Air Force in World War II. When correctly rigged it was a pleasure to fly, having good all round visibility and fully aerobatic; it was powered by a 130 H.P. 4 cylinder inverted Gypsy Major, consuming approximately 7 gallons an hour from a fuel tank situated in the centre section of the upper wing with a capacity of 20 imperial gallons of 73 octane petrol. This allowed a flying time of 2½ hours at an economic cruise of 70 knots, leaving sufficient in the tank for emergencies; in the absence of refuelling facilities, the range in terms of aerial reconnaissance was limited to a radius of 80 miles from the airfield. In the original design a Gosport voice tube served as a method of communication between crew members, but for obvious reasons it was necessary to replace this and a battery operated intercommunication system was designed and installed.

Photography from the rear cockpit proved difficult to achieve due to obscuration from the lower wing, but the front cockpit however presented a more favourable aspect. From the configuration of the aircraft there was a limited area of forward visibility on either side of the aircraft which was free from interference by the wings, bracing wires and propeller arc; this viewpoint presented no problem of any consequence in terms of recording landscape features in level flight but it was necessary for the writer to develop a flying procedure to facilitate oblique photography.

To simplify camera operation, the side doors could be lowered in flight or removed prior to the sortie. Having once located a site and determined the optimum lighting conditions for photography, an approach was then made in level flight to one side of the target and the camera placed in position (Fig. 2.2), the port viewpoint being preferred; by lowering the port wing and nose of the aircraft the camera could be accurately aligned on the target (Fig. 2.3). It was essential that changes in attitude were made smoothly and quickly, it was also important to correct for drift on the run in to avoid getting too close to the target since the attitude could become too steep and decidedly uncomfortable, and also more height would be lost than necessary. The subsequent recovery and climb to regain height was a simple and safe procedure, but it was desirable to have the camera inboard before the event, because its bulk and weight of 18 lbs made it difficult to handle in the propeller slipstream and positive 'G' force experienced during recovery. There was an advantage in this method of photography in that the target area remained constant with no turning movement. Initial experiments were conducted with the assistance of a colleague using a hand held K24 type reconnaissance camera fitted with an Aero-Ekta 7 inch lens (Fig. 2.4), this was subsequently replaced by an F24 similar in size, weight lens and characteristics; but initially, some problems were experienced with image movement on the negative.

There were four main causes of movement,

(i) Due to the observer.

(ii) Through the camera making contact with the fuselage, introducing vibration.

(iii) Failure to hold the aircraft steady on the target.

(iv) Air Pockets and turbulence.

Nothing could be done about the latter except to repeat the photograph, the other difficulties were to be overcome with care and practice. The technique involved a variable height loss of up to 200 ft depending on the angle of the oblique, with approximately 2 to 3 seconds in which to make the exposure. There remained the problem of propeller slipstream effects, this was to be overcome by reducing airspeed on the approach to the target and finally closing the throttle on initiating the manoeuvre. The airspeed was adjusted to approximately 55 knots at the point of entry into the oblique attitude, any corrections required had to be initiated in the first few seconds, after which the increasing airspeed made the controls more firm and further adjustment difficult to achieve, this could also result in an excessive loss of height.

However, photography presented problems from the writers point of view as pilot in the rear cockpit; communicating the precise requirement and indicating the ground feature to an observer was time consuming, and not always successful. As a consequence two interested colleagues were persuaded to undertake the flying procedures, allowing the writer to assume the position of aerial photographer and navigator in the front cockpit. Team work was essential, for the mode of operation required an accurate approach to the objective and precise timing in initiating the manoeuvre in order to achieve the required oblique, and in the process avoid including any part of the aircraft structure or propeller arc on the negative. It would not be out of place at this juncture to record a debt of gratitude to co-pilots J Leatherbarrow and the late B Chadd who were to accompany the writer on aerial reconnaissance for many years, it was only through their skills and patience that the conduct of air archaeology in the West Midlands proved feasible.

Operating the F24 in the confines of the front cockpit presented handling difficulties because of its size and weight, but these were overcome with experience, needless to say the camera was securely attached to the writer at all times. The cockpit seating was of the bucket type designed to accommodate a seat type parachute, since this was not a requirement seating in the front cockpit was padded in height to allow increased freedom of movement for observation and camera operation. Steep angle obliques were possible, but near verticals were not a conspicuous success following several experimental attempts which served as an effective deterrent. There were refinements in the flying procedure, in that the pilot could hear the camera shutter release through the intercom system and anticipate recovery without delay. Changes in heading on the approach were given by the writer and expressed in degrees, this was important because the target could not be seen by the pilot in the latter stages of the approach prior to the manoeuvre, due to obscuration by the lower wing. There was no time to use the aircraft compass for corrections, the commands were simple for example, right 5° or left 10° or dead ahead, and the pilot's estimate was adequate. Different angles of oblique were also designated as numbers which helped the pilot anticipate the angle required, when this was achieved and on the command 'hold' the pilot stabilised the attitude for photography. The only advantage of the writer as a qualified pilot was a knowledge of aircraft performance and air safety aspects. Patter was kept to a minimum and the intercom switched off when not in use to reduce background noise. The pilot in the rear cockpit was in command at all times and his decision was final on any aspect of the flying discipline; there were occasions when it was necessary to suppress enthusiasm for a diversion from track on the return journey to the airfield, bearing in mind the weather conditions and fuel state.

In later years the Aero Club disposed of the DH82A due to difficulties in obtaining spares, and opted for a low wing type aircraft which proved entirely unsuitable for the task in hand. Fortunately, a privately owned Piper Cub was made available for use (Fig. 2.5). This was a high wing cabin type aircraft fitted with dual controls and accommodating pilot and observer in tandem, affording excellent all round visibility. The performance was similar to the DH82A with the facility of opening the starboard upper and lower side doors in flight presenting the observer and pilot with an unrestricted viewpoint, although in steep obliques the position of the undercarriage had to be borne in mind to avoid including a wheel in the negative. Compared with the DH82A the technique was simple, involving a precision turn with the target as the focal point. An endurance of 3 to 4 hours also considerably improved the prospect of increasing the area of observation without the need to refuel. In some circumstances extended flight times are not necessarily an advantage, for example operating in turbulent weather conditions is not a pleasant experience and can have a detrimental effect in maintaining the acute sense of perception and concentration required throughout the flight, particularly for observers who may not be in current flying practice or inexperienced.

There were other considerations, namely the availability of pilots and aircraft. Although the aero club eventually operated more than one DH82A, the advent of flying training and scheduled servicing together with other club activities did impose some restrictions, and there was always the prospect of inclement weather to contend with.

The situation was further complicated in that flying could only be achieved in the writers free time, in terms of week-ends, evenings or annual leave, even lunchtimes were not sacrosanct if conditions were suitable.

2.2 Flying disciplines

Although the work of G W G Allen (Page 10) was accomplished by flying solo with all its attendant problems, in the present day environment it would not be considered good airmanship, and should be avoided. Prior to World War II the density of air traffic was minimal compared with the complex situation which exists today; control procedures were not as demanding, and no doubt it was possible to fly all day without sight of another aircraft. In the present circumstances it would not be prudent for a pilot flying solo to timeshare between an intensive search of the landscape including photography, and the welfare of the aircraft. The presence of an observer or co-pilot can only be in the best interests of aircraft safety and flight objectives. In the lower levels below 2000ft the incidence of air traffic can be high in the form of service aircraft on exercise or gliders which are very difficult to identify when in line with the aircraft track, together with helicopters and a variety of other air activities. During the relatively busy period of May to August it must also be borne in mind that there may well be other practitioners operating in the same airspace; under such circumstances the ability to maintain a good lookout is therefore imperative.

It is considered that a pilot in the present environment has enough responsibility in monitoring radio communications, map reading, general navigation, weather and overall aircraft performance to become too involved in searching for archaeological detail in the landscape, particularly in conditions of poor visibility. It follows therefore that there is little to be gained in training observers to attain a private pilots licence to facilitate the conduct of aerial reconnaissance, but it is considered essential for an observer to be aware of, and take an interest in flying disciplines, together with an understanding of aircraft performance and the pilots viewpoint, including all aspects involved in flight planning and meteorology to ensure a successful sortie. To undertake a photographic reconnaissance flight in the absence of adequate training with an experienced practitioner, can be a waste of resources in terms of achieving a viable result. The discussion has been centred on aircraft in which the pilot and observer are seated in tandem with good all round visibility, but there are problems with side by side accommodation in aircraft such as a Cessna 150 for example in that the observer's viewpoint is restricted to one aspect; under these circumstances flight plans have to be arranged accordingly if an area is to be completely surveyed.

2.3 Flight planning and Navigation

The DH82A presented specific problems in flight planning. for the aircraft was only equipped with primary flight instruments (Fig. 2.6), with no radio communication or modern aids. Navigation was accomplished by map reading and a P8 compass. Headings were only maintained if the aircraft was accurately flown with wings level, sloppy flying invariably introduced compass errors resulting in deviations from track which required frequent corrections. Following river valleys, railway lines or indeed a Roman road alignment was a relatively easy procedure; cross country flights to specific areas demanded a different approach to maintain an accurate track, for this purpose fix points are required on the ground every 10 miles in order to apply any corrections which may be necessary. With good visibility navigation presented little difficulty, but in adverse weather conditions detailed flight planning was a prerequisite to a successful sortie.

However, repeated flights over the same area resulted in a degree of familiarity with the terrain which eased the problem considerably. In terms of normal flight between two points in the landscape there was no difficulty, but reconnaissance required a more flexible flight pattern involving frequent deviations from the planned track to resolve features of interest.

With no radio facility, entry into any controlled airspace, military, airfield or zone had to be prearranged with details of the proposed flight pattern including height, area and purpose, the time of entry and departure had to be strictly observed; deviations from the agreed schedule were not acceptable. Flying in the vicinity of sensitive airfields in the upper Thames valley was particularly difficult, and on one occasion the writer had the experience of looking down on Concorde in flight from a DH82A. In some circumstances it was necessary to overfly an airfield at a predetermined height in order to obtain clearance from the control tower by Aldis lamp. Fortunately operating in the West Midlands did not present too much of a problem in this respect except for the Birmingham Control Zone which restricted flying in the upper Warwickshire Avon, and also along the river Severn in the vicinity of Shawbury airfield to the northeast of Shrewsbury.

In an area such as the West Midlands, flight planning and navigation was dictated by the limitation in aircraft endurance. From the writers point of view three modes of operation were involved,

2.3.1 Prospecting.

2.3.2 Reconnaissance.

2.3.3 Project oriented survey.

2.3.1 Prospecting

This may be defined as a random search for features of archaeological interest over landscape previously thought to be unrewarding, or areas which have not been surveyed for reasons of cost, time, aircraft availability or other priorities. In the writers case the West Midlands was unknown territory, which justified this method of investigation. There are two ways in which a survey of this nature can be carried out, by a planned area search, or concentrating in the first instance on the well drained soils, in particular those which overlay sands and gravels known to be productive in other areas in terms of early settlement with the prospect of extending the survey over other soils where feasible.

To conduct an area search involves flying a series of parallel tracks to provide complete ground cover. For this purpose it is reasonable to observe features in the landscape up to a distance of 1 mile from one side of the aircraft, flying at a height of 2000 ft, bearing in mind the changes in angle of view and resultant perspective distortion with range, in terms of resolving small features or patterns; a range of 1 mile at 2000ft represents a shallow angle of 20^{o} down from the horizontal, any reduction in height or field of view due to poor visibility would increase the overall flying time to complete the survey. To cover an area of 20 miles square at a ground speed of 80 m.p.h. with tracks spaced by 1 mile would require a flight time of 5 hours, this does not include diversions for refuelling, photography, or transit time to and from the area under observation. Furthermore, apart from any navigational difficulties in maintaining parallel tracks, a speed of 80 m.p.h. would only allow some 20 seconds in which to scan an area of ½ mile by 1 mile equivalent to 316 acres. Such a pattern is best flown into wind and downwind to avoid any difficulties in observation which may result from aircraft orientation along track to correct for drift. Using a DH82A aircraft with a duration of only 2½ hours at a cruising speed of 70 knots the best that could be achieved would be to survey an area of 200 square miles in the vicinity of the airfield. Considering that the Severn valley and its tributaries occupies an area of some 2000 square miles, this mode of survey was clearly impractical. If such a pattern could be flown there are two options open to the observer in monitoring any features of interest, either to repeat the pattern or select smaller areas for continued observation. Although a pattern of this nature could be flown by light aircraft with an adequate endurance it is considered more appropriate to a long range aircraft equipped with a vertical camera and modern navigation aids, with the prospect of an added facility for a 30% overlap in the interests of stereo viewing, and a hand held camera for oblique photography.

With the writer's light aircraft it was necessary therefore to devise a more flexible method of survey. Bearing in mind the prospect of finding evidence for early settlement on the river gravels, flights were planned accordingly. The procedure adopted was to divide the course of the river Severn and its tributaries into specific areas. The DH82A was not equipped with a fuel contents meter, the only indication was provided by a thin external rod attached to a float chamber in the tank; having established the rate of fuel consumption from previous flight data, timing was the criteria. The method adopted was to subtract the total transit time from the maximum aircraft endurance, the remainder representing the time available for observation and photography. Any deviations in the outward journey reduced the time over the area accordingly. To extend the survey, points were plotted along the valley to establish the latest time of departure for the airfield or refuelling facility. This mode of operation provided the necessary flexibility with the prospect of flying a small pattern in any given area.

2.3.2 Reconnaissance

From the writers point of view reconnaissance implies the flying involved in progressing features of archaeological interest discovered through prospecting, using similar flight techniques. If time permitted, deviation from the flight pattern could be anticipated in the interests of prospecting, provided adequate flight plans were prepared for the eventuality. However, the advent of new sites each year added to those already known, placed restrictions on the possibilities of further prospecting in the absence of adequate refuelling facilities or an increase in the number of sorties necessary to maintain the continuity of observation required; as a consequence priorities had to be allocated accordingly. Weather was significant in influencing the mode of operation, particularly in drought conditions, when features of archaeological interest were more prolific, leading to a measure of frustration in the inability to adequately cover or extend the area of survey. In the event it was considered more appropriate to concentrate on specific areas in detail, rather than conduct a superficial assessment and attempt to extend the flight pattern in anticipation of a more rewarding outcome elsewhere. The concept that something is better than nothing may be acceptable in prospecting, but reconnaissance implies a more detailed site evaluation in terms of observation and photography.

2.3.3 Project Oriented Survey

This method of survey constitutes a flying programme dedicated to continuous observation over a specific area, or site in successive seasons. In the writers case the project involved reconnaissance over the Romano British town of Viroconium at Wroxeter, which is the subject of a later chapter. It may also apply to a regional survey preferably in the vicinity of an airfield, where flying can be maintained in the interests of retrieving the maximum amount of archaeological information. Sites revealed through variations in the growth of vegetation are sensitive to changes in weather conditions, particularly in cereal crops. Even over a short period of time details can appear or disappear, although usually the dominant features continue to develop throughout the period of growth. Under such conditions the prospect of anticipating the optimum response is a matter of opportunity or luck. The only possible method of achieving the best result is to maintain continuous observation to the point where a crop is harvested, or the advent of rain completely erases all surface indications.

Although the rate of discovery in terms of complex sites or individual features may be considerably reduced over the years, it is unusual for a crop response to indicate all the details of interest in any one year, bearing in mind also the effects of crop rotation with different varieties such as wheat, barley, oats, roots and pasture. With a knowledge of the geology and soils in the area the frequency of flights can be adjusted, taking into consideration the effect of the prevailing weather conditions on crop response. There is no rule of thumb to be applied it is simply a question of fly and see, but judgement will to a large extent be influenced by experience over the area; although it is desirable that flights should increase toward the end of crop development, there is always the question of cost effectiveness, if such a consideration is applicable in air archaeology. It is not the rate of acquisition which is the criteria but the quality and relevance of the contribution, large or small.

2.4 Maps

For the purpose of navigation and site identification, various maps were required for use in flight. The primary headings, tracks and times were marked on a 1:500 000 scale aeronautical chart which identified the principal landscape features and included all airfields, control zones and danger areas, this was carried by the pilot. General navigation and timing was the responsibility of the writer as observer, with the same information plotted on a 1:250 000 series ordnance survey map. Prior to flight it was essential that maps were prefolded in such a way that the information was readily available; the prospect of refolding maps in the confines of an open cockpit is both frustrating and time consuming for obvious reasons. Initially one inch to one statute mile ordnance survey maps (scale 1:63360) were also carried, but because of the large scale they proved difficult to fold and use for the purpose of marking in site positions. It was feasible however for the writer to record points of interest on a 1:250 000 series map, and the one inch maps were eventually dispensed with in areas away from the airfield.

Following aircraft refuelling and preflight inspection, a detailed briefing was required for the sortie including a discussion of the options available in each area of operation, should the weather or reconnaissance prospects merit a change of plan. This was important in view of the limited duration of the aircraft, and the necessity of meeting the latest departure time for the return flight to the airfield. A debrief after each sortie was also considered essential in order to discuss any problems or refinements to the technique, and confirm the areas of interest for subsequent transfer to one inch ordnance survey maps; accurate site grid references could only be determined when the photographic prints were made available. This was an advantage in that the one inch scale maps could be used on the ground as a master reference. To ensure an accurate plot it was necessary on occasions to include a photograph of the site in the context of the surrounding landscape to provide sufficient fix points for map reference in the form of roads, farms or other dominant features. Flights in the locality of the airfield over familiar terrain posed little difficulty in fixing any features of interest, indeed it was possible to fold and use a spare one inch map for this purpose, subsequently transferring the data to the master copy after the sortie.

CHAPTER 3

PHOTOGRAPHY

3.1 Camera

Prior to the acquisition of a specialist camera, experiments were conducted using a 35 mm Leica, colour photography was in its infancy at that time but the prospects looked promising. With monochrome the small format of 35 mm implied enlargement, and using fast film the grain proved unacceptable. The method adopted to minimise the effects of slipstream and vibration was to mount the camera on a hand grip and operate the shutter release by means of a flexible cable. With the quality of the film available in 1951 the results overall were not considered to be of a sufficiently good standard and the experiments were discontinued. As a consequence the Williamson Type F24 reconnaissance camera with a focal plane shutter was adopted for photography in the West Midlands. The format comprised a 5 inch square negative from roll film at ASA 200; the cassette capacity was 100 exposures with a hand wind facility and counter indicator. Winding on the film also set the shutter release spring.

A range of apertures was available, adjusted and set by keying a lever into the respective slot in a metal ring attached to the camera housing. This required frequent checking to ensure that the selected aperture remained in place, after experience had shown that movement could occur during handling. The hand wind required a controlled rotation, any snatching movement could cause the mechanism to tear the film perforations resulting in a no wind situation even though the counter continued to function. The records from one flight were lost because of this malfunction, and there is no method of checking film movement in flight other than removing the cassette which would fog the film at that point. A hand hold frame complete with sight was attached to a ring on the body of the camera and firmly secured by a knurled nut adjustment; a trigger mechanism attached to the frame operated the shutter release via a flexible Bowden cable. Cassette loading in a darkroom had to be done with care to avoid any stiffness in film release, which could also result in the cassette sprockets tearing the film perforations on winding; it was possible to check film movement on the cassette itself, but it was difficult to estimate the tension and preflight tests were necessary with the cassette attached to the camera. A motor drive was also available, but since there was little prospect of installing a generator in the DH82A a hand wind facility was chosen. With the focal plane shutter there was a choice of fitting one of two blinds, 0 to 1/500th of a second or 1/500th to 1/1000th of a second, intermediate exposure times could be selected by means of a calibrated spring adjustment attached to the camera body.

Experiments were conducted using a 5 inch wide angle lens, but this required an unacceptable reduction in height and a 7 inch lens was substituted, more suitable for photography and reconnaissance at heights between 1000 and 2000 ft. There was a facility for fitting individually mounted glass filters to the camera, but this was considered a hazard in the cockpit should it inadvertently become detached during handling; for the best compromise a Wratten x 2 yellow filter was incorporated in the lens assembly to improve contrast, particularly in poor atmospheric conditions due to haze, and allowance was made for this in the aperture adjustment. The prospect of any loose items in the cockpit was to be avoided since the aircraft is equipped with dual controls which were virtually unprotected; for this reason it was decided not to carry a spare cassette and all pencils and maps were contained in the pockets of flying overalls. This precaution also applies to aircraft with enclosed cockpits such as a Cessna 150 where there is adequate storage space for loose articles. For take off and landing all items including the camera and maps were made secure prior to checking personal safety straps. It is perhaps worth mentioning that inflammable articles must never be carried, particularly phosphorus based matches, lighters or fuel.

3.2 Operating Height

A height of 1500 ft was a reasonable compromise for general reconnaissance with a facility to search the landscape by viewing either side of the aircraft, but for photographic purposes height is subject to adjustment depending on the extent of the features of interest. If these were spread over a considerable area it was desirable to photograph the complete complex, and subsequently deal with individual features at a lower height. Indeed it proved necessary on occasions to divide the area into manageable sectors, prior to the assessment and photography of individual features such as may be contained in one field. Height of operation however can impose restrictions, the regulations state that the aircraft must at all times be 500 ft. from property, people or vehicles, in other words 500 ft is the minimum height at which a powered aircraft is allowed to fly, except for take off and landing from an airfield or in the event of a forced landing elsewhere, even so, any low flying in the region of 500 ft must be undertaken with care so as not to cause annoyance in such a way that may bring the activity into question or contravene any regulations, farmers livestock in particular can be very sensitive to noise.

Height over built up areas or public gatherings should be sufficient to glide clear of the area in the event of a forced landing due to engine failure or aircraft malfunction. The regulations in this respect are quite clear in that an aircraft should maintain a height of 1500 ft above the highest fixed object within 2000 ft or fly at such a height as would ensure safe clearance, whichever height is the greater. But difficulties do arise at low levels bearing in mind that in an airfield circuit the altimeter is preset to a QFE, that is to say the barometric pressure at the airfield height above sea level. Flying in areas away from the airfield an altimeter is normally referenced to an average area pressure known as QNH which is dependant on the weather conditions at that time. Over variable terrain therefore it was necessary to exercise caution if low level photography was anticipated down to 500 ft in the absence of a radio altimeter. Because most of the area concerned was in the bracket of 0 to 500 ft above sea level a QFE setting was maintained, in this instance, adding the airfield height of 200 ft above sea level to the altimeter reading, which provided an adequate safety margin at an indicated height of 1000ft; flying was conducted in relatively stable weather conditions when changes in barometric pressure over areas away from the airfield were minimal. There is a further restriction to be observed in that care must be taken to ensure that aerial photographs do not include any sensitive areas, military or otherwise where photography is forbidden.

3.3 Photography from other Aircraft

Although the mode of operation with a DH82A proved successful, the limitation in range imposed a penalty. During later years the opportunity to use a Piper Cub with its increased endurance was a distinct advantage, particularly as the cockpits were enclosed, together with the facility of opening the starboard side panels in flight for the purpose of photography. This was necessary because the bulk of the F24 made it impractical to operate within the confines of the cockpit. Tandem accommodation for the crew of two allowed observation from both sides of the aircraft, and there was adequate storage for film and maps. The same flight patterns were adopted as for the DH82A, and an endurance of 3 to 4 hours provided opportunities to extend the area of operation. Photography was accomplished by banking the aircraft at various angles depending on the oblique required, general views may be taken at angles of 30^{o} to 45^{o} from the horizontal, but over specific sites angles of 50^{o} or more are to be preferred to minimise perspective distortion; vibration effects were tolerable allowing flexible throttle adjustment in the turn, it was quite unnecessary to initiate a tight turn which would require maximum power to compensate for the increase in stalling speed, nor was there any need to reduce airspeed as in the mode of operation with the DH82A, for the body of the camera was to a large extent screened from the propeller slipstream. Flaps could be used to reduce airspeed if required, but in the event proved quite unnecessary provided the camera operation was decisive and introduced no delays.

Flight directions were given by the writer to position the aircraft into the angle of bank required, drift had also to be taken into consideration otherwise a turn downwind could result in overflying the target, or conversely a turn up wind may place the target too far away. At low shutter speeds there may be some advantage in taking a photograph under conditions of reduced groundspeed when the aircraft is flying into wind, should this be coincident with the required viewpoint. With the aid of a viewfinder it was desirable to frame the target and initiate any height adjustment required during the process of flying round the area to determine the best aspect for photography, there was little time to dwell on the image content of the negative in the action of exposing the film; many features are sensitive to changes of only a few degrees and any delay could result in repeating the orbit.

Exposure times in the range of 1/500th to 1/1000th of a second proved to be the most acceptable in reducing any possibility of image movement on the film due to vibration or slipstream effects. However, in using an F24 camera with a focal plane shutter, image distortion could occur due to movement of the aircraft relative to the target. In the mode of operation with the DH82A the target remained constant, but in the case of the Piper Cub some relative movement was present, the magnitude depending on attitude, ground speed and height. Unlike a leaf shutter integral with the lens, the action of a focal plan shutter involves admitting light to the film by means of a slit in a blind moving across the plane of the negative. At slow shutter speeds, distortion is introduced progressively across the film resulting in a blurred image. With exposures in the range of 1/500th of a second or above, this effect was negligible.

3.4 Lighting and Perspective

Lighting and exposure is dependent on the existing weather conditions and the subject to be photographed. Clear skies with good visibility presented the best conditions, and during summer a speed range of 1/500th to 1/1000th of a second proved adequate, using apertures ranging from F5.6 to F.16. In the early experimental stage a light meter was used as a guide, but this of course only indicates an average figure, not necessarily applicable to individual features or areas where there is a contrast in the colour and density of the surrounding vegetation, and particularly where the subjects concerned do not necessarily fill the negative. Fortunately there was a reasonable latitude in the film, and with experience the use of a light meter was discontinued.

There were marked differences in lighting conditions particularly between a 45° oblique and a horizontal viewpoint, the latter required a reduction in aperture of two stops to compensate for the increase in light. In thin overcast conditions the light distribution is more even which simplified the settings, it was advisable to select as high a shutter speed as possible to minimise any effects of camera or aircraft movement, and adjust the aperture accordingly. In full sunlight the response from cereal crops requires special consideration, which will be dealt with in a later chapter on the technique of air archaeology. In some circumstances the optimum viewpoint was down sun, and under such conditions it was inadvisable to have the aircraft shadow appearing on the negative, the worst effect occurred when the camera was in a direct line with the sun, which not only resulted in an aircraft shadow in the centre of the negative, but also introduced the possibility of a bright halo effect which could render the negative useless; the highlight and aircraft shadow could easily be avoided with a small change in the angle of approach without necessarily degrading the features of interest.

Where the subject is large enough to fill the negative and the lighting is even there is little difficulty in selecting exposure settings, but if the features are contained in a relatively small area of the negative with contrasting vegetation in the vicinity, the exposure should be adjusted to accommodate the required features, that is assuming a reduction in height is not feasible to increase the size of the image; in full sun photographing features in ripe cereal are particularly difficult in this respect. Weather in general is the dominant factor and haze can be a problem, but following the advent of a clear air policy the effects were not so severe. The use of a x 2 yellow filter offered a significant improvement in haze penetration and contrast, other than a direct viewpoint into the sun; but the effects of haze can be offset with a decrease in height and an increase in the angle of the oblique from the horizontal.

In oblique photography some degree of perspective distortion is always present, this results in features appearing at a larger scale in the foreground compared with those which are receding; the effect becomes progressively worse from foreground to background even vertical photography exhibits some perspective distortion, but the effect is more pronounced in oblique photography and is accentuated as the angle of view approaches the horizontal. In terms of presentation the appearance of such distortion is also influenced by the geometry of the feature under observation, rectangular or square shapes for example are best photographed with two sides parallel to the camera and preferably not from a corner which emphasises the distortion, unless a steep angle of oblique can be achieved together with an increase in height. A viewpoint less than an angle of 30^{o} down from the horizontal is difficult to correct with any form of plotting technique, in terms of transferring the features accurately on to a map. Although flying time is expensive it is a false economy to hasten the process of photography, a single exposure is insufficient particularly where the features of interest extend over a large area. Even so the prospect of observing the site again in another year cannot be relied upon, and every advantage should be taken of the opportunity to obtain adequate records.

An example of perspective distortion in oblique photography is illustrated in Figs. 3.1 (a),(b) and (c), the photographs of a double ditched enclosure as a crop mark in a field of wheat near Bishampton in Worcestershire were taken within a few minutes of each other, at approximately the same height but different viewpoints. In Figs. 3.1 (a) and (b), although the angle of approach has changed by only a few degrees there are significant differences in definition and shape, the former due to changes in lighting and the latter the result of perspective distortion.

In Fig. 3.1 (c), the approach has changed through 180^{o} together with a steeper oblique, and the difference in the configuration of the enclosure is now more pronounced and representative of its true shape compared with Fig. 3.1 (a) and (b). To facilitate plotting it is essential to include at least four control points on the photograph which can be identified on a map. For this purpose in Fig. 3.1 (c), at least four control points can be identified round the field boundary in which the enclosure lies, from these points a polygonal network can be constructed to rectify the image on the oblique photograph; the resultant transcription of the enclosure on to a 1:2500 scale ordnance survey map is shown in Fig. 3.2. With the continued destruction of field boundaries and other features, it may prove difficult to include sufficient control points on the negative without a significant increase in height which will reduce the area of interest on the negative format. In this event, provided the dominant features are clearly visible, the detail may be filled in from obliques at a lower height but with less accuracy.

3.5 Weather Factors

Facilities in the open cockpit of a DH82A were rather primitive, but the provision of a helmet, face mask and goggles, together with a small windscreen positioned above the cockpit combing afforded some degree of protection against the slipstream and the weather. With the wind direction from the Northwest, showers were often funnelled through the Cheshire gap down the valley of the river Severn; usually they occurred in conditions of good visibility and could be easily seen, but it was not always convenient to divert from track to avoid them unless they were of a heavy thundery nature. A knowledge of the prevailing weather conditions in areas away from the airfield was important and a detailed meteorological briefing was necessary before flight, particularly in conditions following a warm front where the possibility of low cloud could obscure high ground. Any anticipated changes in wind speed and direction were also relevant in calculating the timing and headings anticipated; in general a cloud base of 1500 ft. was regarded as the minimum requirement, and in the event of poor visibility five miles was considered acceptable. A thin overcast situation is tolerable for photography, but a dense overcast considerably reduced the prospect of achieving satisfactory results. Scattered cumulus cloud also presented difficulties, particularly if the feature under observation was partially obscured, it was preferable to wait for a gap depending on the wind speed, but where these were infrequent there was no alternative other than to accept complete cloud cover. There is little advantage in attempting to chase an open space in the hope of achieving the desired photograph.

The prospect of turbulent air conditions following a cold front intensifies with the action of the sun and could have a detrimental effect on aircraft stability and photography, particularly in the vicinity of high ground, bearing in mind the mode of operation with the DH82A; but conditions usually improved by the late afternoon and evening. In other light aircraft such as the Piper Cub with a high wing profile the conditions were not so critical in this respect, apart from a measure of discomfort to the occupants. During dry periods in summer a forward forecast was essential to the conduct of the flying programme, the advent of heavy rain other than showers could have a drastic effect on cereal crops or features revealed by parching in pasture. With limitations in the flying hours available, decisions had to be taken regarding which areas should be surveyed to the best advantage. Because of the extensive area involved in the valley of the river Severn together with little prospect of refuelling, priorities were always difficult to decide. However, even in wet periods micro climates could be anticipated in sheltered areas with improved prospects, and flights were not necessarily unproductive in such conditions.

3.6 Photographic Results

It is considered essential following a sortie to process a film at the earliest opportunity, preferably on the same day. It is not necessary to acquire prints in such a short time, but there is an urgent need to examine the quality and content of the negatives, to ensure that the results are viable. Obviously in the event of any serious camera malfunction, it may be required to repeat the sortie without delay, bearing in mind the possibility of deteriorating weather conditions which may have a detrimental effect on the features of interest, or the prospect of harvesting which would result in the complete loss of data observed and recorded in cereal crops. Problems may also arise from defects in a particular reel of film. Processing should be to a good professional standard in developing, fixing, drying and handling in order to avoid any prospect of scratches or chemical residue appearing on the negative; the storage of negatives and their retrieval for printing purposes also requires extra care in handling to avoid damaging the emulsion.

In order to reduce the possibility of loss of data through camera malfunction during a sortie, it is imperative to maintain a continuous check on camera performance, with small cameras it is not unknown for the protective lens cap to remain in place. A malfunction in the F24 camera as used by the writer was not so easy to detect, the choice of shutter speed was limited by the range of the particular blind selected with interim adjustments securely locked by a spring mechanism, on the other hand the mechanical aperture settings could be dislodged during handling (page 29). Other marks may be introduced on the negative caused by damage to the blind, as a result of mishandling during fitting or subsequent checks. The film register plate had also to be kept scrupulously clean, and care taken to avoid introducing any foreign bodies when changing cassettes. Considering the weather and the wide range of subjects to be photographed in the landscape, there is always the possibility of misjudgement in the selection of aperture and speed. Provided the film has enough latitude this may not present a serious problem, errors in exposure times or different densities on one negative can in some circumstances be compensated for in the printing process. For example, where a feature on the negative is partially obscured by cloud cover, selective printing may retrieve the complete feature. The camera lens should also be inspected and carefully cleaned prior to, and after each sortie, flying time is expensive and failure to take sufficient care of photographic equipment could result in a complete loss of data, and disappointment if there is no opportunity to repeat the sortie. As in the case of aircraft, camera equipment also requires periodic maintenance, to ensure as far as possible that the performance has not been degraded.

CHAPTER 4

THE TECHNIQUE OF AIR ARCHAEOLOGY

4.1 Introduction

It is not intended to detail all the aspects involved in the technique of air archaeology, but only to highlight those which in the writer's experience are considered relevant to the presentation of the results of aerial reconnaissance in the valley of the river Severn. In landscape archaeology some evidence for past cultures is reflected in the structures visible at ground level or upstanding, as a whole or in part. Over the centuries the majority of such features have completely disappeared from view as a direct result of intensive land development and agricultural activity, leaving perhaps only a vestige of their existence concealed beneath the soil in the form of building foundations, post holes or ditches cut into the subsoil for one purpose or another. Such remains as may have been contained within the depth of the plough, were ultimately destroyed leaving perhaps only the prospect of casual surface finds to testify as to their existence. It follows therefore, that only a fraction of the evidence for early occupation in the landscape as a whole may be recovered for the purpose of archaeological study and analysis. Of the features remaining above ground level, the configuration, size, situation and general appearance may well be sufficient to determine their purpose, and establish the origins in terms of specific periods of occupation, reflecting some aspects of the lifestyle, ritual and other activities at that time.

The task facing an air observer is formidable, and requires an acute sense of perception for aerial reconnaissance constitutes real time interpretation, and apart from the problems involved in distinguishing archaeological features integral with the effects of present day agricultural practice, including natural phenomena, there is always the difficulty in site recognition. To a certain extent some features may be identified by comparison with those already known and recorded, but without doubt there is information which still remains unrecognised in terms of its latent archaeological significance. New features are continually being discovered and may suggest that they exist in isolation or restricted to a given area, but once identified they begin to be observed and recorded elsewhere. An independent interpretation of the evidence from a given aerial photograph may be subject to uncertainty and speculation, but how much more difficult to identify and assimilate the information initially in an airborne environment, with only a limited time available for observation. It is the dominant features which draw attention to a site in the first instance, with the detail superimposed through further visual assessment; but subsequent evaluation can on occasions reveal additional detail not necessarily appreciated when the photograph was taken, this is particularly relevant in features revealed through changes in the growth of vegetation.

The requirement to fly round a site and determine the best angle of approach to record the information is easily said, but there are circumstances where the angle, attitude or height is critical, and detail may be missed. With a variation in aspect of only a few degrees, even a brief camera check can be a sufficient distraction in terms of lapsed time. Subsequent interpretation and evaluation by experienced personnel is totally dependant upon the quality and content of the aerial photograph, and should an observer fail to record all the detail that has been identified, archaeology will be the less informed. It must also be appreciated that there is always the problem of deciding what is, and what is not considered to be important at that time in the context of the flight objectives.

4.2. The Technique of Air Archaeology

For the purpose of this presentation, the technique of air archaeology is defined as the medium through which the evidence for past cultures integral with the landscape is observed and recorded, as follows:

4.2.1 Highlight and Shadow - to enhance upstanding structures or variations in land profile.

4.2.2 Soil Marks - through which features reduced by the plough can be observed and recorded.

4.2.3 Changes in the Growth of Vegetation - which are instrumental in revealing remains concealed under the soil, for which there are no surface indications.

4.2.1 Highlight and Shadow

The photography of upstanding structural remains of historical or archaeological interest does not necessarily require specific weather conditions, provided there is sufficient distributed light in which to adequately record the feature, as illustrated by a photograph of Warwick Castle given in Fig. 4.1 (a). Indeed, a high level of direct illumination by the sun on a masonry structure could result in intense highlights and shadows, which may influence the aspect for photography in order to achieve an acceptable presentation. In conditions of clear skies the photography of buildings is entirely dependant on the angle of the sun, and the form of the structure itself. In the absence of the ability to predict the optimum conditions, advantage has to be taken of the illumination prevailing at the time. With the sun low in the sky the resultant long shadows are often undesirable, and a balance has to be considered to obtain an acceptable presentation; much depends on the particular aspect which may require emphasis. This is illustrated in the remains of Ludlow Castle in Shropshire, which is situated in a built up area, Fig. 4.1 (b) shows the feature photographed looking into sun, and the result has little to commend it, although the outline is defined the shadows tend to obscure the fabric and the overall effect is in poor contrast and perspective with the surrounding features. In Fig. 4.1 (c) the aspect is down sun resulting in a strong highlight from the structure, which is also present on other local buildings, under this condition the feature is dominant in the area but the presentation is not ideal and leaves much to be desired.

The result may be more acceptable by varying the viewpoint and angle of approach, this is illustrated in two photographs of Attingham Park, Shropshire, taken at an angle to the illumination in order to present the building detail and avoid excessive highlights and shadows. Fig. 4.2 (a) shows the general appearance of the building when the highlights are sufficiently reduced to appreciate the detail in its construction. A vertical or high angle oblique would be necessary in order to present the whole arrangement, but this would result in the loss of the building facade. In the event a second photograph was taken from a viewpoint of 180°, which illustrates the courtyard and outbuildings without undue interference from highlight and shadow (Fig. 4.2 (b)). However, in the case of a high angle oblique shadows can serve to show details of variations in the construction, which would not be readily apparent in conditions of distributed light unless a very low angle of oblique was feasible. The photography of upstanding structures, is a combination of presentation and technical skills necessary to achieve an acceptable result; so much for the structure itself, but the value of recording its situation in the landscape must not be forgotten. On the other hand, surface features which only appear as variations in land profile are not so readily observed in distributed light, but they can be considerably enhanced when illuminated by the sun at low angles of elevation. In general much depends on the profile and form of the features to be photographed, together with their position in the landscape; small variations will require a very low angle of incidence from the sun to reveal them in relief. Clearly the optimum conditions for presentation occur when such features appear in open ground, with no obstructions to interfere with the sun's rays. Almost any form of surface remains may be enhanced through highlight and shadow, but difficulties were experienced with hillforts in the Welsh Marches where the screening effects of vegetation, such as trees or shrubs, tend to obscure the outline and internal details through long shadows drawn with the sun low in the sky. Subtle differences in the height of vegetation as is evidenced in cereal crops, may also be resolved by shadow effects.

With surface remains such as a bank or ditch, the optimum enhancement is achieved when the feature is aligned at right angles to the sun, in this configuration the face of a bank is revealed as a highlight with the rear slope in shadow. The outline of a ditch will appear in much the same way, with the inner face in shadow and the outer face presented as a highlight. In the illustration of an Iron Age fort on Bredon Hill, Worcestershire (Fig. 4.3 (a)), photographed with the sun at a high angle of incidence, the defences and general arrangement can be determined, but with little appreciation of surface detail. By comparison, with the fort illuminated by the sun at a low angle of incidence, the outline of the defensive system is considerably enhanced through highlight and shadow, together with the detail of tracks and other internal features which now appear in relief as shown in Fig. 4.3 (b). In a complex site, changes in land profile will have a varied response according to their relative position with respect to the sun, the minimum effect occurring when a ditch or bank is in a direct alignment with the illumination. An example of this can be seen in a view of an Iron Age fort situated on the south aspect of Bredon Hill, Worcestershire (Fig. 4.4), in this photograph the outer defences of the fort which are in line with the sun are not so well defined as those presented at right angles to the sun. It can also be seen that the fort consists of an inner enclosure, with an annexe circumscribed by a ditch with no evidence for an inner bank. Under the conditions of a low incidence of illumination, the detail of shallow variations in profile within the main enclosure appear in relief; the banks of a field system adjacent to the fort are also revealed in the form of highlights. Unfortunately with the sun at low angles of incidence, long shadows from dominant features will tend to obscure any detail in the path of the shadow. The presence of vegetation in the form of trees or shrubs on, or adjacent to a site, will create a similar situation as shown in a photograph of Elmley Castle on Bredon Hill in Fig. 4.5.

During the summer season, early morning or late evening is the best time for this work, but there are occasions where a feature located on a slope facing away from the sun will require illumination at a higher angle of incidence. The converse occurs when a site is situated on a slope facing into the sun, where very low angles of illumination will be necessary to present the feature in relief. The winter season is of course to be preferred for recording sites in highlight and shadow, when the arc of the sun is lower in the sky for most of the day; there is a further advantage in that any screening effects due to deciduous vegetation will be at a minimum. Aerial reconnaissance by the writer in the Severn valley was restricted during the winter months, not only because of financial restraints, but also the advent of low temperatures which is not the best condition for operating in an open cockpit, and as far as the DH82A aircraft is concerned there was no facility for cockpit heating, or carburettor de-icing essential to maintain engine performance in air temperatures below freezing level. For photographic purposes, the aspect into sun presents the optimum conditions in terms of recording features in relief, Fig. 4.6 (a) shows the site of an Iron Age fort at Choulton, Shropshire, photographed looking down sun, and from this viewpoint the site appears almost featureless; Fig. 4.6 (b) illustrates the same site from a change in aspect of 180^{o} looking into the sun, the multi-vallate defences of ditch and bank together with a well defined entrance are now clearly visible in highlight and soft shadow. The banks of a secondary internal defence system are also visible, subdividing the fort and suggesting two periods of occupation; it is of interest to note in Fig. 4.6 (a) that the site is not illuminated at a low angle of incidence, but the land dips away from the sun at a sufficient angle for the defences to appear in relief when viewed directly into the sun.

A clear sky is a basic requirement, providing there are no detrimental effects due to the presence of atmospheric or industrial haze, the effect is intensified with the sun at low angles of elevation, and may appear more dense when hygroscopic material is contained under a low altitude temperature inversion in the atmosphere. This is distinct from a reduction in visibility due to an early morning mist, which soon evaporates as the surface temperature rises. Where haze is present visibility is considerably degraded when looking into sun, but there is a significant improvement in the viewpoint down sun, and a compromise may be necessary to achieve an acceptable presentation, bearing in mind the added advantage of a decrease in height and a high angle oblique for photography. Obviously vertical photographs are to be preferred, particularly where features extend over a considerable area. However the viewpoint from an oblique can be equally telling, in the opportunity to present a feature in the context of the surrounding landscape, particularly where a site with a shallow profile is situated on the brow of high ground, with little prospect of the feature appearing in relief; the view of an Iron Age hillfort at All Stretton, Shropshire, as shown in Fig. 4.7 is a good example of this situation. In general much depends on the profile of the feature to be photographed and its position in the landscape, particularly where it is required to record small variations within the area concerned. In an attempt to record all the features of interest on a site, photography may need to be repeated during the day from early morning to late evening in order to take advantage of the varying angle of illumination. Timing also presents a problem if it is required to predict the optimum lighting conditions, and under such circumstances specific sites may need flights dedicated to that purpose. There are other ways in which variations in site profile may be observed, during the winter months a light covering of snow can produce a dramatic effect in terms of presentation, but not necessarily with the same degree of detail as may be revealed through highlight and shadow, (Wilson, 1975(a);21-23). An example is shown in Fig. 4.8 where the defences of an Iron Age fort situated on the Malvern range in Worcestershire, are enhanced under conditions of snow.

4.2.2 <u>Soil-Marks</u>

Soil-marks are derived from the reduction of surface remains through the action of the plough, where the land profile is levelled for the purpose of cultivation. Most soils will reflect some form of colour differential, the contrast depending to a large extent on the nature of the subsoil. On chalk for example, the ploughed out remains of banks or barrow mounds are revealed with their chalk content in sharp contrast against the darker tone of the topsoil. The effect is most pronounced when the features are first reduced by the plough, becoming more diffuse with repeated cultivation. An example is given in Fig. 4.9 on Berwick Down, Wiltshire, where the banks of a Celtic field system are outlined in darker tones against the background soil. The darker humus infill of ditches or pits will also appear in contrast with the surrounding mix of chalk and soil. In the Severn valley the soils do not exhibit the characteristics necessary to the presentation of features with any degree of clarity through this medium. There are few surface remains in the area that have not been subjected to intensive cultivation over a considerable period; also the fields tend to enclose much smaller parcels of land compared with those over the chalk downlands of Wiltshire or indeed the contrasting soils of the Fens, as a consequence ploughing is patchy and would merit an extensive flying programme over the area, in an attempt to recover features which in the event may be of dubious archaeological value. It is not intended to dwell on this form of site recovery, as the writer has no contribution to make of any significance in the valley of the river Severn, on the more contrasting soils the subject has been eloquently dealt with, (Wilson, 1982;39-51).

4.2.3 Changes in the growth of vegetation

In landscape archaeology, a differential change in the growth and colour of vegetation is the primary method through which concealed remains may be revealed and recorded. The response varies according to the type of soil and subsoil, and is influenced to a large extent by prevailing weather conditions in terms of temperature and rainfall. The nature of the vegetation is also of importance, and appears in the form of a natural or cultivated environment. Pasture is the more common form of natural vegetation, in which the presence of concealed features or variations in land profile may be revealed. In areas of permanent pasture, the surface remains of ditches reduced initially by a humus infill, may be enhanced by the stronger growth and darker green appearance of the grass growing over them, arising from an increased moisture content in the humus infill. Natural surface variations can also produce similar marks, but it is the overall pattern which identifies a feature of interest, as for example in the remains of ridge and furrow cultivation. In this instance the water run off from the ridges accumulates in the furrow, and the overall effect is emphasised by the lighter tone in the colour of the grass over the relatively dry ridges.

The appearance of archaeological remains in pasture is not necessarily confined to the surface profile. Where the topsoil is thin and features in the form of ditches lie concealed close to the surface, the advent of dry weather conditions will be instrumental in revealing their outline through a colour variation in the vegetation due to the increased moisture content of the ditch infill. This is illustrated in Fig. 4.10 on a site at Astley, Worcestershire, where the outline of a circle and the ditches of a settlement are visible in pasture, the ditches appear as lines of darker green contrasting with the surrounding parched area. The converse applies in the presence of building foundations or the hardcore of a road surface which will appear as a lighter tone in the grass due to parching as the dry conditions persist. The effect is illustrated in Fig. 4.11, on the site of the Romano-British town of Viroconium, Shropshire, where the pattern of streets and buildings can be traced as lighter tones in the dry pasture. A similar tonal variation may occur where the soil is impacted, as in the case of a well used footpath. The difficulty in understanding the response in grassland is compounded by the effects of other surface activity, and will be dealt with in a later chapter on interpretation. In other than long established pasture, similar results may be anticipated on cultivated land which has been put down to grass. Weather is an important factor in that the advent of dry conditions will enhance the response initially, but in an acute drought the colour change over ditches may fade; as will the lighter tones arising from concealed hardcore as the surrounding grass exhibits severe parching effects, and the features of interest will become more difficult to resolve. The response in pasture can also be affected by heavy rainfall following a dry period, which will reduce the colour differential to a point where the features disappear as the moisture balance is restored.

On cultivated soils, vegetation in the form of cereal and root crops is the most important medium through which the remains of past cultures in the landscape are observed and recorded. The pattern of such features may be revealed through variations in the colour and height of the crop growing over them, and are designated as crop-marks; both effects usually occur together, but can appear separately depending on the soil characteristics and the type of crop. Although surface remains reduced by the plough may be enhanced by crop-marks, the most important contribution to archaeological knowledge is derived from features concealed in the subsoil, for which there are no obvious surface indications. Once the subsoil has been disturbed by excavation for whatever purpose the content of the infill will never be fully representative of its original state, and crops are sensitive to such changes. The infill may not necessarily constitute the original material, for example, where a ditch is left open silt can accumulate within the profile due to weathering of the surface soil, or it may have been deliberately back-filled with material from other sources. Although the infill may consolidate over the centuries, the mix will always reflect a difference in its structure and texture compared with the surrounding subsoil, however subtle the change may be. But it is obviously a matter of degree, insofar as such a difference is sufficiently marked to affect a crop growing over it. Where the intrusion is of a more impermeable state, as in the case of stonework or hardcore, the effect on a growing crop is more definitive.

The depth at which the evidence exists is also a limiting factor, in that it must lie within the range of plant root penetration. As a consequence deeper structures remain undetected through variations in the growth of vegetation, and such remains would only be revealed through excavation of the land for industrial purposes, sand and gravel extraction or other development. In cultivation, the surface soil is influenced by agricultural practices designed to increase fertility and improve its general condition, leaving the subsoil relatively undisturbed. It is only in the event of deep ploughing, or the need to use a tyne or lay a pipe system to improve drainage, that the subsoil may be disturbed to the detriment of any features which are contained within it. The conditions which govern plant growth are varied and complex, and it is only intended to discuss the basic principles involved, which are relevant to the presentation and interpretation of the results achieved in the valley of the river Severn. For this purpose however, some illustrations are included from other results obtained by the writer in the West Midlands, on similar soils. Prior to considering the circumstances under which crop-marks may appear, it would be relevant to appreciate some of the factors which affect crop growth. The form, development and recording of crop-marks is detailed in Chapter 5.

Soil is the medium through which plants obtain their needs of minerals and nitrogen in a watery solution, they synthesise carbohydrate, the main organic compound, from carbon dioxide derived from the atmosphere and water absorbed by the roots. The source of energy for this process, is sunlight acting through the chlorophyll of green plants. Apart from the various minerals which are essential to produce healthy plants, their development is mainly influenced by the moisture content of the soil, and the available nitrogen to support a vigorous growth. Soil moisture is dependant on the climatic conditions in terms of rainfall and temperature, and the nature of the soil itself. It is the particle size which determines the water holding capacity, a course structure such as sand or a stony environment, will drain more freely due to the relatively small surface area available for moisture retention. Soils vary from sand, sandy loams which contain a clay fraction, to clay loams and clay which comprises very small particles providing a greater surface area for water retention. It follows therefore that the onset of dry weather will exhaust the available moisture in lighter soils more quickly than with the fine texture present in heavier soils, which will retain water over a longer period of time. The pore space in well drained soils will also provide soil aeration which assists plant development, whereas in very wet soils growth will be slower and if waterlogged may inhibit plant development completely, hence the requirement for draining heavy soils in order to regulate the moisture available to the plant. Temperature is also a consideration, in that the lighter warmer soils will assist germination, as compared with the colder clay soils where germination is slower, but the period of crop development in heavier soils is also longer and will be more resistant to dry conditions due to moisture retention.

At the seedling stage water evaporation is confined to the open land surface, but as the plant develops and increases the leaf area to its maximum expanse, water and nutrient requirements progressively increase to the point where the plant approaches its ripening stage, after which the water requirement ceases. In cereal crops it is during the intervening period of vigorous growth prior to heading, that the root system develops and increases the ability of the plant to withstand dry conditions provided there is a sufficient depth of soil. Its resistance to a water deficit is dependant on the efficiency of the leaves in controlling transpiration, and the existence of a wide ranging root system. The main rooting zone for cereals is contained within a depth of approximately 40 cms from the surface, but any water deficiency will cause the roots to penetrate deeper in search of moisture. The ability to do so is dependant on the type of plant and the depth of soil. The difference between rainfall, soil drainage and evaporation, represents the water available for plant development, and where this is less than the plant requirement a soil moisture deficit is created, and if this is progressively increased growth will slowly decrease to the point where permanent wilting occurs and the plant dies; but prior to this stage the plant may recover through a subsequent supply of water and nutrient. Obviously this depends on the type of crop, and the rooting depth of the varieties under consideration are listed as follows, together with the type of soil best suited to their development.

Depth of root penetration - in order

Cereals	Roots
Wheat	Sugar-beet
Rye	Kale
Barley	
Oats	

Type of soil for the best result

Wheat extremely deep rooted, best soil heavy loams and clays.

Rye	Good loam, but mainly grown on poor light soil as other cereals yield more per acre than Rye on the good soils. Very resistant to acid conditions.
Barley	light free open texture, best on chalk. Cannot withstand acid conditions.
Oats	clay loam with abundant moisture.
Sugar-beet	best on deep free working loam.
Kale	best on a deep rich loam.

Loams are recognised as the best general type of agricultural soil suitable for growing almost any crop. They contain 8 to 15 per cent of clay which enables them to withstand dry conditions, in addition a high content of sand ensures good drainage and aeration which assists the decomposition of organic manures, (Watson & More, 1962).

The nature of the subsoil is also of importance in the plant growth cycle, and in the valley of the river Severn comprises glacial moraine, riverine deposits of sand and gravel and soils derived from the underlaying rock formation. The distribution of the various soils and subsoils is discussed in a later chapter. A variation in crop growth will therefore be influenced by the conditions which exist in the vicinity and under its primary root system, and if a change is sharply defined it will be reflected through a variation in the colour, density and height of growth contrasting with the surrounding crop and visible in the form of a crop-mark. Although similar changes may occur due to natural phenomena, lack of minerals or crop disease, crop-marks are also instrumental in revealing the presence of concealed archaeological features. The degree to which they become visible is accentuated by a soil moisture deficit arising from the onset of dry weather conditions, with considerable enhancement in circumstances of acute drought. Variations in the profile of the subsoil resulting from the activities of past cultures may be considered under two primary headings, as follows:

4.2.3 (a) Ditched features in the subsoil.

4.2.3 (b) The presence of impermeable remains.

4.2.3 (a) Ditched features in the subsoil

Features cut into the subsoil constitute a wide variety in both form and construction ranging from ditches, pits, post holes, robber trenches left following the removal of stonework or hardcore, to the beam slots of timber buildings. Where the top soil has been removed for whatever purpose, the pattern of any intrusion may be observed through the darker tone of the infill contrasting with the surrounding properties of the subsoil. A simple example is given in Fig. 4.12 on a site near Fifield in Gloucestershire, in this instance the pattern of enclosures and ditches in the field are revealed as a lighter tone in the ripe crop, and in an adjacent gravel pit where the overburden has been removed, continuity of the ditches can be traced through the darker tone of their humus infill contrasting with the lighter response of the exposed gravel. It can be appreciated that a complex pattern of features may present problems, from an excavators point of view, particularly in terms of a rescue dig where the time available for survey and investigation is strictly limited. This is well illustrated in Fig. 4.13 on a site at Lechlade in the Thames valley, where the evidence for early occupation in the form of ditches and pits visible in the exposed gravel, are integrated with other marks including those left by machinery in the process of removing the overburden. To the archaeologist on the ground, a site survey under these circumstances may present difficulties in interpretation for the purpose of planning any intended excavation, and a photograph from the aerial viewpoint is of value in presenting an overall pattern of such features for assessment.

A second area in the locality was also stripped to reveal a similar complex situation as shown in Fig. 4.14; there is a further complication in evaluating sites of this nature in that with a gravel subsoil the evidence revealed in terms of ditches and pits represents a synthesis of all periods of occupation. In a situation where the remains appear with such clarity, it would seem that a single aerial photograph may suffice for the purpose of plotting and ground survey. With oblique photography this is not necessarily the case, and it is an advantage to fly round the site to determine whether or not there is any detail which may be sensitive to a change in viewpoint, and also to record any continuity of the evidence in the surrounding fields. On this site there is a particular feature in the form of an incomplete circular ditch, not recognised during ground survey or in Fig. 4.14, but is more readily identified from a change of 180° in viewpoint, as illustrated in Fig. 4.15. A vertical photograph would be an obvious advantage for overall plotting purposes, but over areas such as this where sufficient local control points are difficult to establish, photography may be required at a height at which detail is not readily apparent, and complimentary low level obliques would be necessary; in the absence of a vertical presentation, and because the remains are accessible on the ground, steep obliques would enable detail to be resolved and plotted in the context of the general arrangement of the site.

<u>4.2.3 (b) Impermeable remains</u>

Features of this type concealed under the surface will exist in many forms, the most common perhaps is represented by building foundations, other features include the remains of pavements, yards, the exposed supports for heated floors or granaries, covered drains, column bases or the hardcore of a road surface. As in the case of ditches, impermeable features may be complex, an example is illustrated in the excavated remains of the Baths site in the Romano-British town of Viroconium, Fig. 4.16, where the outline of walls and the detail of the exposed pillars which supported heated floors is well in evidence. To reveal detail of this nature through crop-marks will require a high degree of resolution in the relatively poor response of the vegetation growing above it. Unlike ditches however, the remains of hardcore nearest to the surface soil represents the last phase of construction, and will conceal any feature of an earlier date which may exist directly below it. It must be remembered however, that remains of an earlier date could appear in conjunction with those of the last phase of construction. The relative depth of the feature is also of importance, for example, the presence of a floor adjacent to a wall, may exist at a lower level and is not necessarily of the same date as the latest wall structure.

CHAPTER 5

THE RESPONSE AND PHOTOGRAPHY OF MARKS IN CULTIVATED CROPS OVER ARCHAEOLOGICAL REMAINS

5.1 Crop development

At the seeding stage following preparation of the ground, germination will depend on the temperature and soil moisture content. On other than flat land, soils which face south will invariably be warmer than those on a northern aspect; the nature of the soil itself is also of importance, in that the lighter well drained soils will warm up more quickly and encourage germination, as compared with the heavier, colder clay soils. The seed drills vary, but a spacing of some 200 mm between rows in cereals is not uncommon. It may be expected that germination would be evenly distributed, but it can be affected by conditions in the soil horizons, for example the presence of a ditch infill on, or near the surface may reflect an increase in soil temperature sufficient to influence the percentage germination above it, producing more seedlings per unit area compared with those in the adjacent soil. As a result, in the early stages following germination the outline of a ditch may appear as a band of denser growth compared with the distribution elsewhere, but the effect could be emphemeral as subsequent rainfall stimulates growth over the surrounding area. As the plants develop, the leaf will expand affecting the rate of transpiration, and under these conditions the moisture requirement will increase, and it is during this early period of growth in cereal cops that the plants become more susceptible to a moisture deficit particularly on shallow soils, leading to the appearance of crop-marks resulting from disturbances in the profile of the subsoil. This is reflected in an increase in stalk height, but not necessarily in a colour difference. Such changes in growth are not readily observed, but may be revealed as a shadow effect when viewed against the sun.

When a moisture deficit occurs, the more vigorous development over a ditch will be maintained as the plants draw on the available moisture contained in the infill, and a colour difference will develop, this process will continue to the ripening stage assuming rainfall does not restore the soil moisture balance. Where there is an adequate depth of soil over concealed remains, germination and subsequent plant development would be more evenly distributed, and differential growth may not be apparent until a soil moisture deficit becomes acute and a deeper root system develops. A knowledge of the average rainfall over the area is not necessarily an adequate guideline, for the advent of heavy thundery showers may be sufficient to overcome a deficit in the locality and thus increase plant development overall, effectively reducing the contrast with any crop differential which may exist over a feature. The presence of impermeable remains under the surface soil will produce the opposite effect on plant growth, as the soil moisture content is depleted through transevaporation, a deficit will inhibit plant development resulting in poor growth and will appear as a lighter tone against the background of the adjacent crop. As in the case of a ditch the depth of soil over a feature would influence the onset of a deficit, any surface residue from impermeable remains may have a detrimental effect on the percentage germination and would accentuate an area of poor growth. The presence of a hard pan under the soil would also constitute an impermeable layer with similar results, effectively screening any features contained in the lower soil horizons. If the plants over hardcore do not reach the wilting stage, they can be expected to recover in the event of adequate rainfall.

The period over which crop-marks in cereals can be anticipated extends from May to August, there are of course variations with latitude and results appear much earlier in the south than with crops in northern latitudes. The timing of crops reaching maturity will also depend on the period of seeding, those sown in autumn can be expected to develop earlier than a spring sown variety. However, familiarity with an area of interest will provide the necessary guidelines, in the valley of the river Severn the most profitable period for reconnaissance is June to August. For obvious reasons, provided time and finance is not a limiting factor, surveillance should be maintained from April to September, intensifying during June and July. As crops approach maturity there are significant changes in their response to features concealed in the subsoil which require consideration, raising problems in presentation and photography.

It is apparent that under conditions of increasing moisture stress it is the plant leaf area which suffers first, then the stem and subsequently the root system. This is an important consideration in the development of crop-marks, in that it is the leaf area which is responsible for the marked contrast in terms of relative density and colour. In order to define a crop response resulting from concealed features, a nomenclature has been adopted in archaeology to identify the two fundamental differences in appearance, the more vigorous growth which occurs over the remains of excavations in the subsoil is designated as a 'Positive' mark; the advent of poor growth resulting from the presence of impermeable features is defined as a 'Negative' mark.

5.2 Positive crop-marks

Provided moisture stress is maintained during the period of crop growth the differential in height, density or colour will intensify, and a pattern of ditched features will slowly emerge appearing as lines of darker green contrasting with the lighter tone in the colour of the surrounding crop. If at any stage during its development the soil moisture balance is restored, the contrast will tend to fade. As dry conditions persist soil moisture is held under increasing tension, and more detail in the pattern will become evident, and can emerge over a period of a few days as the plants respond to discrete pockets of available moisture and nutrient, but over relatively shallow variations in the soil profile the marks may disappear as parching intensifies. An example of positive crop-marks in the green stage of development is shown in monochrome at Fig.5.1(a) revealing a settlement site near Wickhamford, Worcestershire, where a complex pattern of features can be seen as darker tones in the crop over the concealed ditches. Fig.5.1.(b) illustrates the same site in colour, where the darker green of the crop-marks contrasts with the lighter tone of the adjacent crop. It is of interest in that at least three different landscapes are identified; hedgerows define the present day field boundary with associated roads and buildings, a series of parallel green bands in the field reveal the ditches remaining from earlier ridge and furrow cultivation, and under this can be seen a complex of ditched features representing the remains of early settlement concealed in the lower soil horizons, and this will itself in all probability comprise various periods of occupation.

Although there is a decade between the two photographs, the monochrome being the earlier, it is apparent that there is no obvious degradation in the site detail overall, and the remains do not appear to have been affected as a result of cultivation over that limited period. Even the surface variations arising from the ridge and furrow which exist in the form of ditches were sufficiently substantial to survive the plough, but the introduction of deep ploughing or subsoiling could well have an adverse effect on such remains. Although the type of crop, weather and precise date of the photographic results is unrecorded, the comments made are considered relevant, features on, or near the surface are undoubtedly disturbed by cultivation, but those concealed in the soil horizons below plough level remain substantially intact.

In the West Midlands, heading in spring sown cereal crops, that is to say the translocation of carbohydrate to the growing point, occurs from mid-June to the end of July; with varieties sown in autumn development may be earlier, the ears on barley for example can appear during May. It is during this period, that an increase in the height of the stem and development of the seed head will begin to influence and enhance a crop-mark response, which reaches its maximum contrast with the surrounding plants just prior to ripening assuming moisture stress has been maintained during the period of growth. These conditions may only exist for a few days, and depending on the aircraft height, with good visibility, marks at this stage of development may be observed over considerable distances. This is illustrated in Fig.5.2 which shows crop-marks in the Long Wittenham area of the Thames valley. In the foreground ditched enclosures are well in evidence, and a series of ringed ditches can be seen extending into the background landscape. Although the darker tones of crop-marks are clearly defined in a monochrome photograph, the presentation in colour is more representative of the aerial viewpoint and easier to comprehend, as given in Fig. 5.3, which shows the outline of a complex settlement consisting of enclosures and pits at Broadway, Worcestershire. In this condition the crop adjacent to the features is ripe, whilst that over the ditches is still growing as the plants draw on the moisture available in the increased depth of soil presented by the ditch infill.

Not all marks in a crop will necessarily turn at the same time due to variations in the depth, or nature of the infill, and differential ripening can occur. The effect is shown in Fig.5.4(a) at Foxley Farm in the Thames valley, on this site the oval feature and two ringed ditches still remain green in an otherwise ripe crop. The plants over the far ring attached to the oval together with the ringed ditch in the left foreground are in the process of ripening, whereas over other features in the area (Fig.5.4(b)) the crop-marks have ripened and appear as a lighter tone against the general background. This event in the development of crop-marks is defined as a 'Crop Reversal' and no further growth can be anticipated, as a consequence the site detail revealed is the optimum response under the prevailing conditions in that particular season, and it may or may not represent all the concealed remains which exist in the subsoil. As the crop over a ditched feature ripens, plants tend to turn individually and the marks may disintegrate, but the effect is short lived in the completion of the ripening process.

The principle is illustrated in Fig.5.5(a), during the period prior to ripening, the crop stand above a ditch constitutes better plants in every respect, compared with those in the adjacent area. A soil moisture deficit will tend to restrict the overall crop development, whereas that above the ditch has maintained its growth and developed a root system penetrating into the deeper soil of the ditch infill, where moisture and nutrient is more readily available, as a consequence the plant stem, head and leaf area is significantly increased. At this stage in its development a differential change in the height of stem is a bonus and varies with the type of cereal. Because the stand above the ditched feature is more dense, and may be accentuated by any increase in the percentage germination and colour, the reflection coefficient will be less than that of the surrounding crop, and as a result the outline of the ditch will appear as a darker tone against the lighter background. The converse occurs when the crop is ripe as shown in Fig.5.5.(b), where the relatively vigorous growth over the ditch now reflects more light compared with the adjacent crop and will appear as a highlight. Soil moisture conditions may vary considerably over a particular field, and where damp areas occur, crop development may be equivalent to that growing over a ditch. As a consequence continuity in a pattern of ditched features which extends into a relatively damp area will be lost, as it merges with a similar crop response. The effect is clearly illustrated in Fig.5.6, which shows such discontinuities in a complex settlement site near Pershore, Worcestershire. Areas of equivalent response can occur due to an increase in the depth of soil available to sustain plant growth, an increase in the clay content of the soil could also produce a similar effect.

It will be appreciated that it is difficult to forecast a time at which the optimum result may appear over any specific site, bearing in mind all the variables in weather, soil condition, type of crop and time of sowing. This emphasises the need to maintain continuous observation over the period of crop development. The interpretation and recording of a crop-mark feature is only representative of that particular time and condition, the results may improve or degrade during subsequent crop development. It is a folly to delay photography in anticipation of an improved response at a later date. In any event it is unusual for crop-marks to reveal all the site detail in any particular year, and reiterates the need to maintain continuity in reconnaissance over successive seasons. Recall is also an important factor, for it is as well to be familiar with previous survey results prior to the start of a new season, in order to appreciate any additional detail with may develop in a site configuration; in the anticipation of new discoveries elsewhere, it is too easy to overfly a familiar site simply because it would appear to have been adequately recorded in previous years. It may also prove necessary to photograph a site again if other records have failed to include sufficient control points for plotting purposes, and assuming that at least the primary outline of the features is visible, the detail can be interpolated from previous results. Even with the aid of a camera sight, there is no guarantee that all the control points intended are on the negative until it has been processed, after which it may be too late to repeat the sortie. It is apparent from the discussion that various crops will reach maturity at different times, but as they approach the stage of maximum development, a difference of a few days can be significant in revealing or clarifying additional features. It would also appear that all the detail in a site configuration should be visible in a ripe crop, but in the intervening period between ripening and harvest, events could prove otherwise, for example heavy rainfall may cause the crop to be beaten down, or weeds may develop sufficiently to degrade the crop-mark response; it follows therefore that when the crop is completely ripe photography should not be delayed.

5.2.1 Analysis of a Positive crop-mark

In 1962 the writer initiated an investigation into Positive crop-marks, in an endeavour to establish a more comprehensive understanding of the soil conditions which govern their appearance. The analysis was undertaken through the auspices of the Ministry of Agriculture and Fisheries, and for this purpose the crop-mark of a Roman fort at Greensforge on the river Stour was chosen as a suitable site. In an historical context, it was the first occasion that an investigation of this nature had been attempted. A detailed report by Dr C.W.R. Smith, who was responsible for the conduct of the work, is presented at Appendix 1. The results show that there was no significant difference in the chemical analysis of the crop, which would explain the more vigorous growth over the fort defensive ditch. The main reason for the crop-mark is the depth of soil in the ditch, and the improved structure of the infill, resulting in moisture retention and to a certain extent an increase in the nutrient content available to the plants. This may be compared with the less advantageous conditions presented by the characteristics of the soil in the vicinity of the ditch, restricting plant development. This initial investigation provided a firm basis for subsequent independent studies, undertaken to determine the variables which influence the appearance and development of Negative and Positive crop-marks. (Jones & Evans. 1975;1-11).

5.2.2 The photography of Positive crop-marks

At this juncture it would be appropriate to consider some of the photographic aspects in the recording of Positive crop-marks in cereal, which does not necessarily require a knowledge of the type of crop or soil conditions in which the marks appear; the attributes of various cereals will be dealt with later in the chapter. There is no specific aircraft height, attitude or viewpoint at which an optimum presentation may be predicted, the weather conditions, angle of oblique. crop status, and area over which the crop-marks appear all constitute variables affecting the presentation. The only feature of consequence is the characteristics of the camera lens, which will determine the height necessary to ensure that the features of interest occupy a reasonable area of the negative. Lighting conditions can vary from full sun to complete cloud cover, and for the purpose of illustrating the photographic techniques involved, the appearance of Positive crop-marks is considered in the three primary stages of crop development as follows, (a) Unripe (b) Differential ripening (c) Ripe.

(a) Crop-marks in unripe cereal

With full sun, clear skies and no haze factor, it would appear that the conditions for photography are ideal, and all that is necessary is to fly round the site to determine the best viewpoint using only a single exposure. Economy of film, however desirable is not a consideration, the appearance of a site at that particular time may well be unique and may not be seen again for a decade or more, even then the configuration can be entirely different. Apart from achieving the best presentation, which may not be the most impressive, there are other aspects to be considered, and of particular importance is the prospect of including sufficient control points to facilitate the transfer of information to an ordnance survey map. In oblique photography there is not only the problem of perspective distortion, but also the appearance and resolution of features in the far field of view; although this may in some circumstances be improved with a steeper oblique, in many sites some features may only be revealed through a lower angle of oblique or a different viewpoint. Because individual sites present their own particular problems, it is only possible to offer guidelines in the form of a representative selection of photographs to illustrate some of the difficulties in obtaining an acceptable presentation. There is advantage in the use of a zoom lens with small cameras in order to increase or reduce the area of interest on the negative, but the facility will not alter the angle of oblique or compensate for a variation in aircraft height should this prove necessary in the interests of a different viewpoint.

Fig.5.7(a) shows a pear shaped double ditched enclosure near Ettington on the Foss Way, on approaching the site a general view was taken in order to place the feature in the surrounding landscape. The aspect in this particular photograph is approximately 90° to the line of the sun and the crop-mark contrast is poor, but there is an adequate number of features to ensure subsequent identification on an ordnance survey map. A change of viewpoint through

180^{o} considerably enchanced the crop-marks as given in Fig.5.7.(b), but with this angle of oblique the feature is still too far away to appreciate the detail in the configuration. With a steeper oblique in a view down sun (Fig.5.7.(c)) the outline of the ditches is more clearly defined. This is a relatively simple feature and presents no problems in photography, except for the orientation with respect to the sun.

Part of a single ditched enclosure with two well defined entrances situated near Lower Slaughter on the Foss Way, was recorded in conditions of full sun in the early afternoon. Fig.5.8(a) shows the feature looking into sun, and from this aspect continuity of the ditch can be seen as a faint mark in the adjacent field at point A. However, although the enclosure ditches are clearly visible, features in the background in area B are less well defined. With a change in viewpoint of 180^{o} looking down sun (Fig.5.8(b)) the detail of the features at B now appear in the foreground, with increased resolution. The outline of the enclosure is not degraded, indeed the contrast is slightly increased but continuity of the ditch at A is less certain. Although the two photographs compliment each other, Fig.5.8.(b) is perhaps the most useful in terms of the number of control points which could be identified on an ordnance survey map to facilitate plotting. A viewpoint across the sun as given in Fig.5.8.(c) is a compromise between the two previous photographs, with some improvement in perspective, although the detail in area B is less evident compared with that in Fig.5.8.(b). The three viewpoints compliment each other, and will assist an interpreter in arriving at a more representative presentation of the features. Further observations over the site at a later date would be an advantage, to progress the evidence for continuity of the ditches in area A.

Not all ditched features appear with such clarity independent of the viewpoint, for example a pattern of ditches is illustrated in Fig.5.9.(a) East of Sherborne near the river Dickler on the Cotswolds looking down sun (area A). There is also evidence for the site extending into an adjacent field in area B, the marks are faint as the vegetation is in an earlier stage of development, and subsequent reconnaissance would no doubt find the overall configuration of the site enhanced as the marks intensify. Of particular interest is the line of a ditch at point C. With a viewpoint into sun as given in Fig. 5.9.(b) the ditched features in area A are diffuse and difficult to trace. The ditch at point C is now obscured by a number of fine lines resulting from animal tracks through the crop, which appear as shadow effects against the sun. A series of parallel dark lines (point D) caused by farm equipment such as a tractor with a crop sprayer are also accentuated in shadow, and tend to obscure the crop-marks. Clearly the differential growth over the ditches, if any exists at all, is insufficient to produce a shadow in these particular lighting conditions, and the darker tone of the crop over the ditches is no doubt due to a more dense growth and/or a darker green appearance. From this viewpoint into sun there is no evidence for continuity of the site in the adjacent field (area B). The dark mark at point E in Fig.5.9.(a) is the aircraft shadow, and care is required to ensure that this does not appear over the site. In this particular example the two photographs do not compliment each other, and Fig.5.9(b) has little to commend it.

The photography of crop-marks in diffuse sunlight is not so critical, much depends on the density of the overcast. Fig.5.10(a) shows a complex site at Sherbourne on the Warwickshire Avon, taken under conditions of distributed light with a relatively thin overcast. Although the view embraces enough features in the landscape to position the site, the oblique is too shallow to reveal other than the general site configuration. A small change in viewpoint from the same direction with a steeper angle of oblique is given in Fig.5.10(b), the arrangement of the ditches is now more clearly defined but the parallel lines of tractor wheelmarks (A) have also become more dominant in relation to the crop-marks. A completely different angle of approach through 140^{o} gives an improved presentation as in Fig.5.10(c). Unfortunately in Figs.5.10(b&c) the control points available round the field boundary have been lost in the interests of enhancing site visibility. If the writer had taken the opportunity to increase aircraft height to include sufficient control points from the viewpoint as in Fig.5.10(c), increasing the angle of oblique accordingly, the problems in transferring the information to an ordnance survey map would have been simplified, and any loss of detail could have been supplemented by the lower level obliques. As it is, the information is sufficient to support a sketch plan, and adequate for the purpose of field walking, or a geophysical survey.

A high angle of oblique or vertical is not necessarily the ideal presentation, depending on the type of crop and definition of the features. With strong contrasting crop-marks, a vertical or near vertical photograph may suffice to record all the site detail, but in the event of a weak or diffuse crop response, low angle obliques with differing viewpoints may be necessary to reveal or enhance particular features which cannot be resolved from a vertical photograph. In Fig.5.11(a) the site of a Roman fort is identified near Stretton, Staffordshire, from this viewpoint two corners and one side of the defences can be seen in the form of a single ditch at A, B and C, at point D two parallel ditches are revealed at this particular corner. An initial assessment appears to suggest an anomaly, in that the line of the defences at point B consists of a single ditch compared with the evidence for two ditches at point D. Although the crop-marks are poor and the ditches incomplete round the circuit, a high angle oblique as in Fig.5.11 (b) contains enough information to appreciate its general configuration. However, the viewpoint at Fig.5.11(a) suggests additional detail not visible in the high angle oblique. The aspect in Fig.5.11(c) confirms the existence of two parallel ditches at point A, with the outer ditch at point F continuing to form part of an annexe; the feature is more clearly defined in Fig.5.11(d), but the evidence for an annexe at corner C is inconclusive. There is also a faint indication for a corner at point E in Fig.5.11.(c) which appears to be in alignment with the outer ditch at point D. Clearly in the conditions presented by this particular feature, a vertical or steep angle of oblique has limitations in recording the site, and justifies the additional oblique photography from other viewpoints in order to resolve specific details. All the photographs therefore compliment each other and sufficient control points can be identified in Fig.5.11(d) to facilitate plotting.

(b) Differential ripening in Positive crop-marks.

At the stage of ripening crop-marks over ditched features exhibit a more vigorous growth, and as a result maintain their green appearance after the surrounding crop has ripened. Variations in the depth of soil under the crop-marks can result in differential ripening, and all the features will not necessarily change at the same time. The marks may also break up the line of a feature as individual ears in the cereal ripen. This effect can present problems in photography, but fortunately the dark green appearance of the crop that is still growing over a ditch will appear in marked contrast when viewed against the surrounding ripe crop. This is illustrated in Fig.5.12(a) at Stanton Harcourt in the Thames valley, with a viewpoint down sun three conjoined circles are identified at A, B and C, the crop over circles A and B is nearly ripe and the features appear as a faint highlight due to the crop reversal. The third larger circle at C of which only half has survived, is still in the unripe stage, and the darker tone of the crop over the ditch appears in marked contrast against the surrounding ripe cereal. There is also a suggestion of an inner circle at D, the response is diffuse and the mark is undoubtedly breaking up as the individual ears ripen. In areas E and F there is evidence for other variations in the ripe crop which do not form any recognised pattern. With a change of viewpoint looking into sun as given in Fig.5.12(b) the circles at A and B are now more well defined as a highlight, C is visible but with reduced contrast, the inner circle at D is still diffuse and the profile will only be evident when the crop over the ditch is completely ripe. The features at E & F are now clearly revealed in highlight as a pattern of pits. There is a soft shadow associated with the crop-mark highlight as a result of the differential growth, and the features would appear with increased contrast when the sun is at a lower angle of elevation.

Differential ripening over a complex site may lead to uncertainties in interpretation, particularly if an aerial photograph is considered in isolation with no corroboration from other viewpoints, and an example is given to illustrate the problems which may arise both from the airborne viewpoint and in subsequent analysis. Fig.5.13(a) shows a site East of Culham in the Thames valley photographed from an aspect down sun in early July, the features appear with clarity as a darker tone against the lighter background presented by the ripening crop. There are two principal areas of interest, the enclosure at A and a complex of ditches in area B. The enclosure is subdivided by two inner ditches at C, and the crop response would suggest that these ditches are reduced in width compared with the enclosure outer ditch (A). At point D, in a corner of the inner enclosure, are features which would appear to consist of a group of pits and a small penannular compound. In area B particular reference will be made later to the two ditches at point E.

After a period of 10 days during which rainfall had delayed the ripening process, the site configuration is shown in Fig.5.13(b) from a viewpoint down sun, the majority of crop-marks in area B are ripe but the arrangement of the ditches is obscure, the feature at E still appears to suggest two distinct ditches. The crop over the internal features within the enclosure at C & D is ripe, but exhibits poor contrast. The outer ditch of the enclosure (A) is still defined as a darker tone against the background crop, but part of the configuration is contained between two lighter lines in the crop at F. This effect is enhanced in a viewpoint across the sun as in Fig.5.13(c), the single inner ditch at C is now well defined in highlight as a result of the crop reversal, and the internal features at point D are more in evidence. The lighter lines at F which define the outer ditch of the enclosure appear to suggest the existence of two narrow ditches. This is a good example of differential ripening, in Fig.5.13,(a) there is no evidence for two ditches, it is apparent that this is a substantial ditch with a shallow profile at the edges, crop-marks seldom reflect the full width of a ditch unless the sides are steeply inclined, in this configuration the differential growth over the shallow edges has ripened, whereas that above the deeper soil infill contained within the centre section of the ditch still reflects a darker tone in its unripe state. When the whole crop has reversed no doubt the single ditch will then become apparent.

In area B (Fig.5.13(c)) the arrangement of ditches is emerging as a highlight but the feature at point E is still diffuse. A final exposure was taken looking into sun with a relatively high angle of oblique as given in Fig.5.13(d), the detail in the overall complex can now be traced as a highlight. The marks at point E suggest three ditches, but differential ripening is still evident and four ditches can be seen to converge at this point, the uncertainty in interpretation may only be resolved when the crop is completely ripe. In the vicinity of this particular site the fields are extensive in area, and to include sufficient control points would require a significant increase in aircraft height and in all probability a different viewpoint, with a consequent loss of detail which may only be interpolated with the information derived from low level obliques. It would be argued that Fig.5.13(d) represents the optimum viewpoint, but the other obliques have a contribution to make and emphasise the need for a detailed assessment of the situation prior to photography.

(c) Positive crop-marks in ripe cereal.

When cereal is completely ripe there is no prospect of further growth, and it would appear that in this condition an aspect directly into sun represents the optimum viewpoint for crop-mark photography. This is acceptable as a general statement, but depending on the type of crop, background and lighting conditions, other viewpoints can be equally effective in revealing a site configuration and indeed may be necessary. It must be borne in mind that features of non-archaeological origin may also produce differential growth, and if the viewpoint is consistent with the highest reflection coefficient it may well prove difficult to differentiate between the features of interest and other marks; much depends on the nature of the interference. Such effects will be more pronounced with the sun at a low angle of incidence, when marks are enhanced by strong highlight and shadow.

With the sun at a high angle of incidence, Fig.5.14(a) shows a vague outline of crop-mark features at Foxley Farm in the Upper Thames valley, in a view down sun. With a change of viewpoint to a position across the line of the sun (Fig.5.14(b)) the differential growth is enhanced by highlight and soft shadow. No doubt lighting conditions would be more favourable later in the day when the sun is lower in the sky, but advantage has to be taken of the conditions dictated by the time of flight. Even a relatively small change in aspect can be to advantage, for example Fig.5.15(a) at Foxley Farm in the Upper Thames valley presents a group of pits at point A, revealed as a highlight looking up sun, there is also a background interference pattern in the form of highlights in area B. The marks at point C are diffuse, but suggest a further group of pits possibly resulting from a more dense growth, since there is no obvious crop differential in height; at point D there is evidence for a circular feature. With a change in viewpoint still looking toward the sun (Fig.5.15(b)), the pits at A now appear more distinct in highlight and shadow, and the features at B are appreciably reduced in contrast; the suspect pits at point C do not appear and the effect was obviously part of the background noise. At the ripening stage the relative position of the plant seed heads will exhibit a random distribution, but on occasions they may integrate sufficiently to produce a spurious mark. The indication of a circular feature at D has also disappeared, but because of its particular configuration the evidence for its existence in Fig.5.15(a) cannot be completely disregarded. Fortunately there was little background interference in the vicinity of the pits at A, however in this instance both viewpoints have a contribution to offer.

In conditions of distributed light due to an overcast, it may appear that the viewpoint is not as critical compared with full sun, but that is not to say a casual exposure would suffice. Unless the overcast is dense, there is always an increase in scattered light from the direction of the sun. The effect is illustrated in Fig.5.16(a) over a site at Harvington in the valley of the Warwickshire Avon, where a combination of circular and square features can be traced in the ripe cereal. A change in viewpoint through 90^{o} in the direction down sun (Fig.5.16(b)) offers a significant increase in highlight from the crop-marks resulting in improved definition and resolution.

For the most part, the discussion and illustrations on the recording of Positive crop-marks, has been confined to sites appearing in one particular field and its cereal crop. On occasions features may extend into adjacent fields with different crops, and care must be taken to display the information accordingly. In some instances the difference in crop response may be very pronounced as in Fig.5.17 at Stanton Harcourt in Oxfordshire, where three circles are visible in two crops. Field A is in clover and grass, and field B sown with Purple Vetch and grass. The circles at C and D can be identified in both crops, but the ditches in Vetch appear with remarkable clarity. These plants are very deep rooting, and from the ground the general distribution was scattered and growing to a height of 8 inches, compared with the grass at a height of 3 inches. The Vetch growing over the ditches was very prominent up to 16 inches in places, with vigorous growth and a darker green in colour. The circle at E is contained in the clover, and exhibits a weak response which could not be enhanced through a change in viewpoint, apart from the ditch infill the depth of soil on this site is only 8 inches down to gravel.

Crop-marks extending over two types of cereal are illustrated in Fig.5.18(a) on a site near Wick in the valley of the Warwickshire Avon in the county of Worcestershire. The crop in field A is Wheat and in field B, Barley, and the oblique is too close to the site to appreciate the overall configuration. In Wheat the drill lines are also dominant and the Barley exhibits speckling effects in the crop which are confusing. The aspect and increase in height of the presentation given in Fig.5.18(b) is more informative, and the background effects less intrusive. The crop-marks in Wheat are well defined appearing with good contrast against the background crop, but the continuity of the ditches into the field of Barley is less evident. In Fig.5.18(c) a viewpoint of 180° with respect to that of Fig.5.18(b) clearly identifies continuity of the site into the Barley crop with no loss of detail in Wheat. Crop-marks in Barley appear more sensitive to lighting conditions, and there are differences between the two crops in terms of definition and resolution, the reasons for this are discussed in section 5.4 of this chapter. The three photographs were taken under conditions of a thin overcast. It is of interest in that from a ground inspection there was no differential height from the marks in Barley, only an increased density of growth, when the crops were ripe the marks had completely disappeared in Barley but were still evident in Wheat.

A more convincing example is given at a site near Bricklehampton, Worcestershire, the crops are unknown and the photographs on this occasion were taken in conditions of full sun. The viewpoint in Fig.5.19(a) is looking into sun, and under this condition of illumination crop-marks show a number of features in field B, whereas in field A there are only faint traces of ditched features. To a certain extent the evidence in both fields is obscured by the remains of a ridge and furrow field system (C). With a change in aspect of 180° down sun the remains of a settlement in field A are revealed, and appear in conjunction with the marks in field B which are only slightly reduced in contrast. Continuity of the crop-mark pattern is confirmed at point D.

From the examples given in the recording of Positive crop-marks, it is clear that there are many variables to be taken into consideration, from the time of day, lighting, weather and type of crop including its status in terms of the growth cycle. Careful assessment from the aerial viewpoint is a prerequisite, if photographs are to reveal all the detail that has been identified. In the case of a single feature one viewpoint may well prove acceptable, but with a complex site a sequence of differing viewpoints are an advantage in subsequent interpretation. In the writer's experience there have been occasions in later assessment, where one would have wished for a change in aspect of a few degrees, or perhaps an increase in height or angle of oblique; it is as well to hold a post-mortem on a season's results to identify any shortcomings which may influence the conduct of the following season's reconnaissance. An interpreter however, has to accept the result and may not be aware that a particular presentation could have been improved.

5.3 Negative crop-marks

The presence of an impermeable feature in whatever form may have a detrimental effect on the crop growing above it, provided the remains lie within the depth of the plant root system. In the early phase, growth is unrestricted and is the same as for the crop in the field as a whole. It is only when transevaporation demands an increase in moisture and nutrient, that the root system expands until it encounters an impermeable horizon, and in the absence of adequate rainfall the plants will begin to exhibit the effects of moisture stress. If the condition intensifies its colour will fade, leaf development will be inhibited and the stalks become thinner and darker in appearance; if the ear is visible its size will be reduced compared with that in the adjacent crop. The effect is illustrated in Fig.5.20(a), where the well developed and darker green appearance of the surrounding plants have a lower reflection coefficient than the relatively retarded growth of the crop over an impermeable feature. This is illustrated in Fig.5.20(b) at Viroconium, Shropshire, where the poor growth over the road system round the town Forum is identified as a lighter line (A) against the darker tone of the surrounding plants. The crop-mark over the roads is substantial, compared with the relatively fine structure of building foundations in the vicinity (B). The marks should not be confused with the parallel lighter lines (C) which also indicate a poor crop response arising from the open furrows which derive from the method adopted in ploughing the field.

When the crop is ripe the features appear as darker lines against the background and constitute a crop reversal effect. This is illustrated in Fig.5.21(a), and arises from the relatively dense and more vigorous growth of the surrounding crop exhibiting a higher reflection coefficient, than that of the relatively poor crop appearing over the hardcore of concealed roads and building foundations. Fig.5.21(b) shows the features as a crop reversal compared with the earlier crop-mark response over the same site as shown in Fig.5.20(b). Because of the relatively well defined profile exhibited by structural remains, in the writer's experience there are no obvious misleading effects in differential ripening, such as may occur in a Positive crop-mark response over ditches. Although for a short time during the ripening process, the contrast of a Negative mark may be reduced as the individual ears ripen in the surrounding crop, the effect is ephemeral as the relatively poor growth over hardcore will usually ripen earlier. The appearance of a crop-mark response over impermeable remains is the opposite to that over a ditch, and a comparison can be made with the crop-mark of a short section of a ditch at point D as shown in Fig.5.20(b) and Fig.5.21(b). As a result of crop development during the time lapse between the two photographs, the Negative crop-marks were enhanced with more detailed features appearing in the form of building foundations (Fig.5.21(b) area E.

5.3.1 The Photography of Negative Crop-marks.

The recording of Negative marks is not so varied in techniques as is the case in Positive marks over ditched features. In the valley of the river Severn impermeable remains were not abundant, and only to be found associated with Roman forts and road alignments. It was in the area occupied by the Romano-British town of Viroconium in Shropshire, that remains of this nature were revealed in a complex pattern of building foundations and roads. In general, lighting is not so critical as for Positive marks, and in conditions of moisture stress the features are well defined exhibiting good contrast between poor and relatively well developed plants.

In conditions of distributed light under an overcast, Figs.5.22 (a), (b), (c) and (d) show the foundations of a castle site at Lower Fulbrook on the Warwickshire Avon. The different viewpoints round the site may be identified by reference to point A on each photograph. The building foundations appear as lighter lines over the poor growth in the unripe cereal, and it can be seen that, with this particular lighting condition, there is no significant difference in the appearance and resolution of the site. Of these illustrations, the aspect at Fig.5.22(d) with a steeper angle of oblique constitutes the better presentation. Much depends on the overcast and intensity of the distributed light, Fig.5.23(a) for example illustrates a complex of roads (A), building foundations (B) and ditches (C) Northwest of the Forum at Viroconium, Shropshire, recorded in good lighting conditions but with no direct illumination by the sun. With a change in aspect of only a few degrees and an increase in the angle of oblique as given in Fig.5.23(b), the features appear with improved contrast and perspective. Background noise is also of importance, Fig.5.24(a) illustrates a complex of building foundations and roads contained in an area West of the Forum at Viroconium, photographed with the same lighting conditions as for Fig.5.23. From this aspect there is considerable interference from striations in the crop due to cultivation. A small angular change in viewpoint and attitude has considerably reduced the interference (Fig.5.24(b)), and the features now appear with increased definition and also improved contrast as a result of more advantageous lighting. It is an unfortunate circumstance if the worst aspect of background interference is coincident with the optimum lighting conditions, and a compromise may be necessary to achieve an acceptable presentation.

Problems may also arise in conditions of full sun, particularly in a crop of Barley. Because of the high intensity of reflected light from the ear and beard, the recording of Negative marks becomes sensitive to changes in viewpoint. To illustrate this, a series of photographs with variations in aspect and angle of oblique is given in Figs.5.25 (a), (b), (c), (d), (e) and (f) over the area occupied by the remains of the Forum at Viroconium. The aspect at Fig.5.25(a) is a high angle oblique looking across the line of the sun, the Negative crop-marks of roads (A) and building foundations in area (B) appear as lighter lines but with poor contrast in the unripe crop. There is also background interference in the form of parallel lines of dots distributed evenly over the field. From the viewpoint at Fig.5.25(b) directly into sun, the high intensity of reflected light from the Barley crop has almost completely obscured the features of interest at A and B, and the interference pattern now appears in highlight and soft shadow (C). These Positive crop-marks originate from a differential growth caused by heaps of manure left in the field prior to cultivation. As a consequence nutrients have leaked into the soil under the heaps, promoting an increase in crop growth which is revealed as a series of dots. The absence of shadow effects associated with the Negative marks over the remains of roads and building foundations, implies a poor height differential.

With a change in viewpoint of 180° degrees looking down sun and a low angle of oblique, the intensity and resolution of the features is improved but the oblique is too shallow (Fig.5.25(c)). From a similar viewpoint down sun a higher angle of oblique was attempted as given in Fig.5.25(d), but the presentation left much to be desired due to the presence of highlights in areas D. With a small deviation in the angle of approach away from the sun (Fig.5.25(e)), the highlights were reduced and the clarity of the marks improved, but the features are still too far away. In a final exposure the angle of view across the line of the sun was increased, and the photograph taken closer to the features at a lower height to give a more acceptable presentation (Fig.5.25(f)), even so the aspect is now looking into striations present in the crop, which fortunately do not interfere unduly with the crop-marks. This series of photographs has been included to illustrate not only the vicissitudes of Barley, but the need to arrive at the best compromise between aircraft height, angle of oblique, viewpoint and lighting condition.

5.4 The characteristics of various crops.

In the recording of crop-marks it is not a prerequisite to identify the type of cereal under observation. It would be difficult in the early stages of development to recognise one type of crop from another, but after heading when the leaf area is well developed, it is possible to distinguish between the lighter tone of Barley, or in some varieties a brownish appearance, and the darker green of Wheat. When fully developed there is some advantage in identifying the crop, in order to anticipate the problems which may arise in photography. In the valley of the river Severn, Barley and Wheat comprise the more popular varieties, with a scatter of Oats and roots in the form of Sugar-Beet.

5.4.1 Barley

The response from Positive crop-marks in Barley is perhaps one of the most difficult to photograph, although in dry conditions the crop is capable of showing good marks, differential growth in the height of the stalk can vary from zero up to a factor of 2 depending on the depth of soil available for plant development. In circumstances where there is little or no variation in height, marks appear due to a more dense growth combined with a colour difference, any increase in percentage germination above a feature will also enhance the mark. As the plants develop, the ears will bend over in a random manner, but in conditions of a strong surface wind they will tend to orientate in line with the wind. When completely ripe the ears may have a marked droop, and this will increase if harvesting is delayed leaving only the stalks as the reflective medium, this can degrade the crop-mark to such an extent that it is barely visible. The effect may be compounded by weeds, or if undersown with ley its dark green appearance would make the marks even more obscure. If weeds have developed integral with a crop-mark, they will remain after harvesting and allow the outline of features to be traced in the stubble, the effect is illustrated in Fig.5.26 at Grimley, Worcestershire, where weeds define the remains of two ditched enclosures.

An example of differential growth in Barley is given in Fig.5.27 on a site at Stanton Harcourt, Oxfordshire. With the overburden removed, two conjoined circular ditches are revealed with part of a third ditch, the darker infill contrasting with the gravel (A). Continuity of the feature is visible as a crop-mark (B) in the adjacent field of Barley. The site was photographed early in July prior to ripening, and it can be seen that the crop-mark is darker in appearance compared with the circular ditch and enclosure at C. Because of the substantial increase in growth over the ditch at B, the plants have been beaten down by rain (Fig.5.28), and the darker green of the laid stalks reflect less light than the crop over the ditches at C, which is still upstanding (Fig.5.27). A visit was made to the site during August when the crop was ripe, and samples obtained as illustrated in Fig.5.29(a) and (b). In sample (a) a comparison is made between a single stalk taken from the centre of the crop-mark at a point where the plants were still upstanding, and one from the adjacent crop in the field. It is clear that the leaves on each plant have withered and the reduced area will have little effect on the appearance of the crop, leaving the stalk and ear as the predominant features. In sample (b) groups of plants were taken from the same positions and are more representative as an illustration of the crop differential, the average height of the plants over the ditch is nearly twice that of the normal crop, with a significant increase in the size of the ear and its beard. Strong crop-marks of this nature can be anticipated over poor shallow soils; on this particular site the depth of soil was only 9 inches over the gravel. The extent of the ditch infill was unknown, but sufficient to have a marked effect on the plants growing above it. The seed drills over the field were spaced 200 mm apart with soil visible between the rows of plants, but not in the case of the more dense crop-mark. Plant distribution was approximately 30/35 stalks per foot with no increase in germination over the ditch infill. The converse applies in Negative marks in barley over impermeable remains, the relatively poor growth is accentuated under conditions of moisture stress, and some plants may wither and die reducing the density and increasing the contrast with the adjacent crop.

5.4.2 Wheat.

Of all the cereal crops Wheat is the most deep rooting and drought resistant, the individual plants are sturdy and less susceptible to damage in adverse weather conditions. During growth the ears remain upright, but at the ripening stage will tend to curl over in a random manner although when fully ripe the droop is not as pronounced as in Barley. An example of a Positive crop-mark in Wheat is given in Fig.5.30(a) in the form of a double ditched enclosure near Bishampton, Worcestershire. The crop is unripe and samples were taken as illustrated in Fig.5.30(b), over the ditch the crop stand was an average of 38 inches with well developed ears, a sample taken from the adjacent crop in the field shows an average height differential of 11 inches, with a substantial reduction in the size of ear and leaf area. The contrast between the two samples reflects the tonal change which reveals the outline of the ditches, in terms of the relative density in growth and colour. Not all crop-marks are well defined, and in a wet season the difference in growth may be marginal as shown in Fig.5.31(a), in this illustration the road system (A) round the Forum at Viroconium is barely discernible in the form of a Negative mark in unripe Wheat. Samples were taken at a later stage in the crop development, as given in Fig.5.31(b), the plants in the field and adjacent to the road exhibit normal growth to a height of 30 inches, by comparison the sample taken from the crop above the road shows only a small difference in height and general appearance, resulting in a poor crop-mark.

5.4.3 Oats

Oats present an entirely different appearance in that, instead of a single ear, the head comprises individual seeds which integrate to form a canopy. There is no obvious colour contrast in a crop-mark, it is the difference in height which predominates. This is illustrated in Fig.5.32(a) where Positive crop-marks reveal the ditches of a Roman fort at Jane Lane, near Leintwardine, Herefordshire. The feature appears in Oats as a shadow site, when illuminated by the sun at a low angle of incidence. Crop samples were taken at point A, as given in Fig.5.32(b), it can be seen that the plants growing over the ditch are well developed compared with the sample from the adjacent crop, but it is the difference in height of some 12 inches which is significant.

5.4.4 Roots

Sugar-Beet is the more common form of roots cultivated in the valley of the river Severn, but the crops are very infrequent compared with cereals. Beet is sown in spring and harvested in autumn, and the plant density is very much less than for wheat or barley; an area of some 200 sq.inches per plant may be assumed, to allow sufficient soil and light for individual plant development. This may be allocated by sowing in rows 18 inches apart with plants spaced by 11 inches. The ratio is variable, and the density of sowing will depend to a large extent on the nature of the soil, which will determine the yield; on rich soils individual roots will grow large, but on light soils more plants will be required to achieve the same overall yield. Sugar-Beet is very deep rooted and its development will be influenced by the available depth of soil, in much the same way as for cereals. Assuming a soil moisture deficit occurs, the effect on plant growth is shown in Fig.5.33(a), in the form of a Positive crop-mark produced through the moisture and nutrient available in the deeper soil of a ditch infill. The leaf area of the plants growing over the ditch is considerably increased, with a darker green appearance from the more vigorous growth contrasting with the surrounding crop. Because of the plant spacing, the appearance will be more coarse in its structure than for cereals. This is illustrated in Fig.5.33(b), which shows the crop-mark of a simple ditched enclosure in Sugar-Beet at Enville Staffordshire. It is apparent that it will be necessary to adjust the aircraft height in order to achieve an acceptable integrated response.

The converse applies in the case of a Negative mark as given in Fig.5.34(a), in conditions of an acute soil moisture deficit growth is inhibited over impermeable remains, and the plant leaves will turn yellow and wither increasing the reflection coefficient in contrast with the green leaves of adjacent plants, the features appearing as lighter lines in the crop. An example is shown in Fig.5.34(b), where the outline of roads and building foundations are revealed in a field adjacent to the Baths site at Viroconium, Shropshire. The effect can be quite dramatic as in Fig.5.34(c) where a ground photograph of the site in colour illustrates the relatively poor growth of the plants over the road surface at A in Fig.5.34(b). In this field the rows were spaced 17 inches apart with 12 inches between the plants. The alignment of the rows is indicated at B in Fig.5.34(b), and it can be seen from the ground photograph that the width of the road is sufficient to accommodate at least 6 rows of plants, which integrate to give a dominant response from the aerial viewpoint. The building foundations in areas C are not so well defined, the response over narrow walls will vary depending upon their orientation with respect to the rows, if for example the foundations are aligned between the rows they may not appear at all. The same will apply in the case of small features such as the remains of a column base, or the pillars to support a granary or heated floor. The most important difference between crop-marks in roots as compared with cereals is the absence of a crop reversal, any tonal change will remain until harvesting, assuming the conditions which influenced their appearance are maintained. In Sugar-Beet it is the root which matures for its sugar content, and not the surface features as in cereals. Because of the broad expanse of leaf area and no stalks, the lighting conditions are not so critical for photography, as is the case with cereals.

It is of interest to compare the Negative crop-marks in roots at Fig.5.34(b) with the same site in Wheat at Fig.5.35 and in Barley at Fig.5.36. Irrespective of the conditions of growth and date of photography it is clear that the marks in roots leave much to be desired, in Barley the crop-marks are well defined and appear with good contrast. In Wheat the resolution is considerably improved due to the characteristics of the plant, that is not to say that the crop is to be preferred as a better detector of concealed remains. Crop-marks in Barley can be very strong and will appear in less severe conditions of moisture stress than Wheat, which is more drought resistant.

5.5 Conclusions.

a) From the discussion and illustrations, it will be appreciated that the conditions which govern the appearance and recording of crop-marks comprise a wide range of variables, and it is difficult to arrive at a definitive set of rules. In the writer's experience it is a question of personal judgement, together with a disciplined approach, in the observation and recording of a site to the best advantage. The passing snapshot in lieu of a considered evaluation prior to photography is to be deplored, particularly in view of the detailed preparations necessary in order to arrive there in the first place; this is quite apart from the considerable effort involved at a later stage in processing and printing the film, interpretation, plotting, archival storage, retrieval, and subsequent evaluation for archaeological study or excavation. Further, if the site in question has ultimately been destroyed, the only record is represented by the aerial photograph.

b) The problems involved in the transfer of information on to ordnance survey maps should not be forgotten, and enthusiasm in committing a site to film must not override the necessity to include sufficient control points for this purpose, and the writer has not been guiltless in this respect. With the removal of hedgerows, a field can extend over a considerable area and it may be difficult to obtain adequate coverage, particularly with oblique photography. Even if this can be achieved, a change in the area as a result of land development could make subsequent identification on the ground difficult, and for the purpose of investigation a geophysical survey may be necessary.

c) Many papers and journals tend to include the best photographs, which may create a false impression of the overall results expected from aerial reconnaissance, in reality, the majority of crop-marks are not so well defined in the variable weather conditions experienced during each season. Even after many years of observation over a particular site, photography in conditions of acute drought may present all the detail and more than has been previously recorded. Such occasions are rare and should not denigrate the work that has been done prior to the event, which originally established the existence of the site. It is also apparent that a single photograph may be insufficient to record all the detail in a site configuration, indeed it would be a fortunate circumstance if it represented the optimum presentation at that time.

d) There is a need to progress a crop response to its final stage of development if feasible, but that is not to say that the previous series of photographs in that season are no longer viable, for detail can appear and disappear during the growth cycle. Where fields enclose small parcels of land, only part of a feature may be visible, and with the advent of crop rotation it may be many years before a complete mosaic of the site can be plotted, even then the information may only represent a small percentage of the evidence concealed under the surface.

CHAPTER 6

THE EFFECTS OF WEATHER, SEASONAL VARIATIONS AND INTERPRETATION OF NON-ARCHAEOLOGICAL FEATURES

6.1 Weather.

Weather conditions influence the conduct of air archaeology in three specific areas of interest, flying, photography and the appearance of crop-marks. The aspects which govern the flying and photographic disciplines have been dealt with in previous chapters, but there are other variations in the weather to be considered relating to the appearance of crop-marks, and the most important is rainfall, essential to maintain plant development over the growth cycle from seeding to harvesting. It is not necessarily the average amount of rain which is of concern, but the period when it occurs and its intensity. This varies widely from the heavy rain normally associated with a cold front, or the advent of scattered showers in unstable atmospheric conditions, to the lighter more consistent rain which may be anticipated with the passage of a warm front.

When transevaporation exceeds rainfall a soil moisture deficit is created, the intensity being influenced by air temperature and the characteristics of the soil. If the conditions are favourable, crop-marks will develop, and the effect on cereals is more pronounced during the months of June and July as the plant water requirements increase. If at any time during this period rainfall restores the soil moisture balance, crop-mark development will be retarded, and should the condition persist the marks will begin to fade as the surrounding crop responds to the increase in moisture. An example is given in Fig. 6.1(a) which shows a complex of ditched features near Appleford in the Thames valley, the site was photographed early in July when the crop-marks appeared with good contrast and definition. For the purpose of comparison, particular attention is drawn to the features at A. After a period of twelve days the site was still visible (Fig.6.1(b)), but with reduced contrast due to the effects of rain in the intervening period, and the features at A are now barely discernable. It is doubtful that the marks would recover before the crop ripened, and the advent of further rainfall could only make the situation worse.

The effects of rain may extend over a wide area, or confined to the track of occasional showers. However, the advent of heavy rain from whatever source can result in crop damage, particularly late in the season when plants are well developed. With Positive marks in cereals, the tall stalks and heavy ears are most susceptable to lodging. In circumstances where the damage is confined to the crop-marks, the outline of the features may still be revealed but with reduced resolution. This is illustrated in Fig.6.2 over a site at Wick on the Warwickshire Avon, not all the crop-marks have sustained damage, but where it has occurred the line of the ditches can still be traced. The effect is more pronounced when the crop is at the stage of ripening, as shown in Fig.6.3 at Little Clanfield, Oxfordshire, in this instance lodging is confined to the crop-marks and the outline of the features appear in marked contrast with the ripe crop. Because the cereal over the ditches is not fully ripe, the darker green of the laid stalks has enhanced the marks.

Over impermeable remains the relatively poor growth is not as prone to lodging, but the fine structure of wall foundations for example may be obscured by the adjacent laid cereal; with a concealed road surface the mark is more substantial, due to the increased area of poor growth. This is illustrated in Fig.6.4 where the Negative marks of roads and building foundations are visible in a crop of Barley at Viroconium, Shropshire. The crop damage is patchy with little interference in the area of the building foundations, but the roads at A can still be seen within the damaged crop. The rain was sufficiently intense to affect the Positive crop-marks of ditches at B. The appearance of crop damage may be reduced and Negative marks more distinct, when photographed down sun. With a combination of wind and rain, crop lodging may be total as shown in Fig.6.5.

A strong surface wind can also have an adverse effect on the appearance of crop-marks, particularly in Barley where the orientation of the ears may be brought into line with the wind direction, producing a pronounced ripple across the field. An example is given at Fig.6.6(a) in a field of Barley at Viroconium, Shropshire, the ripple effect is clearly evident and the movement of the plants over the Negative crop-marks of building foundations at A has produced an interference pattern, giving the marks a blurred appearance. A viewpoint into wind or down wind may reduce the effect, but in this instance where the marks are weak, an aspect down sun which fortunately is nearly in alignment with the wind direction, resulted in a significant improvement in definition (Fig.6.6(b)).

The need to maintain aerial reconnaissance over successive seasons has been emphasised, for it is unusual for all the detail of a site to be revealed in any one year, indeed the full extent of concealed remains may only be apparent when excavated. In very dry weather crops are subjected to intense moisture stress, and under these conditions a site can appear with considerable detail. An example is given in Fig.6.7(a) at Welford on Avon, Warwickshire, in 1959 a feature appeared in the form of a simple enclosure over a well drained area of the field. In the relatively dry period which occurred during the summer of 1962, the site was transformed into an area of complex settlement revealed in a pattern of ditches and pits, with the enclosure as the dominant feature (Fig.6.7(b)), the arrangement of the ditches suggests more than one period of occupation. There is still potential in the faint indications of other features in the area, which would justify continuity of observation.

The onset of a soil moisture deficit necessary to initate the appearance of crop-marks, is difficult to assess in view of all the variables involved in terms of soil types, crops and weather conditions. There is however, a publication available from the Meteorological Office, for a modest subscription, which provides a monthly estimate of the soil moisture deficit and evapotranspiration over Great Britain. The assessment is based on accumulated data and does not constitute a forecast. This is not the place to detail the methods involved, but a set of explanatory notes is included on initial application. It is emphasised that the information provided can only offer a guideline as to the general trend, and is no substitute for an airborne assessment of the prevailing conditions, but it does serve a useful purpose, particularly where a flying resource is limited. It is an advantage to supplement the information through active liaison with other practitioners in the field. An example of the data as presented in map form, is given at Fig.6.8. This is accompanied by a set of notes drawing attention to important features in the distribution of soil moisture deficits, and related to significant changes in the weather since the previous issue. Based on information of this nature, crop-marks may be anticipated when the deficit is 50 mm or greater.

6.2 Seasonal variations in crop-marks.

The observation of a site over successive seasons brings its rewards and disappointments, due to variations in weather conditons and crop rotation. If the site has been partially excavated there may be a tendency to discontinue reconnaissance, particularly if subsequent results over a few seasons fail to reveal any additional detail in its configuration. Where the site is not threatened by destruction, an excavation may be confined to dating the feature leaving the remainder for posterity. In this event it is still necessary to maintain continuity of observation where feasible. in the interests of future research. To put this into perspective, a series of results is presented over the site of a Roman auxiliary fort at Buckton Park Farm in Herefordshire, during the period 1959 to 1975. It was not possible to maintain reconnaissance in every individual season due to other priorities, but the continuity is adequate to illustrate the inherent problems and prospects.

In 1959 the fort appeared in Wheat, as given in Fig.6.9(a). and from the nature of the crop-marks suggested that the structure was in stone and of one period, no earlier than AD100. Negative marks clearly define part of the internal road system at A, there is also evidence for a wall inserted into the face of the rampart (B) and the foundations of gate towers at C. Because there was sufficient material under the surface soil from the remains of the rampart, the feature appeared as a Positive mark (D) which is very unusual. With the exception of the North alignment, the defences can be traced over the remaining three sides of the fort with no conclusive evidence for an outer ditch system, and from the axis of the via Principalis at E the fort faced East. This road continues south for a short distance external to the fort defences, and on each side of the extension Negative marks suggest stone foundations (F) aligned with the gate towers and of approximately similar dimensions. The fort is situated on the North bank of the river Teme commanding a viewpoint along the river valley to the West into Wales, and in an Easterly direction to a confluence with the river Clun and the fort complex at Leintwardine.

Reconnaissance in 1960 revealed the site in much the same detail (Fig.6.9(b)) except there was now some indication for an internal structure to the West of via Principalis at G. The rampart wall B is now well in evidence, and the Positive crop-mark at H suggests a single outer defensive ditch. In 1959 the East defences were sectioned by Dr S C Stanford and confirmed the crop-mark evidence, it was of interest that sufficient turf remained from the rampart construction to produce the Postive crop-mark indicating its alignment. The results also revealed a single outer defensive ditch, unfortunately the section did not extend far enough to explore the prospect of other ditches. Excavation continued in 1960 at the East gate and produced two periods of occupation, Period 1 in timber circa AD80 with Period 2 in stone and constructed within the first two decades of the 2nd century, (Stanford, 1968), no further investigations were initiated.

It was in 1962 that the complete outline of the fort defences appeared, as given at Fig.6.9(c), in this photograph the North alignment is identified by the rampart wall B and outer defensive ditch H, with a short section of the via Sagularis at J; Dr S C Stanford's figure of 5.9 acres over the rampart walls was now confirmed. The somewhat dubious evidence for foundations adjacent to the extension of the via Principalis at F still appeared, and the marks were subsequently confirmed as a shadow site during an evening sortie with the sun at a low angle of incidence, Fig.6.9(d). The evidence for the features in alignment with the fort gate towers (C) is persuasive, and it is the writer's opinion that they are associated in some way with the fort construction. It is unlikely that they formed part of a Vicus, if indeed any existed within this limited area. It would no doubt be speculation to suggest that the fort reconstruction was intended to occupy a larger area than that of Period 1, but it does represent an unusual feature for future investigation, and emphasises the need to take full advantage of the technique in the interests of resolving detail.

In the following season 1963, the results as shown in Fig.6.9(e) were disappointing in that only the outline of the North defences could be seen, as in Fig.6.9(c) for 1962. The Positive mark at K is an anomaly in that it lies behind the alignment of the via Sagularis (J) and is discontinuous. In the area occupied by the fort the field is divided between three crops, none of which reveal any evidence for its existence. The results in 1964 (Fig.6.9(f)) were no better, with poor Negative marks of the internal road system, and in 1965 only part of the North defences could be seen, Fig.6.9(g). During the following two seasons, 1967, Fig.6.9(h) and 1968, Fig.6.9(i) only fragments of the remains appeared and barely justified the photography, and if this had constituted the initial survey results over the area, it is doubtful if the site would have been recognised for what it represented. In 1969, Fig.6(j), only the pattern of the internal road system was recorded with a vague outline of the fort defences.

Understandably, there was a reluctance to continue observation over the site in view of the disappointing outcome during the last few seasons, but in 1970 the weather conditions improved considerably, and the fort detail began to emerge again. The results in late July are given in Fig.6.9(k), the adjacent field to the North was down to grass and the line of the defences in this area did not appear, but within the fort itself crop-marks confirmed the existence of granaries at G, and the possibility of building foundations associated with the via Principalis in area L. From the results of previous surveys, there was no convincing evidence for any structures or development in the vicinity of the fort, but on this occasion crop-marks revealed the existence of building foundations to the East of the fort (M), and in the opinion of the writer represents the remains of a Bath-House. The dry conditions persisted and when the crop was ripe as shown in Fig.6.9.(L), the internal features appeared with improved definition, suggesting the remains of the Principia at L and Commandants house at N. No further reconnaissance was undertaken over the site until 1975, when the fort appeared in conditions of drought, Fig.6.9(m). There were no additional features in the fort configuration, but the remains of the Bath-House (M) were more clearly in evidence, Fig.6.9(n).

This sequence of photographs constitutes a representative selection of the results, illustrating the variations in the appearance of a site over a number of years. A similar outcome may be anticipated over any particular site, and is not only indicative of the limitations in aerial reconnaissance, but the problems in interpretation and the need to maintain observation. Although the returns from a financial point of view may be called into question, it is the accumulated evidence that is of importance in the interests of future research. A sketch plan of the information derived from aerial reconnaissance over the fort site at Buckton Park Farm, is given in Fig.6.10.

6.3 Interpretation of non-archaeological features.

In addition to the appearance of archaeological remains in the landscape, the presence of other features of non-archaeological origin can lead to misinterpretation. Subsequent analysis of aerial photographs is a static situation, and provides an extended period in which to distinguish one feature from another, but from the airborne point of view, there is a limited time in which to assess the composition of the landscape. The procedure in both cases is the same, that is, to eliminate all the evidence which can be identified as non-archaeological, prior to the interpretation of the remainder in an archaeological context. Non-archaeological patterns appear in many forms and are wideranging in their origins, and it would be appropriate at this point to include some of the features observed by the writer during aerial reconnaissance in the West Midlands. For this purpose they are classified under three broad headings as follows,

6.3.1 Natural phenomenon.

6.3.2 Effects of cultivation.

6.3.3 Industrial and other land use.

6.3.1 Natural phenomenon

In terms of geology perhaps the most common feature is the appearance of patterned ground, representing the remains of ice-wedges, residual from the ice age and conditions of permafrost. After the ice had melted, the infill of the wedges will often result in Positive crop-marks and appear in the form of polygonal systems, produced by the contraction of frozen ground brought about by extreme cold, and are indicative of the pattern resulting from shrinkage cracks in mud induced by very dry conditions. The features generally occur on porous soils, and are readily observed as crop-marks over gravel deposits. A typical example is given in Fig.6.11 at Abbot's Salford on the terrace of the lower Warwickshire Avon. The polygons vary in size from about 25 ft across to the largest approximating to 100 ft, (Shotton, 1960). Concentrations are also evident in the valley of the river Severn, as in Fig.6.12, where polygonal structures appear over glacial till at Atcham, Shropshire, the ditches of a Roman temporary camp are also visible at A.

Fossil ice-wedge casts may comprise larger and more irregular forms, open to misinterpreTation as the remains of field systems, particularly if they appear in conjunction with overlaying archaeological features. This is illustrated in Figs.6.13(a) and (b), at Brampton, Oxfordshire, where the Positive crop-marks of a regular shaped enclosure (A) can be seen together with the marks from ice-wedge casts at B. The oval in Fig.6.13(a), formed by grass track racing will no doubt leave some evidence for its existence in the following season, which may be safely interpreted as the remains of a ritual site in 1972. During the excavation of a Neolithic earthwork at Broome Heath in Norfolk, the remains of periglacial features were initially interpreted as bedding trenches for timber posts, (Evans, 1972). It can be appreciated from the parked cars in Fig.6.13(a) that the surface remains of these wedges are at least 6 ft wide, and compare favourably with the excavation results at Broome Heath. Ice-wedges of regular form in an active state are shown in Fig.6.14, as photographed by the writer in the Arctic over Ward Hunt Island.

Other evidence of geological origin is reflected in the remains of fractures in rocks, an example is given at Fig.6.15 as revealed in crop-marks over Limestone on Wenlock Edge, Shropshire. Some forms may suggest the remains of an archaeological feature as in Fig.6.16, at Cutsdean on the Cotswolds, where an oval pattern of darker and lighter lines appear at first sight to be the ploughed out remains of the defensive system surrounding a hill-fort, but the absence of entrances and also a discontinuity in the alignment at A suggest a natural origin. The site was investigated by D R Wilson, and what appeared to be ditches originate from bands of clay contained within Limestone, this had been eroded by the weather and subsequently infilled with darker soil to give an impression of ditches. A similar banding effect is shown in Fig.6.17 on the South aspect of the Malvern Hills, Herefordshire, caused by differential weathering in the strata of Siltstone, Shale, and Mudstone.

Another natural feature to be found in river valleys are the infilled remains of meanders, resulting from diversions in the course of the river or stream over a long period of time. These show up very well as crop-marks, and an example of the complexities which can arise is given at Fig.6.18 in the valley of the river Lugg near Mortimer's Cross, Herefordshire. Integral with the remains of meanders (A) the ditches of two enclosures can be seen in faint outline at B. Damp marks may also deceive, as in Fig.6.19 near Upton Snodsbury, Worcestershire, where water draining from a knoll or small hill reflects a more luxuriant growth in vegetation round its base, giving the impression of a defensive ditch.

6.3.2 Effects of Cultivation.

One of the features in a cultivated environment which may lead to misinterpretation is the action of ploughing. In this process three basic methods are used, a) ploughing in "lands", (b) square ploughing c) one way ploughing.

a) The first operation in this method is to mark out the headlands in which to turn the plough, secondly to divide the field into "lands" or strips, the procedure is to plough alternate "lands" in the opposite direction. This action will create two distinct variations in soil depth where the "lands" adjoin. This is illustrated in Fig.6.20, where two adjacent furrows turn outwards the soil will be relatively shallow and appear as a lighter line or Negative mark in the crop at A. The converse occurs where the two adjacent furrows turn inwards giving an increase in the depth of soil, resulting in a darker line or Positive mark appearing in the crop at B. The headland at C is ploughed as the last stage in the operation. The width of "lands" may vary, on heavy wet soils they will be narrow providing a larger number of open furrows to serve as shallow drains. The fine parallel lines across the field at D are the remains of tractor wheel marks, left after crop spraying.

b) To save time on turning a tractor the technique of square ploughing may be adopted, in this method the field is ploughed round and round with furrows parallel to the field boundary. The remaining area in the centre will be ploughed as a "land". Turning the plough at the corners constitutes a diagonal headland aligned with the corners of the field, this appears in the crop as a lighter line or Negative mark as shown at A in Fig.6.21. The effect in this particular field, together with the crop-marks of ice-wedge polygons, creates a complex background against which it could be difficult to resolve an archaeological feature.

c) With one way ploughing, "lands" are not necessary, and only two headlands are required in which to turn the tractor. Ploughs of this type are equipped with right hand and left hand shares, arranged so that they can be changed over on the headland. This particular form of ploughing presents no problems in interpretation.

There are other effects in agricultural practice which are open to misinterpretation. Where animals are on a fixed tether, the grazing pattern will appear as lighter circular patches in the pasture, as given in Fig.6.22, and may suggest the remains of a group of barrows. A similar effect is produced by rotary sprays, as illustrated in Fig.6.23, at A the spray is active and the circular pattern is intersected by a damp mark in the form of a ring at B originating from the previous position of the sprayer. In an adjacent field the distribution of circular damp marks derived from this form of irrigation are clearly evident. The presence of field drainage systems presents another form of background interference. The layout of the ditches to accommodate the tiles, depends upon the contour of the land and the form of drainage required. A more common arrangement comprises a parallel system, consisting of a series of parallel drains discharging into a single channel. The depth at which the drains are laid varies from 2 to 4 ft and the pattern will be revealed in the form of a Positive crop-mark, as illustrated in Fig.6.24. on Bourton Heath, Warwickshire. In this example the side drains at A feed into a common channel B, the remains of two regular enclosures at C are quite distinct and in this instance easily recognised against the pattern of the drains.

Where trees have been cleared from the land and the stumps withdrawn, the hollows remaining will be infilled when the land is ploughed. Subsequently the appearance of Positive crop-marks may suggest a group of pits, a typical example is given in Fig.6.25 at Puckrup in the Severn valley. In general such remains exhibit a ragged appearance compared with the more clear cut outline of a pit, and may be suspect in the absence of other archaeological features. Reference to ordnance survey maps will often provide an indication as to the previous existence of a wooded area. The removal of hedgerows will also create crop-marks which may be misleading, particularly if they occur in a complex site, but their orientation with respect to existing field boundaries will sometimes assist in identification. An example is given in Fig.6.26 at Wistanstow, South Shropshire, the remains of hedgerows, removed in the interests of increasing the area for cultivation, are visible as crop-marks at A. Within the area, the remains of ditches identify the defences of a Roman auxiliary fort at B, and from this viewpoint there are only faint indications for a second outer ditch. The feature is recognised by its playing card shape, the position of the gates and typical rounded corners.

The crop-marks of vanished hedgerows may suggest a pit alignment when sliced by the plough, but any spread on the individual marks should arouse suspicion. Animal tracks in a crop are unmistakable in their random distribution, as shown in Fig.6.27(a), and no doubt the vegetable gardens of the adjacent houses proved irresistable. On occasions they may form a regular pattern as in Fig.6.27(b), but the path through the crop is clear cut and its narrow profile readily identified. At times unusual features appear, as in Fig.6.28 which shows a vague outline of substantial building foundations as a Negative crop-mark. The field forms part of the estate at Witley Court near the river Teme, and the marks represent the remains of a formally laid out garden, subsequently abandoned for agricultural purposes.

6.3.3 Industrial and other land use.

The remains of contemporary structures may appear at first sight to resemble the shape of well known archaeological features. At Foxley Farm in the Thames valley for example, crop-marks appeared reminiscent of a Roman fort layout complete with annexe, Fig.6.29(a), although there is no recognisable evidence for the existence of internal features or gates. The site was identified as the remains of a store or compound, for in the vicinity a similar upstanding structure could be seen as in Fig.6.29(b). In an adjacent field the ringed ditch of a barrow site is visible, together with the Negative crop-marks of building foundations at A of non-archaeological origin. In the vicinity the remains of other contemporary structures can be seen at B. Similar remains may be expected on, or near disused airfields or military establishments.

Other compounds in isolation can also be deceptive, at Attingham Park in Shropshire, Fig.6.30, there is a configuration in pasture at A closely resembling the remains of a small Roman camp. Even in the absence of entrances, the evidence for ditches and typical rounded corners is convincing, and further, it lies close to the Romano-British town of Viroconium. Subsequent ground investigation revealed the site to be an enclosure for parking caravans. The laying of gas or oil pipelines across the country may be mistaken for a Roman road alignment. The infill of the broad single ditch will appear as a crop-mark, but the nature of the feature is revealed by the gaps made through hedgerows or scrub, and the turning points are usually more sharply defined indicative of a pipeline. An example is given in Fig.6.31, south of Stratford-on-Avon, the crop-marks of a pipe-line at A can be seen to cut through the remains of a triple ditched enclosure B, and continuity in the alignment is confirmed by gaps in the hedgerows at C. Sewage pipelines are not as wide and may be identified in much the same way, also by their termination at a treatment works; the presence of manholes distributed at intervals along the alignment provides a further clue as to the origin.

The remains of gravel pits will produce Positive crop-marks when backfilled, and the larger irregular shapes bear little resemblance to archaeological features. This is illustrated in Fig.6.32 near Warborough in the Thames valley, the crop-marks of ringed ditches and a cursus are well in evidence, and in this complex the remains of a gravel pit at A has been allowed to fill with water, whereas the pits at B are backfilled and revealed as a Postive mark. Some remains are not so easily resolved as in Fig.6.33, at Appleford in the Thames valley, on this site a scatter of marks from gravel extraction are integrated with a ringed ditch, and other features appearing as crop-marks in a relatively well drained area of the field. In this instance the marks from the gravel pits may be misleading, and those within the ringed ditch difficult to interpret with any certainty.

Disused railway lines are recognised by their rounded curves and straight sections revealed by embankments, or continuity in the alignment of shrubs and trees which have subsequently developed on either side of the tracks. By their appearance, banks could be mistaken for the agger of a Roman road, but reference to ordnance survey maps will identify most disused tracks, not necessarily all, depending on the facility they served. A case in point appears in an area west of Hereford, as shown in Fig.6.34. On this branch line the distribution of building foundations A are well defined as parch marks in pasture, some of the features are adjacent to the remains of the single track alignment at B, visible after removal of the rails and sleepers. This particular site probably represented a depot of some kind.

There are other more deceptive features in the landscape, represented by the remains of searchlight batteries or anti-aircraft gun sites from World War II. After the sites have been cleared and the area reverted back to agriculture, perhaps only the ditches of circular compounds and enclosures will remain to testify as to their existence. Such remains are open to misinterpretation as a group of barrows, or ritual monuments. An example is given in Fig.6.35, to the south of Bishop's Tachbrook, Warwickshire. The site is unexcavated and has already been referred to as a possible barrow group and henge. It is certainly unusual, but is it really an archaeological feature, the three small circles appear to have an entrance. The larger circle with a wider ditch certainly has one entrance, with the vague indication for another diametrically opposite, a different viewpoint confirmed only a single entrance which is not appropriate to a henge monument; the small rectangular enclosure remained an enigma. It is the writer's opinion that the site originates from World War II, the three small circles are typical of a searchlight battery, with an entrance as one would expect. The larger circle is representative of a gun site, and the small rectangular enclosure, the remains of a command post. Its situation three miles south of Leamington Spa is convincing. However, it is a matter of opinion and must await the outcome of excavation. Not all gun sites were equipped with a searchlight battery, and may exist in isolation supported by a mobile gun laying radar system, not necessarily protected by a blast barrier. In general, most units were located near towns, or for the protection of military establishments, and none of these sites will be identified on ordnance survey maps.

6.4 Sites and non-archaeological features

To conclude this chapter, it would serve a useful purpose to briefly illustrate archaeological sites as they may appear against a background of non-archaeological features. For example in Fig.6.36 at Eckington, west of Bredon Hill, Worcestershire, the Positive crop-marks of two enclosures are identified at A in an area of ice-wedge polygons B and the dark bands of damp soil C. The Negative crop-mark at D can be seen to cut across the enclosures and represents a pipeline to a sewage plant, identified by the inspection pits at E coincident with its alignment in an adjacent field. The faint dark parallel lines at F which appear across the field are the crop-marks of ditches from the ploughed out remains of ridge and furrow cultivation.

In Fig.6.37 at Salford Priors on a terrace of the river Avon near Evesham, the outline of a regular shaped double ditched enclosure is visible as a Positive crop-mark at A. The entrance is well defined, and one side is lost against the field boundary, within the enclosure a cluster of pits appear together with a penannular ringed ditch attached to a small compound. In an adjacent field are the remains of fossil ice-wedge polygons B. The lighter lines of Negative crop-marks across the field at C represent the open furrows derived from ploughing the field in "lands". Positive crop-marks at D indicate an infilled excavation in the gravel, and the darker band at E an area of damp soil. The remains of ditches from ploughed out ridge and furrow appear as a series of parallel curved lines F across the field. Against this background there is the faint outline of a circular feature at G, and three single ditches at H which suggest an additional enclosure.

The examples given in this chapter are representative of non-archaeological features in the West Midlands, but by no means constitute a comprehensive list. Where such features appear in complex sites, sketch maps or plots will only provide probably one interpreter's viewpoint, and when excavation is anticipated it will be necessary to refer to all the available aerial photographs to substantiate the analysis, particularly if the plot has not been updated.

CHAPTER 7

OTHER TECHNIQUES INCLUDING FAR INFRA-RED

7.1 Other techniques

The results presented in this thesis are confined to the acquisition of data using a conventional camera and monochrome film, and consideration is now given to the application of other airborne techniques. The factors which influence the choice include cost, ease of application, analysis and the ability of the equipment to reproduce at least what can be perceived by the human eye. Any improvement in the image through the use of other sensors falls into three categories, enhancement, resolution and the possibility of revealing information not readily observed by visible light, or variations in colour. The use of colour film has become more widespread, not necessarily because it reveals more information than monochrome, but the eye accommodates more readily. The tonal range in colour is less than that of monochrome film and the popular use of a 35 mm format also imposes a limitation in the process of reproduction and enlargement, but there are advantages in the absence of grain, resulting in an improved presentation.

The introduction and viability of new techniques is best assessed by direct comparison with monochrome, preferably when it is recorded at precisely the same time. This has been demonstrated by work in the field of multispectral photography, (Hampton, 1974). The results using various films and filters over a spectrum from 0.3 um (10^{-6} metres) to 0.9 um (near infra-red) were encouraging, and showed some advantages over a single film and filter combination. In the practical sense the system is of value over specific sites of interest in terms of enhancement, but for general aerial reconnaissance the equipment is expensive and the results may not justify the outlay, quite apart from the provision of specialised equipment for the purpose of analysis. Nevertheless, further experimental work would undoubtedly simplify the system to advantage. The commercial use of satellite cover has always invited comment as equipment is becoming more advanced and sophisticated in design, but the resolution in terms of the detail required in archaeological survey would be inadequate. The results from this form of surveillance are more appropriate over inaccessible areas and extensive tracts of land, where access and ground survey would be difficult and time consuming. Over the limited terrain in the British Isles, there is little advantage compared with current techniques.

The use of radar systems in aircraft to record landscape features is a well known technique, and apart from its function in the form of an airborne warning equipment or weather radar, the scanner can also be depressed in angle to display the outline of coastal features, rivers or towns, as an aid to navigation. The discrimination of the equipment in terms of pulse width and angular resolution however, is insufficient to define other than the more prominent features in the landscape. With the advent of higher frequency bands, an airborne radar linescan system has an improved capability in the form of a narrower beam width and pulse width to produce a well resolved display of the adjacent terrain, but this still falls short of the requirements. Perhaps only in the event of a Laser Linescan would the resolution be expected to approach that of a film. Even so, it is highly unlikely to produce any additional information other than that obtainable by conventional techniques, and would not constitute a viable replacement for a vertical camera installation with a stereo facility. Problems may also arise in resolving the more subtle tonal variations presented by crop-marks, not necessarily accompanied by changes in profile.

With any photographic image, the primary information is derived from the tonal structure of the image. The picture obtained from photography and radar represents a distribution of reflecting surfaces derived from some form of illumination. Photography involves the reflection of visible light over a narrow spectrum, and in the case of radar, the reflection of energy is contained in an even narrower spectral range. In both instances the illumination provides the source of energy, and defines to a large extent the character of the reflected energy. There is however, a technique in the far infra-red region of the spectrum which depends entirely on the emissive characteristics of the landscape, and constitutes a thermal mapping capability which introduces an entirely different concept in the display of information, than that derived from photography or radar.

7.2 Far Infra-Red techniques.

The application of far infra-red constitutes a technique which does not require such critical conditions of illumination to record variations in land profile or vegetation, provided there is sufficient energy to initiate temperature changes in landscape features. This is a very important aspect of the technique, in that it functions through the self-radiation of objects on the ground, not by other forms of reflected energy. Infra-red radiation is generated by vibration and rotation of the atoms and molecules within any material whose temperature is higher than absolute zero (0^{o} Kelvin or - 273^{o}c). Consequently nearly everything in the landscape radiates energy in the infra-red portion of the electromagnetic spectrum. The existence of this form of energy has been known since the latter part of the 17th century, but it was not until the 1930's that infra-red spectroscopy was applied as an analytical tool. The relatively slow development of the technique was due to the lack of sufficiently sensitive detectors, but World War II saw significant progress in this field, and subsequently with the advent of solid state physics suitable detectors were developed. In the course of the writer's experience there was an opportunity to study the prospect of applying the technique of infra-red linescan, in recording features of archaeological interest from the aerial viewpoint. As a consequence it is considered that this form of enquiry has much to offer, and is worthy of further detailed investigation as equipment design is refined and becomes more readily available.

7.3 Infra-red Linescan.

In a natural environment, energy from the sun is absorbed by vegetation and objects on the ground, which in turn emit energy in the form of infra-red radiation, Fig.7.1 shows the wavelengths at peak radiation for given absolute temperatures, and it will be seen that the higher the temperature the greater the radiant emittance and the shorter the wavelength. This constitutes electromagnetic energy with comparable characteristics to those of radio waves and visible light. Although commonly referred to as 'radiant heat', it is not transferred by convection or conduction in a physical medium. Self-radiation from surface features at ambient temperatures only takes place at wavelengths longer than 3 um, and cannot be detected by photographic techniques using infra-red film.

The energy emitted from natural objects increases with wavelength, approaching a maximum in the region of 10 um, after which it slowly decreases. Within this spectrum there are constraints in the transmission of radiation because of its attenuation in the atmosphere, arising mainly from the presence of water vapour and carbon dioxide. There are other constituents in the environment which influence the loss of energy, but these are relatively unimportant in the context of aerial reconnaissance in archaeology.

Between 5.5 and 7.5 um the atmosphere is almost completely opaque, and this condition persists beyond 14 um, leaving two atmospheric 'windows' through which the airborne sensor can function; these lie between wavelengths of 3-5.5 um and 7.5-14 um, with most of the available energy contained in the latter bandwidth (Fig.7.2).

Within these limitations a thermal picture of the landscape can be achieved, the clarity or contrast being dependent upon the relative emissivity or radiation efficiency of adjacent surface features. The amount of infra-red radiation emitted will be determined by factors such as absolute temperature, surface texture, thermal capacity, composition and colour. Thermal imagery, as in conventional photography, is also subject to variations in environmental conditions as given by time of day, air temperature, wind velocity, precipitation, and seasonal variations, all of which have a profound effect on its use in landscape interpretation.

Before considering the possibilities of this medium for the detection of archaeological features in the landscape, some technical aspects require further elaboration. A brief outline of the technique involved in obtaining thermal imagery will be followed by a consideration of the nature of the imagery itself.

The conversion of infra-red radiation into a visual record may be achieved by a linescan system (Fig.7.3). In this method a thermal image of the landscape over which the aircraft is flying is built up by the successive scanning of parallel lines across the aircraft track.

The size of the scanning spot directly below the aircraft determines the linear resolution, which is the product of angular resolution and height. The angular resolution is the field of view of the detector through a focussing mirror. Obviously, to achieve a coherent picture the scanned lines must be contiguous. It follows that the spacing between the line centres is proportional to aircraft ground speed, while the line width is determined by the spot size, which will vary according to aircraft height. The minimum scan rate is therefore directly related to V/H, that is, velocity over height, and may be expressed as L=V/Ha where,

L = Linescan rate in lines per second.
V = Aircraft ground speed in ft per second.
H = Aircraft altitude in ft.
a = Instantaneous field of view in radians.

Essentially linescan comprises an optical system using a rotating mirror from which energy is focused on a detector device, this is generally mercury-doped germanium, maintained at a low temperature by a cryogenic system using liquid helium. The resultant signal, corresponding to changes of thermal input produced by the scanner, is electronically processed and used to modulate the beam of a cathode ray tube, which in turn is exposed to photographic film (Fig.7.3). Since each recurring line on the cathode ray tube is synchronized with the optical scanner and stays in the same place on the tube face, the image is produced by moving the film across the modulated time base at a rate proportional to the aircraft V/H. In this way the line spacing on the film is consistent with that on the ground given by the forward motion of the aircraft. The final product is a continuous thermal picture of the terrain along the aircraft track in which hot objects appear white and cold objects black on the photographic print.

Before an interpretation of some typical thermal photographs is attempted, it may be as well to consider the significance of the term emissivity. This is defined as the ability of a substance to absorb and subsequently emit energy in proportion to the total amount of energy incident upon it. To arrive at a numerical value, a theoretical object known as a black body is used. By definition such an object absorbs all incident radiation and emits the same amount; its emissivity factor can therefore be regarded as unity. On this basis, assuming the same absolute temperature, the emissivity factor of sand approximates to 0.95 and that of masonry and dry grass to 0.87. From this it is apparent that parching effects in pasture, for example, would register extremely well.

A further important factor is the total radiation emitted by an object and is known as radiometric temperature. Total radiation equals the emissivity times the absolute temperature to the 4th power, $Rt = ET^4(c)$, that is to say, doubling the temperature will increase total radiation 16 times. It is possible, however, to postulate a situation where adjacent features having different temperatures and emissivity factors could produce the same radiant emittance values at the detector with no signal contrast as a consequence. Two natural objects at the same physical temperature could not be resolved unless they exhibit different emissivity factors. In general terms, provided that there is a significant change in absolute temperature between two objects, with a 4th-power law they will stand out in marked contrast.

If these factors are now related to archaeological features, extant remains illuminated by the sun at low angles of incidence should produce strong thermal shadows with contrasting highlights arising from the difference in temperature.

Height, or the distance between the radiating object and infra-red detector, is also of significance in that, if height is increased by a multiple R, the intensity of radiation received would be decreased by I/R^2. In other words, increasing height by a factor of 2 would result in only one-quarter of the radiation being received at the detector. Taking this into consideration, together with limitations in sensor resolution and sensitivity, implies survey at low altitudes if crop-mark features are to be resolved and small differences of radiometric temperature recorded.

7.4. Results from Infra-red Linescan

There is no doubt that the technique of far infra-red offers advantages in air archaeology. It is particularly able to record variations in landscape profile, presented by substantial structures such as hill-forts, or the detailed pattern of banks and tracks. The features are enhanced by direct sunlight, although the conditions are not so critical as those required for shadow sites using conventional photography. Obscuration of surface remains by the effects of shadow is also considerably less, in that higher angles of incident illumination can be tolerated. There are of course disadvantages, rainfall will reduce variations in the surface temperature of natural objects to a more constant level, result in a loss of contrast, particularly under overcast conditions. From the point of view of interpretation, there is a natural tendency to compare a thermal map with an aerial photograph, but the similarity ends with the pictorial characteristics of the image. The tonal variations in an infra-red image represents entirely different information. With photography and radar the image is derived from variations in reflectivity of the elements on the ground, whereas a thermal map constitutes a pattern of energy radiated from the landscape due to temperature changes and emissivity distribution.

Initially a thermal map must be interpreted in terms of a mosaic of variable temperature, to be followed by converting the pattern into physical features of recognisable form, such as trees, roads, rivers, field boundaries or buildings. For example, green vegetation will be cool and appear as darker marks on the print, whereas roads, animals and buildings with a higher temperature potential show as strong lighter features. The grey areas inbetween the two extremes of temperature may or may not form a recognisable pattern, but they constitute a residual the detail of which may not necessarily appear on a conventional photograph. In some circumstances it is possible to relate these marks to a well known feature, for example the continuity of a ditch, bank or hedgerow subsequently destroyed and not visible in terms of soil marks or crop-marks, may be revealed through a subtle change in the temperature of the upper soil profile. Where remains of this nature are barely discernible through the medium of reflected light, they can be expected to be considerably enhanced in the far infra-red region.

There will be a marked difference in direct sunlight as the ground warms up faster, exceeding the air temperature. A feature may not necessarily appear as a result of direct energy from the sun, for surface temperatures can be influenced by features concealed under the surface vegetation. This is not to say that the application of the technique is to be considered as a substitute for the more conventional form of observing and recording archaeological features, as represented by the current techniques in air archaeology, but rather as supplementary data, in much the same way as false infra-red or multispectral photography, and is to be considered in conjunction with the results of conventional photography, either by direct instantaneous comparison or in isolation for specific purposes, in the interests of archaeological study and research.

Prior to the interpretation of a thermal presentation some limitations in the system are considered. Because the scanning mirror sweeps an angle on either side of the vertical, the image will have an inherent geometrical distortion across track, as if a true picture had been folded symmetrically round a cylinder with its axis in the direction of flight, and in the absence of rectilinear correction in the recording process the scale would be compressed at each edge. The scanning spot across the ground is also subject to distortion which in the oblique view increases relative to the centre or nadir resulting in a gradual loss of across track resolution which effectively limits the useful angle of scan to approximately 60° either side of the aircraft; the effect is similar to the distortion experienced in a fixed vertical spotlight when subjected to an in line angular motion. Stabilisation to correct for aircraft roll, pitch and yaw would also be necessary as required in the installation of a conventional vertical camera.

The signal received by a scanner will also follow Lambert's Law of Cosines, which states that the radiation received from a diffuse source will vary as the cosine of the angle between the line of sight and the normal. Ground resolution of course is important as a function of height, and is determined by the angular resolution of the system. The angle of resolution is defined as the angle subtended by two features which allows the features to be identified as two rather than one. In an infra-red linescan system the resolution is a function of the instantaneous field of view and is expressed in milliradians, if for example a system has an angular field of view of 2 milliradians, at a height of 500 ft above ground level the resolution would be 1 foot, doubling the height would give a resolution of 2 ft, and so on. In view of all the variables involved, the height band necessary to recover archaeological features with any degree of comprehension, is not dissimilar to that required in the use of conventional hand held cameras.

A representative selection of illustrations will serve to demonstrate the latent archaeological potential of this technique. The illustration in Fig.7.4 presents a vertical photograph of a landscape using a conventional camera, by comparison Fig.7.5 is an example of a thermal landscape as recorded by an infra-red linescan sensor. The tonal variations reveal the pattern of fields, hedgerows, roads and buildings in much the same way as in conventional photography, but the contrast in individual fields is substantially enhanced due to variations in vegetation and surface texture. An example is given in Fig.7.6 over a golf course, the lighter bands are hotter and represent the relatively short grass on the fairways, compared with the darker tone of the cool uncut surrounding grass; the darker diffuse patches are the effects from scattered cloud cover. The parallel lines represent an interference pattern, derived from the signal processing network, introducing a modulation effect.

The ability to reveal detail in an illuminated landscape is demonstrated in Fig.7.7 where tracks form an interlacing pattern. Under these conditions with the sun at a high elevation, the impacted ground presented by the tracks exhibits a higher temperature and is revealed as lighter tones. The darker lines are indicative of paths or tracks from cooler indentations in the ground profile. To record such features by conventional photography in terms of any slight changes in ground profile would require illumination by the sun at a very low angle of incidence; a further advantage of importance in an archaeological context is that the direction of the illumination is not a criteria, in resolving features with a variable aspect relative to the sun. Tonal variations in vegetation as represented by crop-marks, will also be revealed in the form of differences in temperature as given in Fig.7.8. In this illustration the cereal crop is at the differential ripening stage, the cooler unripe crop defines a ringed ditch surrounded by an outer ring in the light tone of ripe cereal and may be interpreted as the remains of a bank, in this instance the crop has ripened early due to its relatively poor development compared with that over the ditch; the lighter patches in the field are symptomatic of differential ripening, and the broad white band at the bottom of the image clearly indicates the high emissivity of a road surface. Damp marks will also respond very well exhibiting a lower temperature as shown in Fig.7.9, in which a pattern of field drains appear as darker lines in marked contrast with the surrounding thermal background.

On Idmiston Down in Wiltshire, Fig.7.10 shows an assembly of rings in pasture as presented by infra-red Linescan. This feature has been interpreted and illustrated in the form of a conventional photograph (Wilson, 1975(b);61). The smaller rings are indicative of round barrows of 'Wessex' type, but the two large rings are relatively modern structures, although the weather and lighting conditions are unknown the interpretation in infra-red is of interest. The two large concentric rings consist of a ditch revealed as a cooler darker tone, bounded on either side by a mixture of soil and chalk which exhibits a higher emissivity, appearing as lighter tones; a number of entrances are visible in both circles. The external smaller rings appear with good thermal contrast, and the two circles at A and B are identified by an inner ditch bounded by what appears to be a bank in lighter tones; continuity of the ditch as a darker tone in circle B is clearly evident under the vegetation which is growing over it. The remains at C are completely screened by vegetation, but the circle at D is defined by the darker tone of its surrounding ditch.
The outline of banks or lynchets appear in marked contrast when illuminated by the sun, as given Fig.7.11, the radiometric temperature on the slopes facing the sun is high, and the signal strength may also be enchanced where an oblique view is foreshortened by rising ground. Even

in the relatively cool shadows there is sufficient thermal contrast to reveal the outline of banks.

Variable textures are illustrated in Fig.7.12, the water in the canal down the centre of the image is very cold and appears as a black line; vegetation in the form of trees and hedgerows also exhibit good thermal contrast. The incidence of the illumination is sufficient to emphasise the variable texture in individual fields, but not low enough to induce intrusive shadow effects from the trees. The high emissivity of sheep at A shows in good contrast against the general background, it is also of interest to note the effects of a surface wind, revealed in the lighter warmer areas which appear in the lee of the trees at B. This is equivalent to the screening effect of shadows with the sun at a low angle of incidence, as in a conventional photograph, and is a similar disadvantage; obviously the extent and intensity of this form of thermal shadow will be a function of windspeed and direction.

The following illustrations will suffice to show the difference between conventional photography and far infra-red, when recorded simultaneously; Fig.7.13 is a normal photograph and may be compared with Fig.7.14 in infra-red, the lynchets at A are considerably enchanced in infra-red as are other landscape features, by thermal highlight and shadow. The field texture is important, the tonal variations in area B visible in infra-red are barely discernible on the photographic image. It will be appreciated however, that the resolution of infra-red Linescan imposes limits on reproducing the fine background structure visible on the photographic image.

7.5 A comparative analyses of Infra-Red and Photography

A comparison of information derived from the interpretation of infra-red imagery with that of photography over a site, each taken in different seasons, is still valid as would be the case with two photographs; the content of course may be different in the site detail. The following illustrations will serve as an example, the site in question is a static feature in that the area is a scheduled monument and therefore unaffected by any change in surrounding land use. A normal photograph of a group of barrows on Normanton Down in Wiltshire is given at Fig.7.15, and taken in overcast weather conditions in a late summer. During a subsequent season, the same group was recorded in infra-red as shown in Fig.7.16 under conditions of scattered cloud cover with bright periods, in an early summer; because only thermal highlights and shadows are visible, indicates that illumination by the sun is at a high angle of incidence. Overall, the outline of the features is substantially the same as one would expect, but there are significant differences in detail between the infra-red image and the photograph. The general configuration was confirmed during a visit to the area in early August 1990, when the weather was dry and the grasses were high. All the individual barrows were examined, and there appeared to be no interference from subsequent cultivation in the surrounding area.

For ease of reference and interpretation the individual barrow sites are numbered on a sketch plan at Fig.7.17; in the text, (I) refers to the infra-red image (Fig.7.16), (P) to the photograph (Fig.7.15), and (G) to the findings from observation on the ground.

Site 1

I. The remains of a ringed ditch appear as a darker tone.

P. Site only partially covered but not identified.

G. Nothing visible in ground profile.

Site 2

I. Shows the existence of a mound and possible ringed ditch.

P. Site appears as a dark circular patch.

G. Very shallow mound and associated ditch.

Site 3

I. Mound revealed in thermal highlight and shadow.

P. Mound visible.

G. Height of mound at least 10ft.

Site 4,5 & 6

I. Slight indication for a mound, surrounding ditch well defined as a darker tone and warm highlight on outer face of the ditch.

P. No indication for a mound, an outer ring in lighter tone suggests a ditch.

G. Very shallow mound, no more than 2ft, ditch identified in lighter tall grasses.

Site 7

I. Thermal pattern defines a mound.

P. Irregular light patch.

G. Mound approximately 6ft, no evidence for a ditch.

Site 8

I. Area diffuse, but tonal variation suggests a barrow site.

P. Irregular tonal pattern, diffuse.

G. Slight change in profile to approximately 2ft, surface very uneven, probably the remains of a barrow.

Site 9

I Central mound visible surrounded by an inclined berm with an outer ditch, the face appears in lighter tone. A depression on top of the mound indicates the remains of excavation.

P. Mound and berm visible, with remains of a ditch in a lighter tone. Depression appears as darker tone of vegetation.

G. Remains of a Bell barrow with central mound standing at least 12ft, the surrounding berm was flat with a sloping outer face. The centre depression is well defined in profile and darker green vegetation. The outer face of the berm and ditch covered with light tall grasses.

Site 10 & 11

I. Shows two barrow mounds enclosed by an oval in lighter tone, with evidence for a disturbance on each mound.

P. The two barrows are visible, but the outer enclosure is indistinct, the indications for an excavation on each mound are diffuse.

G. The mounds are prominent, and the vegetation in the hollows on top of each mound is a darker green. The area round each barrow is flat with no evidence for individual ditches, both mounds were enclosed within an oval ditch with slight evidence for an outer bank.

Site 12

I. Thermal discrimination in highlight and shadow indicates a small mound.

P. Merely records an area of vegetation.

G. Revealed a very shallow grassy mound with no evidence for a ditch.

Site 13

I. A flat area circumscribed by a ditch and outer bank. There are tonal variations within the enclosed area with no evidence for a mound.

P. A circular feature indeterminate in terms of a ditch and bank.

G. The ditch and outer bank of a Disc barrow are well in evidence, the enclosed area is flat with variable vegetation.

Site 14

I. Pronounced mound with depressions from excavation and dark spots of cooler vegetation. There is also evidence for an outer ditch in lighter tone.

P. A mound is visible with a scatter of darker vegetation. There is partial evidence for an outer ditch.

G. The mound and associated ditch are well defined in the tall grasses, with a shallow depression on top of the mound. There were one or two patches of dark green vegetation.

Site 15

I. Evidence for a small barrow with a short section of ditch. There are also three small dark circles in the vicinity, which represents green vegetation round the base of a small tree or bush.

P. The feature is diffuse and of doubtful shape, there is a scatter of small dark spots in the vicinity indicative of darker green vegetation.

G. Circular feature with very shallow mound, a short section of ditch was traced with a slope on the outer face suggesting a bank. There was no apparent change in the colour of vegetation in the vicinity.

Site 16

I. Very prominent mound and associated ditch, a dark spot on the mound suggests green vegetation, possibly associated with a depression.

P. The mound is visible with a section of an outer ditch, dark spots can be seen on the mound.

G. A distinctive mound with small trees growing in shallow depressions. there was evidence for an outer ditch with what appeared to be a narrow berm round the mound.

Site 17

I. A small mound with centre depression, and the remains of an outer ditch.

P. Indicates a mound with an outer ditch in lighter tone.

G. The profile of the mound and ditch can be seen, with the remains of an excavation on top of the mound.

Site 18

I. Substantial mound and evidence for a ditch, dots indicate green vegetation. Thermal highlight and shadow suggest a shallow depression on the mound.

P. The mound is visible, darker patches show vegetation other than grasses.

G. Mound and associated ditch visible, with a scatter of small trees or shrubs, a depression on the centre of the mound was confirmed.

Site 19

I. Presence of a mound revealed in thermal highlight and shadow, with evidence for an outer ditch.

P. A dark circular patch indicates a barrow site.

G. The mound stands to a height of approximately 8ft, with a scatter of small trees. A surrounding ditch was observed in shallow profile.

Site 20

I. Small mound and remains of a ditch, dark spot represents green vegetation and a depression.

P. Area diffuse with a spread of darker vegetation.

G. Small mound, ditch profile diffuse in tall grasses, depression observed on the mound with a scatter of green nettles.

Site 21

I. Mound with depression on top, and evidence for an associated ditch in dark outline.

P. Comments as for I, but the depression is less well defined due to the presence of vegetation.

G. Mound standing to 6ft, surrounding ditch visible in profile, depression in the centre of the mound covered with nettles.

Site 22

I. Substantial mound, with darker patches of vegetation and a depression visible in marked contrast. A section of an outer ditch is identified.

P. Comment as for I but no evidence for an outer ditch.

G. Small trees were growing on the mound and the depression at the centre exhibited a well defined profile.

Site 23 & 24

I. No mound, an outer ditch and bank well defined in thermal contrast, with a few dark circles in the centre area denoting green vegetation.

P. Ditch and bank can be traced, with variable vegetation in the enclosed area.

G. Remains of Disc barrows, bank and ditch well defined. The bank was covered with dry tufted grass and approximately 8ft wide, the inner ditch was of the same dimension and contained darker green vegetation. The central area contained a scatter of bushes which are identified with the small dark rings, there was no evidence for an internal mound.

Site 25

I. Substantial mound and berm with an outer ditch in lighter tone.

P. Features in infra-red image confirmed, the outer ditch appears as a darker tone and a depression is visible on top of the mound.

G. The features were confirmed on the ground as the remains of a Bell barrow with a dominant mound and an inclined berm. The site is contained and protected in pasture. The contrast in infra-red is insufficient to identify the centre depression.

Site 26

I. Adjacent to Site 25 is the faint outline of another barrow ditch.

P. Not visible as a mark in this particular crop.

G. No surface profile or any other indication for its existence. The grass area around Site 25 is not resolved and it is possible that the remainder of the field was down to pasture in the infra-red image.

In the illustrations the ditch round the barrows is enhanced in lighter tone, on the photograph the effect is due to lighter grasses, whereas on the infra-red image the illuminated side of a ditch is warmer than the centre. Although in some examples from infra-red, continuity of a ditch is evident as a deeper, cooler response, in the case of the Disc barrows the side of the ditch is integrated with the lighter response over the outer bank, giving a false impression of the width of the ditch and that of the bank. There are other features of interest, in the photograph (Fig.7.15) the farm track at A has subsequently been realigned and the remains are visible as a crop-mark at B on the infra-red image (Fig.7.16), a ringed ditch can also be seen at C. From a ground inspection, there are no variations in land profile or vegetation for the existence of either feature. The depressions on the mounds are the remains of excavation, in the 19th century Sir Colt-Hore investigated the barrows only to find someone had been there before him, a visit attributed to Stukeley in the 17th century.

7.6 Conclusions

a) In terms of air archaeology the application of far infra-red techniques has much to commend it, and the contribution in Geology has been recognised in a paper by L H Lattman of Pennsylvania University. Its viability in other fields of enquiry has already been proved particularly in the interests of energy conservation, by identifying the source of heat loss in dwellings and industry. It has also proved of value in determining the extent of Dutch Elm disease in trees through variations in temperature. Although the interpretation of archaeological features in thermal imagery is valid in isolation, its unique contribution is more apparent when compared with conventional photography.

b) Apart from the obvious advantages in the recording of surface remains, the variations in soil, damp marks and crop-marks respond equally well. It is particularly relevant in the recovery of impermeable remains concealed from view under bracken or similar vegetation, and not visible in photography, but revealed through variations in temperature. Without doubt the technique has a contribution to make, and the prospect of applying far infra-red in air archaeology has yet to be fully investigated and understood.

CHAPTER 8

SOILS AND CROP-MARK DISTRIBUTION IN THE VALLEY OF THE RIVER SEVERN AND ITS WATERSHED

8.1 Topography

Prior to consideration of the various soil types and associated crop-mark distribution, an appreciation of the area topography would be relevant. The river Severn is a dominant feature in the West Midlands, and constitutes the longest river in the British Isles. Its course extends approximately 180 miles from its source in the Welsh mountains, to the confluence with the Warwickshire Avon at Tewkesbury from which it continues south to the estuary at Gloucester. The Severn has its origins at Blaenhafran in the Welsh mountain range of Pumlumon Fawr, rising to a height of over 2400 ft. Initially the river flows East, through valleys flanked on either side by high ground, to Llanidloes from whence it flows northeast to Caersws, Newtown and Welshpool. Over this distance of the order of 40 miles from its source, the flow is substantially increased by tributaries draining the high ground along its course.

It is the area from Forden, south of Welshpool to the confluence with the Warwickshire Avon that is the subject of aerial reconnaissance by the writer, and is delineated by four principle areas of interest, A, B, C and D, as given in Fig.8.1(a). At Llandrinio eight miles northeast from Welshpool, the river turns in an easterly direction into the open Shropshire plain. At this point it is joined by the river Vyrnwy, a substantial tributary with its watershed in the Welsh highlands to the west. The river continues in gentle meanders east to the town of Shrewsbury, where the flow changes direction to the southeast toward Telford and the Ironbridge gorge. Across the Shropshire plain it is joined by the tributaries of the river Perry and the Tern which drain the landscape to the north. From Ironbridge the course of the river changes direction abruptly to the south.

This is an unusual diversion, and has its origins in the glacial era, previously its course from Llandrinio would have been maintained in a northeasterly direction to ultimately form a tributary of the ancestral river Trent. It is generally accepted that the original course of the river was diverted by glacier ice, but insufficient is known concerning the details, particularly whether or not an ice dammed lake existed on the Shropshire plain, (Dury, 1986;225). It is perhaps difficult to imagine the form and inexorable movement of an ice cap over the land, and an example is shown in Fig. 8.1(b). Glaciers would also exist in the Welsh mountain regions, to produce a landscape similar to that given in Fig.8.1(c). These features were recorded by the writer in the arctic over Ward Hunt Island. It is as well not to underestimate the power of the ice, and its influence on the natural landscape in the Severn valley.

The course of the river to the south (Fig.8.1(a)) maintains its flow through a relatively narrow valley to the point where it is joined by the river Stour at Stourport, draining an area of the Birmingham plateau to the northeast. The flow continues south to the city of Worcester, where it is joined by the river Salwarpe which has its source on the midland plain to the northeast. South of the city is the confluence with the river Teme, this is an important tributary draining an area of the Welsh Marches and the uplands of Wales to the west, and encompassed by the igneous outcrop of the Clee hills to the north and the Pre-cumbrian sandstone, siltstone and conglomerate of the Long Mynd to the northwest. From Worcester the Severn continues in more gentle meanders through a wide plain to its confluence with the

Warwickshire Avon at Tewkesbury, subsequently terminating in a tidal estuary at Gloucester.

From the Shropshire plain to its confluence with the Warwickshire Avon, the Severn constitutes a demarcation line between the relatively flat land to the north and east and a more variable landscape to the south and west. To the north and east of this line, in the area of interest, the contours lie below 500 ft, apart from isolated outcrops, the most significant being the igneous intrusion of the Wrekin rising to more that 1000 ft west of Telford. The geology is mainly Triassic and Permian rock formations with significant areas of sandstone. The whole region is littered with glacial debris, the importance of which lies not so much in its geological form and content, but in its geographical distribution. To the south and west the landforms become more variable with considerable areas above the 500 ft contour, consisting of complex strata, which apart from the igneous and other outcrops above 1000 ft is interspersed with glacial till or boulder clay, together with mudstone, shale, siltstone and limestone formations.

8.2 Soil characteristics

Pending considered comment relating to crop-mark sites, it would be appropriate to outline the characteristics of the various soil types associated with the Severn valley and its watershed. The classifications are derived from the Legend of the Soil Survey of England and Wales, and apply to the 1:250,000 scale Soil Survey map of Midland and Western England. The information is intended to form the basis for subsequent discussion relating to crop-mark distribution, as presented in section 8.3. The variations in soil status are detailed and complex, but for the purpose of this presentation a general description of the principal constituents will suffice. The comments are concerned with the characteristics of the soil profile from ground level down to approximately 1.5 metres, comprising several layers or soil horizons of sufficient depth to accommodate the rooting system of cereals and root crops. In the Legend, soils are divided into distinct types with sub-groups, these in turn are separated into various categories in terms of geology, soil and site characteristics. To simplify the structure, only the relevant sub-groups and the number of associated crop-mark sites are listed as follows.

8.2.1 Soil sub-groups

Associated with the various soil types the term Argillic refers to a clay enriched subsoil, and Stagnogley a mottled slowly permeable subsoil.

Series		Soil characteristics
411	-	Typical Calcareous Pelosols. Slowly permeable clayey soils with a calcareous subsoil horizon and no clay enriched subsoil. (Crop-mark sites, Nil).
431	-	Argillic Pelosols. Have a clay enriched subsoil, slowly permeable. (Crop-mark sites, 1).
541	-	Typical Brown Earths. Non-alluvial loamy soils with a non-calcareous subsoil without significant clay enrichment, well drained. (Crop-mark sites, 100).
551	-	Typical Brown Sands. Non-calcareous sandy soils, deep and well drained. (Crop-mark sites, 59).

561 - Typical Brown Alluvial Soils.

Deep stoneless permeable loamy or clayey soils with a non-calcareous subsurface horizon developed in alluvium. On flat land, variably affected by groundwater. Poorly drained. (Crop-mark sites, 3).

562 - Gleyic Brown Alluvial Soils.

Deep stoneless soils with a mottled permeable subsoil, poorly drained and variably affected by groundwater. (Crop-mark sites, Nil).

571 - Typical Argillic Brown Earths.

Loamy or loamy over clayey soils with a subsurface horizon showing significant clay enrichment. Well drained. (Crop-mark sites, 14).

571(A)- Brown Earths.

Well drained, fine silty and fine loamy soils locally over gravel. Some fine silty over clayey soils with slowly permeable subsoils and seasonal waterlogging, and some slowly permeable seasonally waterlogged fine silty over clayey soils. (Crop-mark sites, 33).

572 - Stagnogleyic Argillic Brown Earths.

Fine silty and/or fine loamy soils with slowly permeable subsoils, in some instances slight seasonal waterlogging. (Crop-mark sites, 57).

611 - Typical Brown Podzolic Soils.

Well drained loamy soils over rock, on high ground or steep slopes. (Crop-mark sites, Nil).

631 - <u>Humo-ferric Podzols</u>.
Dark coloured humus and iron enriched subsoil. Over sandstone, well drained sandy soils commonly with a bleached subsurface horizon. Very acid where uncultivated. (Crop-mark sites, Nil).

711 - <u>Typical Stagnogley Soils</u>.
Slowly permeable seasonally waterlogged soils, with a clay enriched subsoil. (Crop-mark sites, 60).

711(a)- <u>Stagnogley Soils</u>.
Slowly permeable seasonally waterlogged, often stoneless fine silty or fine silty over clayey soils on rock. (Crop-mark sites, Nil).

713 - <u>Cambic Stagnogley Soils</u>.
Slowly permeable seasonally waterlogged fine loamy or silty soils, with no clay enriched subsoil. (Crop-mark sites, 7).

714 - <u>Paleo - Stagnogley Soils</u>.
Slowly permeable seasonally waterlogged fine silty or loamy soils over clay. (Crop-mark sites, Nil).

811) - <u>Ground Water Gley Soils</u>.
813) These are soils, normally developed within or
821) over permeable materials, that have prominently
831) mottled or uniformly grey subsoils resulting from
periodic waterlogging by a fluctuating groundwater-table.
(811, Crop-mark sites, 4).
(813, Crop-mark sites, 2).

In addition to the characteristics, the depth of soil will also vary considerably with the geological structure and influence the appearance of crop-mark features accordingly.

8.3 Soils and crop-mark distribution.

To simplify the presentation, the areas of interest given in Fig.8.1(a) have been mapped individually as delineated in Fig.8.2(a). The division is convenient in terms of soils and crop-mark distribution, and will include the sand and gravel deposits associated with the various river terraces; the argument in this section is not concerned at this stage with the type of crop-mark in an archaeological context, which may or may not have a bearing on its location in the landscape, for the distribution is complex in that the soils, and associated geology derive from glacial debris, rock strata and the remains of river terraces.

A plot of the drift geology in the West Midlands is given in Fig.8.2(b), and includes the course of the Severn from Telford to the confluence with the Warwickshire Avon. It will be seen that the river terrace deposits between Telford and the river Stour are negligible except for a small area in the vicinity of Bridgnorth. Along the valley of the Stour and to the north, the lighter permeable soils are well scattered. South from the confluence of the Stour to the Warwickshire Avon, the sands and gravels associated with the Severn become more extensive, particularly in the area of Worcester and to the south. This distribution compares favourably with the substantial deposits in the valley of the Warwickshire Avon. The final course of the river Teme to the west has little to offer in this respect, but the terraces of the river Salwarpe north of Worcester are more substantial by comparison.

It is significant that the various soil types in this area extend to the northeast in a wide band, associated with the course of the Warwickshire Avon. Their origins derive from the period of the last but one glacial maximum, prior to this event the Avon did not exist and the area drained to the northeast. The onset of ice from the northern areas produced lake Harrison, dammed by the cotswold range and drained through various gaps to the southeast. The lake eventually filled with outwash and till and subsequently covered completely with ice. When the ice melted from the south due to the advent of warmer air, the drainage pattern was reversed creating the Warwickshire Avon, (Dury, 1986;192). The clay enriched soils and subsoils over the area are poorly drained, and from the writer's reconnaissance in the valley of the Avon the crop-marks of settlement sites were mainly concentrated over glaciofluvial or river drift, (Webster & Hobley, 1965), Aerial Reconnaissance over the Warwickshire Avon. The findings are relevant to the text in 8.3.1 dealing with the lower Severn.

In the following assessment of crop-mark distribution, the various soil sub-groups associated with the Severn valley are also sub-divided in terms of geology and subsoils and will be subject to comment where relevant. The analyses relating to the distribution of crop-mark sites and associated soils, are given in some detail, in order to gain an understanding of the conditions under which the marks appear.

8.3.1 Crop-mark distribution - Worcester - Tewkesbury.

The soil-types and associated crop-mark sites in the area are shown in Fig.8.3(a). Firstly, attention is drawn to the areas external to those delineated round Worcester and Kempsey. To the far west is a band of Brown soils (571(b)) on an undulating landscape, well drained over a geology comprising shale, siltstone and sandstone, only five sites were recorded in this area. It is noteworthy that soils of this type are capable of supporting deciduous woodland although most of the land is now under cultivation. Apart from the igneous outcrop of the Malvern hills (611), the land to the east forms part of the midland plain and consists of surface water gley soils (711, a, b & c), slowly permeable over variable geology comprising mudstone, shale and till, integrated with areas of Brown earths (572 (f)) poorly drained with slowly permeable subsoils consisting of drift over mudstone. To the east of the river the soil distribution comprises the sub-groups directly associated with the valley of the Warwickshire Avon, slowly permeable over Jurassic and Cretaceous clay (411) and mudstone (431). Only a scatter of crop-mark sites were recorded over the area, apart from a small group south of the Malvern range on well drained loams over sandstone (551(a)), and well drained coarse loams over sandstone and siltstone (541(b)). The soils between the Malvern range and the Severn are devoid of crop-marks and consist primarily of series 711(b), seasonally waterlogged loams over clayey soils with a geology of mudstone and till; the area also exhibits pockets of 811 (a & e), river alluvium and marine alluvium respectively on flat land affected by ground water.

Associated with the course of the Severn in the vicinity of Worcester and Kempsey is a very different pattern of well drained soils over glaciofluvial or river terrace drift (541(r)) where the crop-mark distribution is relatively dense. To the north of Worcester is a considerable area of similar soils on both sides of the river, mainly over soft sandstone (541(b)) with a scatter of sites on the east bank. Sedimentary rocks such as clays or shales are impermeable, but sandstones are variably permeable depending on the cementation or pore space. South of Kempsey to the confluence of the Avon, soils of the type 541(r) are present on both sides of the river and two sites were recorded on the east bank. Reference to Fig.8.3(b) illustrates more clearly the discrete areas of drift geology derived from survey maps associated with the lower Severn, locally over gravel, representing well drained soils where the evidence for settlement in the form of crop-marks is undeniable. Nevertheless, there is in addition a significant distribution of crop-mark sites which appear on manageable, but less permeable soils and geology.

It is possible with larger scale maps to be more precise in defining the areas of various soil sub-groups, allowing improved accuracy in plotting crop-mark sites. Unfortunately, maps to a scale of 1:50,000 were only available over limited areas, but they do provide information on discrete pockets of soils not readily appreciated on a smaller scale of 1:250,000. The area associated with Kempsey is plotted to a scale of 1:50,000 as given in Fig.8.4 and the difference in the detailed distribution of the various soil types is obvious, the areas of amenable soils being more clearly defined. A comparison of the sites plotted on Fig.8.4 with those of the corresponding area in Fig.8.3(a) show good agreement, apart from two sites northeast of the river where there is a small discrepancy, due in all probability to the obvious difficulty in defining a precise point on a scale of 1:250,000.

The area of Grimley in the vicinity of Worcester has also been plotted to a 1:50,000 scale (Fig.8.5), the detail of the various soil series is clearly evident when compared with the equivalent area given in Fig.8.3(a). Variations can been seen, for example in the area east of the Severn (Fig.8.5) comprising soil type 541(b) and 572, the distribution is more detailed as would be expected. However both types appear under the general heading of Brown soils, the former comprise well drained loamy soils without clay enrichment, and the latter (572) are loamy soils with a subsurface horizon showing significant clay enrichment. As in Fig.8.4 the larger scale allows a more accurate plot of the crop-mark sites to be achieved, relative to the associated soil type. As a final comment, it is evident from Fig.8.3(a) that between Worcester and the confluence with the Warwickshire Avon, the flood plain of the Severn is well developed, with deposits of alluvium over a mile wide. This area of deep stoneless reddish fine silty clayey soil is prone to flooding with no evidence for crop-mark sites.

8.3.2 Crop-mark distribution - Telford - Bridgnorth - Kidderminster

The crop-mark distribution in the area as presented in Fig.8.6(a) is well scattered, and appears mainly over the midland plain to the north and east of the Severn. The sites are predominantly associated with a geology comprising glaciofluvial drift, till or boulder clay and sandstone. The soil types are on the whole quite distinct from those given in Fig.8.3(a). There is an additional feature of interest in that, along the course of the Severn from Telford to Stourport and Kidderminster the river flows through a relatively narrow valley, with no flood plain of any significance, as a consequence there is an absence of river alluvial and the flow exhibits no meanders of any consequence. The main tributary to the south is the river Stour which drains an area to the northeast, and joins the Severn at Stourport to the south of Kidderminster. From this confluence there is an area of the soil series 541(b) extending to the northeast from Worcester, comprising well drained course loamy soils over sandstone and siltstone; no crop-marks were observed in the area.

Along the course of the Stour to the north is a wide band of soil series 551 subdivided into categories (a) and (g), the former consisting of well drained sands and coarse loamy soils over soft sandstone, the latter (g) are deep and well drained sandy soils over glaciofluvial drift. It is in conjunction with the series 551(a) that the largest number of crop-mark features were observed and recorded, although a limited number appeared over the series 551(g). Associated with the Stour is a very narrow band of alluvium which is of little importance and has not been plotted.

In the vicinity of Bridgnorth the Severn is joined by the river Worfe, a minor tributary draining an area to the north. Associated with its course is an area of soil series 551(a & d) extending as far north as Telford. In this instance (d) consists of well drained sandy loamy soils over glaciofluvial drift. Crop-mark sites are distributed on these soils mainly to the east of Bridgnorth, together with a scatter to the south on soils 572(c) and 541(r). The 572(c) series comprises fine and course loams with slowly permeable subsoils over mudstone, siltstone or sandstone. Interspersed with this distribution are areas of series 572(m), comprising deep loamy soils with slowly permeable subsoils over till and glaciofluvial drift with a scatter of crop-marks.

Between the two tributaries and to the north is an extensive area of variable soils consisting of series 572(c), 541(b) and 711(n) on which only isolated sites appear, of these only 541(b) consists of well drained loamy soils, in this instance over sandstone. In the area to the northeast the series 711(n) is predominant, poorly drained over reddish till, only a few crop-mark sites were observed on these soils. To the west of the Severn the main soil series is 571(b) devoid of crop-marks, and for the most part above the 500 ft contour, the soil is well drained over variable geology consisting of shale, siltstone and sandstone. Between this area and the Severn is a band of soils 541(g), well drained course loamy soils over rock (sandstone and shale). On this soil type only one site was recorded. It is perhaps of some significance that both soil types are capable of supporting coniferous and deciduous woodland, and the Wyre forest is well in evidence in the area today on the series 541(g). There remains however a small group of sites to the West, contained within a narrow band of series 551(d) associated with the course of the Mor brook, the soils are deep well drained coarse sands and loams over glaciofluvial drift. To the south are isolated patterns of series 713(a), a sterile area of slowly permeable seasonally waterlogged loams over clayey soils, over soft rock, (Carboniferous mudstone with interbedded sandstone). A plot of the known drift geology of the area is given in Fig.8.6(b), and by comparison clearly indicates a wide spread of crop-mark sites not associated with the areas of lighter permeable soils as defined by the recorded drift geology.

8.3.3 Crop-mark distribution - Shrewsbury - Craven Arms - Leintwardine - Ludlow.

The soils and geology may conveniently be divided into two areas (Fig.8.7(a)), that is, either side of a line, defined by the outcrop of Wenlock Edge, consisting of a band of silurian limestone aligned from Telford to the river Wye. The area to the west of Wenlock Edge is dominated by outcrops of series 611 (a,c & e) comprising igneous, palaeozoic and pre-cambrian rocks respectively; the soils are relatively shallow well drained loams, which are naturally derived on high ground not covered by the ice. The outline of field systems and other features which appear on this series comprise surface remains. In the area to the northwest of Wenlock Edge the soils are mainly of the 711 (a, q & n) series, all of which have similar characteristics namely slowly permeable, seasonally waterlogged loams over variable geology. In the vicinity of the high ground are areas of series 541(1) well drained silty soils, shallow in places, over siltstone, there are no crop-marks associated with this series. In the 711 (a, q & n) series, (a) lies over shale, mudstone and siltstone, (q) are fine loamy soils over clay with a geology comprising till from palaeozoic rocks, both of these variants show no crop-marks of any significance. The majority of sites appear over the series (n), fine and coarse loamy soils over reddish till, with a wide distribution in the area to the south of the Severn between Shrewsbury and Telford. To the west over areas associated with the Rae brook the prevailing series is 711(q). South of Shrewsbury is an area of soil series 541(r) in the valley of the Cound brook, consisting of deep well drained coarse loams and sandy soils over a geology of glaciofluvial or river terrace drift, the paucity of crop-marks over these soils is surprising.

Associated with the valley of the middle Severn west from Telford are areas of series 541 (r & u), compared with (r), the characteristics of (u) comprise very stoney well drained loamy soils over glaciofluvial drift, on this series the crop-mark distribution is scattered and mainly concentrated over the series (r). To the north the density of sites associated with the course of the Tern and the Roden is substantial, and appear on the series 551 (d), deep well drained sandy and coarse loams over glaciofluvial drift and 572(m), deep loamy soils with slowly permeable subsoils on reddish till and glaciofluvial drift. West and east of this band of soils crop-marks appear on the series 711 (m & n), both notations lie on a geology of reddish till but (m) denotes a clayey subsoil. To the northwest of Shrewsbury is a small pocket of series 572(m), with a group of crop-marks.

To the west of the town and south of the Rae brook is a considerable area of series 711(q) with only isolated evidence for settlement. North of the Severn there are significant areas of amenable soils 551(d) and 541(u) with a scatter of crop-mark sites. Along the course of the Severn to the northwest is a wide band of barren soil series 811(b), consisting of deep stoneless fine silty and clayey soils on flat land variably affected by groundwater and flooding. It is of interest to compare the crop-mark distribution in Fig.8.7(a) with a plot of the known drift geology presented in Fig.8.7(b), clearly there is a significant number of crop-mark sites which appear on soils other than those delineated by river terrace sands and gravels.

Along Wenlock Edge, apart from a cluster of sites over series 541(i), consisting of well drained coarse silty soils over siltstone, there is only one site over 572(a) associated with well drained fine loamy soils over limestone, the area to the southeast is as yet unresponsive; with its course parallel to Wenlock Edge the river Corve cuts through an area of series 572(b) in the upper reaches, poorly drained silty soils over shale and siltstone, and 561(d) along its lower course, deep permeable fine silty soils over river alluvium. The two types are distributed within a band of 571(b), well drained fine silty soils over shale and siltstone; the whole area is devoid of crop-marks except over series 571(p) to the south, deep well drained loams over reddish till which yielded two sites and 561(d) one site. Between the Corve and the Ledwyche Brook is a limited area of 541 (f & c), well drained loams predominently over sandstone which may offer better prospects. The soil types associated with the Corve apply also to the Ledwyche. Further to the southeast are the igneous outcrops of the Clee hills surrounded by variable geology, to a large extent comprising the series 571(p & b). Generally the 571 series appears under the heading of brown soils. The characteristics of suffix (p) consist of deep well drained coarse loamy soils over reddish till, giving rise to slowly permeable subsoils. The variant (b) exhibits well drained reddish fine silty soils over shale, siltstone, and sandstone with slowly permeable subsoils. These soils appear devoid of crop-marks, the contours over the area indicate a variable landscape and it is noteworthy that the series 571(b) will support deciduous woodland.

The situation to the south shows a considerable improvement in the Ludlow/Bromfield area which encompasses the confluence of two tributaries, the Onny and the Corve with the river Teme. A number of crop-mark sites in the area appear over series 571(A), well drained fine silty and fine loamy soils over glaciofluvial drift or river terrace gravel. There is also a scatter of sites to the south of Ludlow over the same series. The soil types are more detailed when plotted on a scale of 1:63,360 (Fig.8.8) where the areas of 571(A) are now more discrete. Southwest of Ludlow is an extensive area of series 541(i) covered with woodland.

To the west of Ludlow the river Clun joins the Teme in the area of Leintwardine (Fig.8.7(a)). The crop-marks are mainly concentrated to the west of the area on soil series 571(A), with a small group on 572(a) and two sites to the south on river alluvium which is very unusual. A plot of the area to a larger scale 1:63,360 is given in Fig.8.9, which details the areas of 571(A) together with the associated crop-mark distribution. At this scale it is easier to appreciate the complexity of the various soil patterns, particularly to the south of the river Teme, for example the small group of sites on series 572(a), (Fig.8.7(a)) are now resolved. It is clear that there are still considerable areas of series 571(A) which may eventually yield more evidence. The deposits of river alluvium (811(b)) are still devoid of crop-marks as in the general case on similar soils elsewhere. To the northwest however is an expanse of series 541(i), well drained brown silty soils over a geology of siltstone comprising undulating ground with steep slopes and small areas of woodland, with a scatter of crop-marks.

Following the river Clun to the north of Leintwardine is the area of Craven Arms associated with the valley of the river Onny (Fig.8.7(a)). A pattern of crop-marks were recorded on two principal soil series, 571(A) and to the north on series 711(q), the former well drained argillic brown earths over glaciofluvial or river terrace gravel, and the latter slowly permeable seasonally waterlogged silty and clayey soils over till. On a larger scale plot 1:63,360 (Fig.8.10) the soil patterns are again revealed in more detail, and it can be seen that the series 571(A) is more fragmented and a number of the sites appear over an area of undifferentiated alluvial soils. There are also significant areas of series 541(i), well drained silty soils over siltstone for the most part devoid of crop-marks.

8.3.4 Crop-mark distribution - Oswestry - Llanymynech - Forden.

The soil distribution in the area as given in Fig.8.11 is very different to that of Shrewsbury and Telford. At the confluence of the river Vyrnwy with the Severn are significant areas of series 811, river alluvium, in the valley of the Severn this consists of 811(b) but along the Vyrnwy tributary the predominate series is 561(b), deep stoneless permeable silty soils with a gravel subsoil in places, although liable to flooding it is more productive in terms of crop-mark sites than 811(b). To the north of the Severn crop-marks are variably scattered over 541 (r, u, x, z & h). The series constitutes well drained brown soils over variable geology; (r) glaciofluvial, (u) glaciofluvial very stoney soils, (x) drift over sandstone and shale, (z) drift over limestone and (h) soils over rock consisting of sandstone and shale, no sites were recorded over this particular variant. A limited distribution of series 711 (n & m) associated with the valley of the river Perry also shows no evidence of crop-marks. There is however, one other important soil series over which sites appear, that is 551(a, b & d) well drained sandy soils (a & b) over sandstone, and (d) over glaciofluvial drift.

South of the Vyrnwy in the valley of the Severn is a scatter of crop-mark sites over series 541 (j), well drained soils over mudstone and siltstone, 541 (1) variably drained soils over siltstone and series 713(d) for the most part slowly permeable seasonally waterlogged soils over a geology of slaty mudstone and siltstone. In this area the series 711(a & q) appear to be barren except for one crop-mark over type (a), these soils are slowly permeable over siltstone, shale and mudstone. Along the course of the Severn are substantial areas of series 811(b), wet and inhospitable soils exhibiting no crop-marks except for a small group to the southwest at Forden Gaer.

8.4 Conclusions

a) Before considering the nature of the crop-mark evidence as presented in the following chapter, it was necessary to examine the soils of the Severn valley in some detail. Not only to put the problem of aerial reconnaissance into perspective, but to evaluate the potential of the area in terms of past cultures and determine the future prospects. An overall plot of the crop-mark distribution is given in Fig.8.12 and suggests that the sites are concentrated on the river terraces associated with the Severn and its tributaries, similar to the findings by the writer in the valley of the Warwickshire Avon and the upper Thames. Plotting the crop-mark distribution in terms of area topography as given in Fig.8.13, tends to support this, in that the majority of the sites appear on land below the 500 ft contour. There is however, a sufficient spread of evidence to indicate settlement over a more extensive area on less amenable soils, derived from glacial drift and outwash. Glacial drift is important in terms of settlement and may be conveniently classified as follows, Glacial - sand, gravel and boulder clay (till), Post Glacial - peat, alluvium and river terraces. In addition there are the remains of older river gravels.

b) In the event there are five other primary variables which influenced the distribution pattern; the reconnaissance objectives, the area covered, the frequency of coverage, seasonal weather variations and aircraft endurance to which may be added the opportunity to fly. Of these perhaps the most important would be the weather variations and the opportunity to fly, for in the rare occurrence of an acute drought there is a choice, either to cover the lighter well drained soils over the river terraces in order to record any additional detail on known sites, which may be relevant to their interpretation or to explore areas of less productive soils for new evidence. The shortcomings in aerial reconnaissance have been clearly demonstrated in Shropshire where many sites have only been covered by one practitioner in any one season, (Whimster, 1984).

c) From the soil analyses there are considerable areas away from the valleys which justify a dedicated reconnaissance programme, noticeably on the Shropshire and midland plain where glacial drift offers opportunities for settlement over less permeable geology such as sandstone. It should not be a question of a reducing potential in new sites over known areas, or indeed cost effectiveness, statistically there may well be a continued shortfall in new sites in successive seasons, which is to be expected over the gravels, but a study of the soil types elsewhere provides an indication of the potential which exists in other areas.

d) In relation to the various soil groups, the crop-mark sites recorded by the writer are presented in tabular form as given in Fig.8.14. What must be borne in mind is the extent of the area involved, in which the distribution of Brown soils with the group prefix 5 has yielded the majority of crop-marks. Even so, in Fig.8.7(a) and Fig.8.6(a) there is an absence of crop-marks in the area of series 571(b), Brown earths, which will support deciduous woodland, and is more predominant in the area south of the Teme. To suggest that the West Midlands constituted dense oak forest devoid of settlement was perhaps an exaggeration, but nonetheless in the 25,000 years since the last glacial maximum the tundra landscape retreated to be followed by birch-pine and hazel forest, which in turn was succeeded, in the warmer climate of 8,000 years ago, by mixed oak forest. It is of interest that the series (5) group of Brown soils listed under, will support deciduous or coniferous woodland.

541(d) Deciduous woodland and conifers
551(b) Deciduous woodland and conifers
551(g) Conifers and lowland heath
571(b) Deciduous woodland
572(a) Deciduous woodland
541(g) Deciduous woodland and conifers.
541(i) Deciduous woodland

Even today woodland is well in evidence, Fig.8.15 is a view west along the valley of the river Lugg, which shows afforestation on sloping ground where the soils are predominantly Brown earths of series 541(i), well drained over siltstone. Another viewpoint in the valley of the river Teme west of Leintwardine, as given in Fig.8.16, shows a scatter of woodland for the most part over series 541(i), interspersed with a pattern of fields under cultivation. The higher ground comprising series 611(c), shallow well drained soils over mudstone and siltstone, is capped by trees.

This does not necessarily imply an absence of settlement for two phases of forest clearance, 4000 BC to 3500 BC and 2000 BC to 300 AD have been suggested, (Darvill, 1987(b)); the second clearance involved the use of metal tools, but the inhabitants of both periods in all probability used fire which has been cogently demonstrated today as an effective method of forest clearance. There are other areas of soils, slowly permeable, comprising series 711, to the north and south of Shrewsbury for example, which have intermittently shown evidence for occupation, but it is clear that many sites over these soils may only be revealed in dry weather conditions. It is worthy of comment that the detail in crop-marks over the lighter more permeable soils may in some circumstances only appear during a relatively short period prior to ripening, it implies that the detail associated with sites over less permeable soils may only develop in conditions of acute drought. The varying degree of wetness in slowly permeable soils is also a factor. There would also have been open spaces of heathland on some glacial sands with a light scatter of vegetation, and areas of marsh on the river alluvial. (Sylvester, 1927).

With reference to the reconnaissance pattern over the area, the number of sorties to the north and west of Shrewsbury were restricted, due to limitations in aircraft endurance and other priorities applicable to the writer's aerial reconnaissance in the valleys of the Wye, Warwickshire Avon and the upper Thames. This is particularly relevant in the areas of the Severn associated with Welshpool and to the south. The more recent aerial survey results by C Musson and the staff of the Clwyd-Powys Archaeological Trust, has clearly demonstrated the latent potential for extensive settlement in the upper Severn and its watershed, (Whimster, 1984). What has been achieved also highlights the advantages of a regional survey, not only in the acquisition of new features but the need to maintain continuity of observation during any one season.

e) Over areas where soil maps are available to a larger scale, the soil distribution pattern is more detailed allowing an improved plotting accuracy compared with the limitations inherent in maps to a scale of 1:250,000. Nevertheless, for the majority of sites the results plotted to this scale are valid and of sufficient accuracy for the purpose of overall assessment. It will be appreciated that from the aerial viewpoint it may be difficult in some circumstances to identify the more discrete pockets of soils, and emphasises the advantages to be gained in conducting a limited area survey where the soil patterns can be studied and observed in more detail.

CHAPTER 9

SETTLEMENT SITES IN THE SEVERN VALLEY

9.1 Site distribution and mapping.

One can be left in no doubt, that the volume of the evidence recovered in the valley of the river Severn will have a profound influence on the study of past cultures in the West Midlands as a whole. In general the settlement sites do not exhibit the same degree of complexity and intensity of occupation such as may be found in the Thames valley and along the course of the Warwickshire Avon; nor are the features necessarily of the same style in layout and form. Nevertheless, they are widespread and indicative of a substantial cultural environment. The infrastructure in terms of land clearance and field systems is not so well in evidence, and constitutes an important aspect of future aerial reconnaissance.

The predominant features appear in the form of a wide variety of ditched enclosures, in some instances with internal evidence for occupation, relatively easy to observe and record; but little is known concerning the distribution of open settlements, much more difficult to identify in terms of isolated dwellings or groups of storage pits. There are however other features such as ring ditches, which have a marked affinity to those observed and recorded in other river valleys. In the absence of detailed excavation little is known concerning the origins of the Severn valley sites, many of which no doubt represent the remains of various periods of occupation. It is only possible to comment on the very few isolated sites in the area which have been subject to investigation, and this work is primarily due to the advent of rescue, dictated by site destruction through urban development, sand and gravel extraction and the requirement to develop and construct new road systems.

There are however some sites which may be compared in profile with similar features elsewhere.

For the purpose of this presentation, crop-mark sites have been plotted on 1:2,500 scale ordnance survey maps, except where otherwise indicated, and sufficient landscape detail has been included to facilitate area identification. The plots constitute sketch plans derived from oblique photographs, and represent the total data acquired by the writer over successive seasons; no particular conventions have been adopted in the interests of simplicity. It may well be argued that plots of this nature are of limited value, but the characteristics of an oblique and the number of control points available will invariably dictate the appropriate method of data transfer. Nevertheless, the overall accuracy of the sketch plans is considered to be sufficiently representative for the purpose of site presentation.

Apart from any uncertainties in interpretation there are three other sources of error in drawing sketch plans, site position, orientation and profile, obviously such inaccuracies will be considerably reduced where features are contained within the confines of small parcels of land, with well defined boundaries and control points. By any method of data transfer, the limitations are determined by the land profile, a consistently flat area offering the best prospects, and in any event the result will ultimately be dependant on the ability to measure the control points on the ground and the print or film, the latter being subject to the geometric distortion in the camera lens. The principal methods which may be applied in the transformation of data from oblique photographs to maps involve paper strip, Mobius network or computer, (Scollar, 1975; Palmer, 1978; Wilson, 1982). Where sophisticated methods of transcription are not readily available, the more simple attributes of paper strip or Mobius network may suffice for initial assessment purposes. On the sketch plans prepared for this presentation, some examples of computer plots have been included for comparison; the results were kindly provided by R Whimster using all the available aerial photographs from various collections.

It is intended to deal with the crop-marks of settlement sites and their distribution, in the same area sequence as given in Chapter 8 (Fig.8.2(a)), to be followed by an overall assessment based on a rudimentary classification. In addition to the crop-mark evidence, it would be pertinent to present some of the results in the area appertaining to the complex of hill-forts, widely distributed over a variable landscape.

9.2 Hill-forts

The majority of hill-forts are assigned to the Iron Age, and situated on relatively high ground occupying commanding positions, the defences in general tending to follow the hill contours. The value of aerial photography lies not only in obtaining an overall plan of the feature, but also the added facility to present the site in the context of the surrounding landscape. The defensive system and internal details are in many cases obscured by vegetation in one form or another, but on occasions where the area enclosed by the defences has been cultivated, new features may appear quite unexpectedly.

Hill-forts situated on open high ground lend themselves to a more dramatic presentation, as shown in a low level oblique of the Herefordshire Beacon on the Malvern range Fig.9.1. The defences of this hill-fort are impressive, the outer ditch of the second period closely following the land contours, and the steep slopes of the high ground on which it stands is accentuated in highlight and shadow. The internal first period ditch encompasses a reduced area of higher ground in the centre and capped by a Norman

Motte. A number of depressions are visible in the foreground and have been attributed to the remains of hut hollows, but not as yet verified by excavation. In an archaeological context it would also be necessary to record the overall plan from a higher altitude, but its relative position in the landscape would not be so apparent from such a viewpoint. Since the photograph was taken in 1957, the area within the first period defences has suffered from severe erosion by visitors, eager to take advantage of such a commanding view over the surrounding landscape.

Not all the hill-forts situated on open high ground are so amenable to a low level oblique, as illustrated in Fig.9.2. The outline of the defensive ditches of this Iron Age fort, situated on top of the Wrekin in Shropshire, are much eroded and barely discernible. Nevertheless from this viewpoint the bleak prospect is clearly evident and enhanced by the rocky outcrops of gneiss, placing emphasis on the considerable effort involved in the construction of an effective defence system on such shallow soils. Two periods of occupation are visible at areas A and B, with no internal surface features, but excavation has revealed the existence of post-holes arranged in groups of four and interpreted as the remains of small huts. (Stanford, 1980;99). The ground rises to a height of 1300 ft and woodland is well established on the steep slopes, compared with the meagre vegetation which exists on the Herefordshire Beacon (Fig.9.1).

On the barren landscape of the Long Mynd area in Shropshire, there is evidence for hill-forts of a more simple construction enclosing areas of under 3 acres. Castle Ring on Stitt Hill to the west is a typical example as shown in Fig.9.3, although of univallate construction the entrance to the south is protected by a series of ramparts across the ridge. On this landscape the soils are shallow well drained loams, and constitute a dry moorland habitat of moderate grazing value, even today cattle may be seen scattered over the area. On the Mynd near Church Stretton is another example of a small settlement known as Bodbury Ring, enclosed by a single ditch and bank, Fig.9.4; both features take advantage of the high ground.

Where the enclosed area of a hill-fort is down to pasture, and there are no variations of any significance in the land profile, the contribution from aerial photography is confined to recording the feature in its natural environment. The fort at Croft Ambrey is a prime example, situated to the south of Leintwardine and sited at the end of a ridge 600 ft above the local valley floor, overlooking the river Lugg. In a view to the northwest, as given in Fig.9.5, the alignment and nature of the south defences is effectively screened by variable vegetation, and only revealed in profile by a section excavated across them at point A. On the north aspect an escarpment forms a natural defence, a feature more clearly illustrated in Fig.9.6 and from this viewpoint the outline of the main rampart and quarry ditch to the south is clearly visible. Although the area to the east is thickly wooded, the sloping ground at the end of the ridge to the west is clear, apart from light vegetation. There are no other visible features of any particular significance from the aerial viewpoint.

The lowland hill-forts also merit attention, as given at Fig.9.7 in a view of Caynham Camp situated to the southeast of Ludlow, Shropshire. The enclosed area is defined by an alignment of trees growing over the remains of the rampart and outer ditch. Other than presenting the site in the context of the surrounding landscape, there are no additional features appertaining to its construction and occupation. However, through land management the local area is relatively clear and there is always the prospect of other details appearing. This has proved to be the case as shown in Fig.9.8, where two ditches in the form of an annexe in area A were subsequently revealed through changes in the colour of the overlaying vegetation.

On rare occasions where the internal area of a hill-fort is subject to continuous cultivation, a unique opportunity may arise to observe and record evidence for occupation through the appearance of crop-marks. This occurred within a fort on the northwest corner of Brandon Hill, situated to the south of Leintwardine overlooking the valley of the river Teme. The enclosed area occupies some 8 acres, roughly triangular in shape, Fig.9.9. The defences to the northwest are aligned along a steep scarp, and for the remainder of the circuit a rampart is clearly visible. In 1965 crop-mark features appeared in the form of a ringed ditch of Bronze Age origin, together with the outline of two irregular ditched enclosures which butt against the rampart. There is also a fine network of crop-marks, many of which may be attributed to the underlaying geology consisting of siltstone. The fort is a multivallate arrangement substantiated by the crop-marks for an additional outer ditch at A, the main entrance is also clearly evident at point B together with the parallel ditches of an approach road crossing Brandon Hill from the east; continuity of the outer ditch on the south alignment is uncertain. In this area the marks at C represent the infill of a pipeline trench excavated across the region. Apart from the more dominant features, the remainder of the internal marks are diffuse and difficult to assign to specific structures. It is of interest that from the Cambridge collection in 1959, J K S St Joseph and S S Frere were able to interpret and identify the remains of subsequent Roman military occupation which appeared in the form of buildings and a large granary, (Frere, 1987). From the writer's reconnaissance in 1965, Fig.9.10, the evidence for some of these structures may be identified, at D the parallel foundation trenches of the granary, and E some indication for the robber trenches of buildings. A general plan of the hill-fort is given in Fig.9.11.

9.2.1 Conclusions

a) The incidence of woodland in the immediate vicinity of many hill-forts must have been widespread, and for the defences to be effective there would be a need for a considerable area of cleared ground to offset the prospect of a surprise attack. In some forts the area within the defences appears to have been densely occupied, (Stanford, 1967; Gelling, 1959,1964). From his work at Croft Ambrey, Stanford postulates a population of some 500 souls based on the recovery of a large number of regular postholes considered to be the remains of dwellings within the confines of the camp. To be self supporting a considerable area of land would be required for agricultural purposes, including pasture for cattle, sheep and goats, for this Stanford estimates some 2000 acres at Croft Ambrey.

b) The paucity of evidence for such activities in the vicinity of hill-forts is surprising under the circumstances. From the excavations at Croft Ambrey and Caynham Camp, wheat appears to have been the predominant crop, and presumably some provision must also have been made within the camps to accommodate granaries. The amenable soils associated with the lowlands and river valleys cannot have been neglected, indeed some enclosures attributed to the Roman period in these areas have also provided evidence for Iron Age occupation. If the concept is accepted that the hill-fort population in general was scattered following the Roman conquest, it implies a more dense settlement elsewhere or integration with the already existing valley sites, and places emphasis on the need and future prospects for continued aerial reconnaissance.

9.3 Site presentation

For reference purposes all the crop-mark sites are numbered, including Roman roads and military installations and plotted on a 1:50,000 scale Landranger series of ordnance survey maps. Fig.9.12 identifies the various maps covering the area concerned in the Severn valley, and the distribution is detailed on individual maps as given in the following figures.

Fig.9.13	Sheet 149	Hereford-Leominster
Fig.9.14	Sheet 150	Worcester - The Malverns
Fig.9.15	Sheet 138	Kidderminster and Wyre Forest including
	Sheet 139	Birmingham
Fig.9.16	Sheet 137	Ludlow-Wenlock Edge
Fig.9.17	Sheet 127	Telford
Fig.9.18	Sheet 126	Shrewsbury

In order to relate the sites to the soil distribution patterns as discussed in Chapter 8, it will be appropriate to present the crop-mark detail over the same primary areas. Because of the number of sites involved only a selection will be illustrated, and the remainder listed in Volume 3 for reference purposes. The sites under assessment constitute the evidence for settlement in one form or another, the remains attributed to Roman military installations and roads is presented in Chapter 10.

9.3.1 Worcester-Tewkesbury - The Malverns

The sites in this area are identified as given in Figs.9.13,14 and 15 and in view of the site density at Grimley in the Worcester area the distribution is divided between Figs.9. 14 and 15. The relevant soil patterns are given in Fig.8.3(a).

a) The Malvern Area Fig.9.13.

To the southwest of the Malvern range is Marcle Hill, a ridge of high ground rising to a height of 600 ft in a north to south alignment, providing a demarcation line between the watershed of the river Wye to the west and the Severn with its tributaries to the east. Situated on the plateau are the extant remains of Oldbury Iron Age hill-fort, Fig.9.19, there are also faint crop-marks north of the fort but insufficiently defined for plotting purposes. In the same area are two sites of distinct periods, a triple ditched rectilinear enclosure reminiscent of a civil war fortification with the suggestion of a spearhead bastion at one corner, and part of a double ditched enclosure indicative of an early settlement site.

To the south of the Malvern range is a group of sites at Brooms Green, situated on Brown soils and consisting of a number of ring ditches with evidence for settlement in the area in the form of enclosures, Fig.9.20. The complex at Site 6 is of particular interest, in that the ditches associated with the enclosures may represent the remains of a field system, indeed one particular boundary cuts through a ring ditch of another period. To the west on the bank of the river Leadon, a tributary of the Severn, are the ditches of two enclosures near Donnington Hall, Fig.9.21, in one example they can be seen to intersect suggesting more than one period of occupation. Although quarrying has taken place in the area it has not as yet interfered with the remains. It is tempting to associate these features with the known Roman settlement at Dymock, 1½ miles to the South.

b) Tewkesbury-Kempsey Fig.9.14.

At Twyning Green, Fig. 9.22, crop-marks revealed a site which is now under threat from urban development. The remains are in the form of a rectilinear single ditched enclosure, including a number of pits and two small ring ditches in the vicinity. There is no apparent evidence for any internal features within the enclosure, and it may well have been used for stock if the site was in the form of an open settlement. Near Ryall on the east bank of the Severn on Smithmoor Common, are crop-marks of particular interest as given in Fig.9.23. In the area is a ring ditch which appears to have an entrance, but this interruption may have been caused by a track intersecting the feature. It is the small enclosures which are unusual in the Severn valley, and possibly constitute the remains of square barrows; they are approximately 9 metres across and compare favourably with similar enclosures in the form of Iron Age burials, as observed in other areas, particularly on the Yorkshire Wolds where they are to be found in considerable numbers, (Whimster, 1981;Fig.33).

In the Kempsey area the sites are more varied in character, at Kerswell Green, Fig.9.24, Site 21 exhibits evidence for boundary ditches and enclosures with a scatter of pits, suggesting different periods of occupation, Site 16 is more conventional in terms of enclosures. At Draycott, Fig.9.25, the predominant feature is a distribution of pit alignments, Site 14 consists of a parallel series of circular pits aligned at right angles to the river, whereas in Site 13 the pits are of rectangular form and the arrangement more indicative of field boundaries. In the vicinity of Kempsey at Fig.9.26, Site 19 illustrates enclosures of a distinct configuration, in each case there is evidence for an internal feature in the form of a penannular ring suggesting the remains of dwellings. The large double ditched enclosure is of particular interest, in that the site exhibits the same characteristics as the quadrilateral enclosure recorded by J K S St.Joseph at Kynaston Farm, Kinnerley, Shropshire, (Hampton, et al, 1985:Fig.29). A further series of crop-marks to the north of Kempsey is illustrated in Fig.9.27. The two sites are quite different in profile and content, the detail in Site 22 is more representative of a native settlement than Site 23 which shows a double ditched enclosure of regular form with an annexe containing a series of pits, the style suggests a Romano-British settlement. The crop-mark evidence in this area is confined to the east bank of the Severn, close to the Roman Road alignment from Worcester to Tewkesbury, and no doubt some affinity to the Roman period may be anticipated.

Between the confluence of the Avon and the Teme, the west bank of the Severn is devoid of crop-marks due to the presence of relatively inhospitable soils, although there are small areas of typical Brown earths of the 541 series (Fig.8.3(a)) over which some response may be anticipated, and two sites were recorded on these soils to the south of the river Teme at Powick as given in Fig.9.28. The complex of marks at Site 24 has all the attributes of an open native settlement, but the evidence at Site 25, including a section of a pit alignment, is more widely distributed and the latent potential in these areas west of the Severn has yet to be realised.

c) Worcester Figs.9.14 & 15.

In the region of Worcester north of the river Teme, the crop-mark distribution is very different, with settlement scattered on both banks of the Severn, and particularly dense in the area of Grimley and Holt. The majority of sites in the latter area have now been destroyed by gravel extraction, fortunately limited rescue excavation was made possible through the co-operation of the gravel company concerned. In some cases individual sites have been scheduled, affording a degree of protection prior to the advent of excavation and subsequent destruction.

The distribution of crop-marks in the vicinity of Grimley village is given in Fig.9.29, the hatched areas indicate the sites now destroyed and the cross hatching the areas where gravel extraction is planned. North of the village are sections of two sites, of these the triple ditched enclosure has been investigated yielding evidence for Roman occupation and considered by the excavator at the time to be the remains of a small Roman military guard post, but subsequently reassessd as a rural settlement. The remainder of the crop-marks including linear ditches, possibly indicate field boundaries, but were unexcavated.

To the north of Grimley is an extensive area of crop-marks delineating enclosures, land boundaries and ring ditches, Fig.9.30; of the latter the most noticeable group constitutes a Bronze Age Barrow cemetery (Site 50). Only the features at A, B, C, D and E (Site 49 and 50) were excavated prior to quarrying. Of these no firm conclusions were reached on the ring ditch at A, the double ring ditch at B exhibited no entrance and was attributed to the remains of a barrow with secondary burials; a number of post-holes were also found but their relationship with the feature could not be established. Unfortunately the exigencies of gravel extraction did not allow sufficient time for a detailed investigation of the area. Within the Bronze Age cemetery the ring ditch at C has a possible causeway to the southwest, and the site was much disturbed, but from its profile the ditch was not inconsistent with a Class 1 Henge monument.

The features at D & E were excavated during two successive years, and from the remains of cremations the ring ditch at E was assigned to the Bronze Age, and the enclosure at D provided evidence for Iron Age occupation. The double ring ditch at F failed to produce any relevant information as to its identity, but the presence of a barrow site was inferred from the aerial photograph, (Hunt, Shotcliff, Woodhouse, 1986). Overall the results of rescue excavation revealed sufficient evidence for intensive prehistoric activity from the late Neolithic period to the Iron Age. It is unfortunate that time was at a premium with so much left unexcavated, and the profile of gravel workings over the area as given in Fig.9.31 is symbolic. There is however, one scheduled site remaining of some significance, (Fig.9.30, Site 47), although plans for gravel extraction are currently in progress; the site in question is illustrated in Fig. 9.32, and it is hoped that sufficient time will be made available for a detailed excavation.

To the south of Grimley village are the remains of two triple ditched enclosures, Fig.9.33, an enclosure with similar characteristics has also been recorded north of Worcester, (Wilson, 1982;PL.117). This site may constitute a late prehistoric farmstead as Wilson suggests, unfortunately the two features at Grimley are incomplete, but the triple ditches do imply a defensive work compared to a single drainage ditch associated with the enclosures of some small farms. Further south at Hallow, crop-marks revealed an area of complex settlement, Fig.9.34, the remains were only faintly outlined and difficult to interpret, but site destruction is well in evidence; clearly urban development is spreading over the area and the whole site will ultimately disappear.

At Hallow Hill, Fig.9.35, is a more simple arrangement consisting of two small single ditched enclosures, not conjoined but attached to each other by a short section of ditch, the entrances are well defined; a group of pits were also identified in the vicinity. There is no evidence for dwellings and the enclosures are small compared with the average farmstead, suggesting the possibility of a open settlement with associated stock compounds. In the same area two substantial enclosures were observed, Fig.9.36. The larger U shaped enclosure is unusual and may be compared with other similar features in the Severn valley.

The majority of the sites on the west bank of the Severn appear on well drained Brown soils of series 541r, locally over gravel. On the east bank, in addition to 541r there is a considerable area of series 541b, (Fig 8.3(a)), well drained Brown soils over siltstone and soft sandstone, which also exhibit evidence for occupation. At Hawford in this area on the north bank of the Salwarpe river terrace, are two rectangular enclosures with a ring ditch in the same field, suggesting more than one period of occupation, Fig.9.37. With the advent of the A449, a rescue excavation was conducted on the remains of enclosure A. The geology was found to be Keuper Marl over gravel overlaying soft sandstone. From the results the enclosure was assigned to the second century AD, (Fennel, 1963). There is every prospect that enclosure B, from its configuration, may also prove to be Romano-British.

Crop-marks at Holt Fleet to the north on soil series 541 b show a rectangular enclosure and the penannular ring of a dwelling as the main features, Fig.9.38. In the vicinity there is a group of marks unrepresentative of storage pits, with an outline suggesting the possibility of a number of graves. At Bevere, north of Worcester are two areas of settlement as given in Fig.9.39. The ditch of an enclosure at Site 40 intersects a double ring ditch indicating more than one period of occupation, at Site 35 the arrangement of crop-marks is complex, a ring ditch serves as a focal point for the corner of a large enclosure and a number of land boundaries, and may be assigned to an earlier date. A second ring ditch defines the corner of two field boundaries, and without excavation it would be difficult to establish the relationship of the ring ditch and its origins.

Fig.9.40 illustrates a subrectangular enclosure at Hindlip, the feature has a rounded end similar to that in Fig.9.36. Both sites compare very well with an enclosure recorded by the writer in the upper Thames at Eynsham, Oxfordshire, a site of the same configuration is also known at Thornborough, Yorkshire and considered to be the remains of a Cursus monument. Elmbridge near Droitwich displays an unusual feature in the form of a rectilinear enclosure coupled with a ring ditch, Fig.9.41. the relationship between the two features is not readily apparent, but the extant remains of a similar configuration in the form of a ring ditch with two parallel ditches leading to a linear ditch, possibly part of an enclosure and known as Hamshill Ditches, was observed on chalk, (Crawford & Keiller, 1928;PL.XI(b)).

At Brockamin to the west of Worcester is a rounded enclosure with a defined entrance, Fig.9.42. The field was previously occupied by a orchard which was subsequently removed, and the land cultivated revealing the feature as a crop-mark. The soils in this area are clayey with slowly permeable subsoils over mudstone, series 572F. Considerable areas to the west of Worcester were given over to fruit farming, and many of the orchards are in the process of being removed with the land reverting to general agricultural practice, offering improved prospects for aerial reconnaissance. The area near Grimley is a good example, (Fig.9.30) where the crop-marks of early settlement were visible following the removal of orchards. The resulting interference pattern is very marked on the air photographs, and the interpretation of the excavation results proved difficult as a direct consequence of the ground disturbance.

9.3.2 Telford - Bridgnorth - Kidderminster

The site distribution is identified in Figs.9.15 and 17, and the soil pattern detailed as given in Fig.8.6(a). The cluster of sites at Grimley has already been discussed in the previous section, leaving the middle Severn and river Stour as the area of interest. The lower reaches of the river Stour are screened by the built up areas of

Kidderminster and Stourport. It is to the north at Caunsall that the first indications for settlement appear in the form of single isolated enclosures, mostly rectilinear in configuration (Fig.9.43); the lack of evidence for occupation over such an extensive area of well drained Brown soils is surprising. The pattern of isolated enclosures continues to the north along the Smestow Brook, with little evidence for settlement in the area of the Roman military installations on the east bank at Greensforge. South of Greensforge the river Stour turns abruptly to the east continuing its course through the built up complex of the city of Birmingham.

To the south of Stourport in the parish of Astley, a group of sites were recorded in the form of ring ditches and enclosures on sand and gravel deposits, as given in Fig.9.44. Apart from one isolated ring ditch (Site 65), all the crop-mark evidence for settlement has been destroyed. Rescue excavations were conducted on Sites 63 and 64, but the rapid advance of quarrying did not allow a systematic and detailed investigation over the whole area, although the results from Site 64 were more comprehensive. From the finds the sites were attributed to the 3rd and 4th century AD, with a few sherds of Iron Age pottery suggesting the possibility of earlier settlement. Several areas were stripped on Site 63 revealing short sections of ditch, but the enclosures could not be positively identified in the limited time available. The nature of the finds indicated a depressed standard of living with mixed farming practices testified by the remains of sheep, cattle and pigs, (Walker, 1958, 1959). Excavation of the ring ditch at Site 64 confirmed the feature as a barrow site, and from the evidence of both primary and secondary cremations, attributed to the late Bronze Age, (Green, 1961). In all probability the ring ditch at Site 65 may be of the same period. Although no evidence was forthcoming to support a Bronze Age settlement,it is reasonable to postulate intermittent occupation from the Bronze Age to the Romano-British period.

The area north of Stourport yielded only two groups of sites on the east bank of the Severn. Of these an area at Blackstone exhibits a series of enclosures, Fig.9.45, of which two are double ditched and sited to take advantage of higher ground overlooking the Severn, Site 68 shows an unusual ovate feature in the process of being destroyed through gravel extraction. In the locality of Trimpley, Fig.9.46, crop-marks at Site 70 suggest the existence of a much larger defended settlement compared with an average area for individual farmsteads in the region of 0.25 hectare. In the area to the east of Bridgnorth crop-mark sites are more conspicuous, and appear over variable Brown soils. At Lodge Farm, Dudmaston Hall, is a complex of enclosures, Fig.9.47, where intersecting ditches indicate more than one period of occupation; the penannular ring may constitute the remains of a dwelling within the larger enclosure. At some period the site was covered by woodland, subsequently creating a random interference pattern of filled in depressions after the trees were removed prior to cultivation. To the north are the remains of an open native settlement, Fig.9.48, the arrangement is quite distinct from the more orderly layout of enclosures in Fig.9.47.

Other sites in the area exhibit different features such as pit alignments, as in Fig.9.49 at Woundale, Site 95 also includes a D shaped univallate enclosure and a small ring ditch, in an adjacent field is the evidence for a series of circular pits in an irregular alignment. This may be compared with the Y shaped configuration of pits as given in Fig.9.50 representing the elements of land boundaries; a similar configuration appears at Maxey, (R.C.H.M, 1960:Fig.6). Other sites in the region mainly consist of univallate enclosures of various profiles. On the west bank of the Severn at Bridgnorth is a complex of ditches situated on a sand and gravel plateau above the river, as shown in Fig.9.51. It is apparent from the arrangement of the ditches and enclosures that more than one period of occupation is involved. The outstanding feature is a double ditched rectangular enclosure within the complex. On the last reconnaissance flight gravel quarrying had already eaten into the site, and it is assumed that nothing now remains. To the best of the writer's knowledge no rescue excavation was initiated.

Further to the west in an area associated with the Mor Brook, a number of sites were recorded on deep well drained soils over glaciofluvial drift. The features are in the form of ring ditches with the exception of a univallate enclosure, Fig.9.52. In general the area to the west of the Severn is relatively devoid of crop-mark sites. It must be borne in mind of course that the Wyre forest predominates to the northwest of Stourport.

In the area where the Severn turns abruptly to the south at Sutton Maddock, is further evidence for an alignment of pits as given in Fig.9.53. South of Redhill at Castle Farm a substantial double ditched enclosure of irregular shape, Fig.9.54, was ultimately destroyed together with the farm during the construction of the M27. From the results of rescue excavation it was apparent that the two parallel defensive ditches were not of the same configuration, and indicate more than one period of construction. The inner ditch was 3 metres wide at the surface and 2.5 metres deep, and suggested gradual silting up with no evidence for recutting. The profile the outer ditch was smaller, shallower and V shaped, indicative of a Roman type of defence work, with a narrow straight sided slot at the bottom of the ditch in some places. There was little evidence for occupation within the defences and the finds suggest a possible Iron Age origin, with subsequent development into the Romano-British period. The relationship between the two ditches could not be established stratigraphically leaving several alternatives in the evolution of the Site, (Roe, 1980).

To the north on the outskirts of Telford, a group of enclosures were recorded at Crackley Bank in the vicinity of the Watling Street, with a configuration typical of settlement areas, Fig.9.55. The close association with the Roman road may suggest a Romano-British community. The sites are identified in Fig.9.17.

9.3.3 Shrewsbury - Craven Arms - Leintwardine - Ludlow

The crop-mark distribution and associated soils is given in Fig.8.7(a), and the sites identified in Figs.9.16, 17 and 18. The evidence for settlement appears to be concentrated in the region of Viroconium at Wroxeter, the remainder being distributed along the course of the Severn and its tributaries, Fig.9.18. This is not necessarily an indication of a relatively dense Romano-British occupation resulting from the development of Viroconium, but is simply due to the number of reconnaissance flights dedicated to the city and its environs. It does however serve to emphasise the prospect of extensive settlement elsewhere in the middle and upper Severn, particularly in view of the scattered remains for occupation in that area, and the high incidence of more amenable soils. Other groups of sites appear in the area of Ludlow, Craven Arms and Leintwardine, for the most part in the form of ring ditches and Roman military installations integrated with the remains of settlement, Fig.9.16.

a) Shrewsbury area Fig.9.17 & 18.

In view of the density of crop-mark sites in the region of Shrewsbury, it is only intended to include a representative selection, sufficient to appreciate the variations in characteristics. East of the Severn and in the area of the river Tern, sites are evenly distributed over different soils, Fig.8.7(a). At Admaston on the Tern, Fig.9.56, is a simple arrangement of rectangular enclosures, typical of a small farmstead with the linear ditch of a land boundary in the vicinity. The whole site is concealed under the remains of ploughed out ridge and furrow. In the same area near Cotwall on the west bank of the Tern is a more complex nucleus of enclosures, Fig.9.57, the central rectangular feature being the more dominant. The configuration obviously represents more than one period of occupation, a feature of particular interest is a semicircle of double ditches with one rounded end and may indicate the remains of a henge monument, possibly associated with the double ring ditch of a barrow site in the vicinity.

East of Telford and south of the Watling street are three sides of a single ditched rectangular enclosure at Cluddley, Fig.9.58. The internal features consist of a penannular ring and a small enclosure together with a cluster of pits, and confirms the presence of a small farming community. West of the river Tern at Isombridge is a distribution of sites in the form of enclosures and possible elements of field systems, Fig.9.59 although at Site 123 some of the linear ditches could well be the remains of fossilised ice wedges. To the north on Rodington Heath, Fig.9.60, is an unusual feature in the form of a rectilinear double ditched enclosure with an entrance well defined by parallel ditches. A section of a similar arrangement was recorded by the writer on the Avon, north of Bredon Hill. For comparison purposes a computer plot of Site 131 is included and taking into consideration the reliability factor of the plot, the sketch plan is considered representative of the configuration.

South of Wroxeter on the north bank of the Severn there is a series of single ditched rectangular enclosures, varying in area, Fig.9.61. The feature at site 355 is unusual in its triangular profile on the east side, this site is now destroyed by sand and gravel extraction and the writer is unaware of any investigation prior to the advent of quarrying. In the area of Berwick Wharf between the Tern and the Severn are the remains of two sites as given in Fig.9.62, the configuration of ditches and small enclosures at Site 161 suggests a small settlement area, but more interesting is an arrangement of ditches at Site 165, the main feature consisting of two parallel ditches approximately 25 metres wide and extending over a distance of some 450 metres. Such a configuration may well represent land boundaries, but on the other hand they may constitute the elements of a ritual monument. Similar features have been recorded by the writer in the upper Thames, but their function has yet to be established. In the same area at Preston Farm is a pattern of subrectangular enclosures, Fig.9.63, only the main profiles are included, but there are other indistinct features in the area insufficiently defined for plotting purposes. Of particular interest is the enclosure at Site 182, situated on the alignment of the proposed A5/A49 Shrewsbury Bypass. Excavation in the area was initiated by the Birmingham University Field Archaeology Unit and the site attributed to the Iron Age, the results show that the enclosure ditch was recut and together with other evidence 3 periods of occupation were established, (Jones, 1989).

A scatter of crop-marks recorded in the area of Upton Magna and Withington is given in Fig.9.64, mostly fragmented evidence in the form of enclosures and ring ditches, but suggesting occupation over a considerable area. By comparison the irregular outline of double ditched enclosures in the vicinity of Downton are well defined, but no internal features were evident, Figs.9.65

and 66. At Site 155, Fig.9.66 it can be seen that the sketch plan compares favourably with a computer plot, and on this particular site the evidence for linear ditches associated with the enclosure may constitute the remains of a field system.

To the south of the Severn, crop-marks appear over considerable areas of Stagnogley soils, slowly permeable seasonally waterlogged, with a scatter of well drained Brown earths (Fig.8.7(a)). The sites are in the form of enclosures, and a representative group on soil series 711 is given in Fig.9.67 at Cressage House, Site 138 in particular exhibits evidence for intermittent occupation. The presence of linear ditches in the area indicate some form of field system, which may or may not be associated with the enclosures. At Great Ryton near the Cound Brook, Fig.9.68, are the remains of a curvilinear double ditched enclosure of which there are other examples in the region. A series of single ditched enclosures, is also evident at Brompton on the west bank of the Severn as shown in Fig.9.69, Sites 159 and 160 are of a more conventional profile compared with the regular curvilinear form of Site 158.

Cross Houses in the same area exhibits one of the most unique features in the Severn valley, and constitutes an arrangement of linear ditches extending over a distance of at least 750 metres. The whole site is an enigma, but it is tempting to associate the configuration with a ritual monument. From the distribution of ring ditches it is doubtful that the two features are of the same period. The site may be compared with the linear ditches at Berwick Wharf, (Fig.9.62, Site 165). It is of interest that the configuration of Site 169 closely resembles that given in Fig.9.30, adjacent to Top Barn Farm in the Site 49 complex. Some of the sites distributed along the Cound Brook appear in the form of open settlements as given in Fig.9.71, although the evidence is fragmented it is sufficient in form and content to indicate considerable areas of occupation.

At Meole Brace on the south perimeter of Shrewsbury near the Rae Brook, Fig.9.72, are the crop-marks of ring ditches and a double ditched curvilinear enclosure similar in configuration to that shown in Fig.9.68. Site 187 is currently under threat from urban development and an excavation of the area was undertaken by the Birmingham University Field Archaeology Unit. From the findings a preliminary assessment places a date for the site in the early to middle Bronze Age (2000-1500 BC). (Cooper, Leach, 1990). Secondary burials in the vicinity of the ring ditch confirmed the site as a funerary monument; Sites 186 and 188 are under investigation, (Barker, Haldon, Jenks, 1965-71).

In an adjacent field to the south NGR SJ 489097, the writer recorded a series of linear ditches together with faint crop-marks of a ring ditch, a scatter of pits and other ditched features. It was considered that the remains were insufficiently defined to justify plotting. The site was under threat from the proposed Shrewsbury bypass, and rescue excavation by the Birmingham University Field Archaeology Unit has confirmed the presence of a complex Roman rural settlement, situated on the alignment of the Roman road from Forden Gaer to Viroconium. (Hughes, 1989-90). Once again a detailed investigation to determine the extent the settlement could not be achieved in the time available, but sufficient data was obtained to demonstrate the archaeological potential of the site. The extent of prehistoric remains in the area is confirmed by the excavations at Sharpstone Hill to the south of Meole Brace which revealed multi-period occupation from Neolithic to Roman, including ring ditches and cremations thought to date from the Bronze Age, (Barker, Haldon, Jenks, 1965-71). These findings may well have some relevance in determining the origins of the feature in Fig.9.70.

Further evidence for prehistoric settlement is given in the crop-marks at Fig. 9.73, in the form and distribution of ring ditches and enclosures at Gravel Hill northwest of Shrewsbury. These features appear on series 572M, loamy soils with slowly permeable subsoils over reddish till and glaciofluvial drift, similar in characteristics to the soils at Meole Brace. To the west on the middle severn at Montford is a complex of enclosures and linear ditches, Fig.9.74. although the ditches in Site 199 suggest a pattern of field systems and enclosures, it is possible that some of the alignments may be periglacial in origin. At Shrawardine on the north bank of the severn is a large circular feature with an annexe, Fig 9.75, the east sector of the site is in the form of crop-marks and the west profile discernible in pasture. The site lies in an area of well drained soils over glaciofluvial drift. The remains are unusual in both profile and its situation close to the river. A Viking site has been suggested and the general arrangement may be compared with a Viking fortress at Trelleborg in Denmark, (Pennick, Devereaux, 1989;Fig.3.6). More convincing is the similarity in size and configuration to an Iron Age site at Bury Hill in the neighbourhood of Danebury in Hampshire, the profile of the annexe is identical, (Crawford & Keiller. 1928;Fig.15 Pl.XI(a)).

To the north at Nib Heath is a further series of crop-marks given in Fig.9.76. Site 201 is of particular interest, a section of a double ditched enclosure is well defined, and it intersects a curved ditch interrupted by entrances. Whether or not this ditch continues to join up with the arc of an external linear ditch is uncertain. From the alignment of pits at Sites 201 and 204. it is possible that they may form part of an extended land boundary.

A further series of enclosures is to be seen at Yeaton, Fig.9.77. The D shaped site is not uncommon in the Severn valley, and a feature of similar profile was excavated at Uppington, Shropshire and shown to be medieval. (Barker, 1959). In general, the evidence for pit alignments in the area appears in short sections, but at Yeaton a complex arrangement clearly defines the boundaries of a field system. Fig.9.78. The pits are of rectangular profile and similar to those identified in the alignment at Drayton, Fig.9.25 Site 13.

b) Ludlow - Craven Arms - Leintwardine, Fig.9.16.

In addition to the site identification in Fig.9.16, the crop-mark distribution and associated soils is given in Fig.8.7(a).

Ludlow.Fig.8.8. At Ludlow sites are scattered over the area with the main concentration at Bromfield near the confluence of the river Teme, Onny and the Corve. To the south at Woofferton, Fig.9.79, the evidence for settlement is fragmented, but the remains do suggest a considerable area of occupation. The presence of damp patches in the field screened the evidence to a certain extent.

At Bromfield the distribution is more complex, and apart from the outline of a Roman temporary camp, the sites are in the form of ring ditches. Fig.9.80; within the hatched area the evidence has now been destroyed by sand and gravel extraction. The features appear on soil series 571A, well drained fine loams locally over river terrace gravels. Rescue excavations were possible and provided a surprising amount of information confirming occupation in the area over the period from Neolithic to Saxon. (Stanford, 1985). The ring ditch at A was subsequently investigated during contractual activity over the site, and identified as representative of a 2nd - millenium BC barrow, (Leach, 1989). It is of interest that a 7th century cemetery was located by Stanford within an enclosure at Site 279. the graves were not revealed by crop-marks. To date the sites at Bromfield represent the most complex series of cemeteries in the Welsh Marches. Included in the locality are five upstanding barrows in addition to the crop-marks of fourteen ring ditches of possible Bronze Age origin.

There are other features in the area, for example at Stanton Lacy in the valley of the river Corve are the remains of a settlement in the form of a subrectangular enclosure. Fig.9.81. To the north at Culmington is another area of enclosed settlement, Fig.9.82. and in the vicinity the outline of a possible mortuary enclosure. In this figure the sketch plan may be compared with a computer plot of the site, and shows good agreement where there are adequate control points. Variations in detail can be expected depending on the season and date of the available aerial photographs. Not all sites are restricted to the river valleys, as illustrated in Fig.9.83. revealing the presence of two enclosures on the high ground in the area of Wenlock Edge to the north. the crop-marks appear on well drained soils over Siltstone. This represents only one example of a sequence of sites in the area.

Craven Arms. Fig.8.10.

In the valley of the river Onny to the northwest is the area of Craven Arms. which also exhibits a scatter of crop-marks indicative of settlement, as is the case at Ludlow. The district is littered with the remains of Roman military installations. and there must have been considerable areas of pasture integrated with an agricultural economy, for one cannot envisage the construction of temporary camps of up to 30 acres in a forest environment. The evidence for communities is reflected in the ubiquitous rectangular enclosure. as given in Fig.9.84. On this site an ovate feature is of particular interest, there are other examples in the valleys of the Severn and Warwickshire Avon. they appear in three basic shapes, 'ovate', trapeziform and oblong, it is difficult to arrive at a suitable terminology in terms of distinguishing a particular monument, to avoid confusion with other enclosures perhaps of similar shape which may occupy larger areas, and such a distinction has been postulated in a paper on these remains, (Loveday, Petchey, 1982).

These sites are not uncommon in the Midlands and East Anglia, and are recognised as a specific type of monument, in the same way as pit alignments in that they were not as first thought confined to a particular area. They may be Neolithic in date but excavations of a site at Coldecote, Buckinghamshire for example, suggests a form of Iron Age Sanctuary. Whereas the excavation of a similar monument, photographed by the writer at Charlecote in the valley of the Warwickshire Avon, assigned the enclosure to the Neolithic period, (Ford, 1968). There are similarities with possible Neolithic long mounds in Western France, (Marsac, Riley, Scarre, 1982).

In the precincts of Craven Arms, Fig.9.85 shows an unusual feature of particular interest, in the form of a regular rectilinear enclosure with a similar internal configuration. The site lies adjacent to the line of the Watling Street and it is tempting to postulate a Roman origin, and may be compared with a similar profile east of Pavenham, Bedfordshire, (St.Joseph, 1967). There are two further sites of interest, as given in Fig.9.86. The fragmentary evidence at Site 267, including part of a ring ditch, suggests the remains of an early settlement; the site is being slowly eroded by rural development. The origin of a large double ditched rectilinear enclosure at Site 268 is unknown, however the profile of the sketch plan shows good agreement with a computer plot although there appear to be significant differences in dimensions.

A very different arrangement of crop-mark sites is given at Fig.9.87, apart from the remains of a Roman temporary camp at Upper Affcot (Site 356), it is the ring ditch at Site 259 which is the focus of interest. The form and well defined entrances reflect the characteristics of a Henge monument, and the evidence for an adjacent series of post-holes constitutes an additional feature to be taken into consideration. In the same field to the north is a parallel arrangement of pits or post-holes, this could well constitute the remains of aisled hall; as an alternative it may represent part of an 'avenue' such as exists near the henge at Thornborough South Circle, North Yorkshire, or part of a Neolithic settlement similar to that at Meldon Bridge, Peeblesshire, (Wilson, 1982;Figs.46 and 76 respectively). The arrangement of pits is not due to the effects of present day agricultural practice, as the features have appeared in other seasons. The presence of a number of ring ditches in the area suggest Bronze Age funerary remains such as exists at Bromfield.

There are two additional sites in the form of a circular ditched enclosure which merit comment, as given in Fig.9.88 and Fig.9.89, each site is situated adjacent to, and on the east side of the Roman road alignment from Viroconium to Kenchester. It will be seen that although both features exhibit the same configuration and size they are oriented 180° with respect to each other. The origin and nature of the enclosures is unknown, but their situation is unique in that the site at Leebotwood is 8 miles from Viroconium and that at Wettles 8 miles from the Roman settlement at Leintwardine, with a spacing between them of $7\frac{1}{2}$ miles. Their relative positions may be of some significance, for it would be a remarkable coincidence if they were in fact pre-Roman.

Leintwardine Fig.8.9

Leintwardine is situated on the Roman road alignment south from Craven Arms and at the confluence of the river Clun with the Teme. In this area also there is significant Roman military activity in the form of auxiliary forts and temporary camps. The evidence for settlement is represented by the remains of ring ditches and farm enclosures of a relatively simple and variable configuration, as observed at Ludlow and Craven Arms. Some examples are illustrated in Fig.9.90 at Beckjay, and at Astley Moor as given in Fig.9.91, both areas are in the valley of the river Clun. There is an unusual feature west of Brampton Bryan on the river Teme, in the form of a long dyke or similar land boundary as given in Fig.9.92. There are also the remains of ring ditches in the area, one of which is a penannular ring suggesting some form of settlement, the feature attached to the boundary may represent part of an enclosure. Similar configurations are to be found in the Midlands and elsewhere, (Foard, 1980). Since there is at present no threat to any of the settlement areas at Leintwardine, there has been no attempt to investigate the remains, although the Roman auxiliary forts in the area, including the remains at Brandon Camp, have been the subject of detailed investigation and excavation. A similar situation exists in the excavation of hill-forts in the Welsh Marches, which emphasises and leaves open the question of population dispersion following the Roman occupation, and indeed the extent of land use in the vicinity of these features prior to this event.

9.3.4 Oswestry - Llanymynech - Forden. Fig.9.18, and Fig.9.16

The area includes the upper Severn and the Shropshire plain to the west. The sites are identified in Fig.9.16 and Fig.9.18 with the crop-mark distribution and associated soils given in Fig.8.11. On the Shropshire plain the predominant soils consist of series 551 and 541, well drained typical Brown sands and typical Brown earths respectively, for the most part over a geology of glaciofluvial drift with some intrusions of Sandstone and Limestone. Along the course of the river Perry are areas of less amenable, wet, peaty soils, but even these have yielded evidence for prehistoric activity in the form of dug-out canoes, (Chitty, 1927). The results of a limited aerial reconnaissance over the plain confirmed the existence of complex patterns of early settlement, an example is given in Fig.9.93 at Knockin Heath, which shows a series of enclosures of varying configuration and testifies to intermittent occupation over a period .

A similar pattern of crop-marks was recorded near Whittington in the valley of the Perry, Fig.9.101, the remains extend over a considerable area with a distribution of linear ditches, some of which may represent field boundaries. The presence of a ring ditch of over 150 ft in diameter is an unusual feature, and the well defined entrance suggests a function other than that of a barrow site. In the area are the remains of a Roman temporary camp (Site 327) of over 30 acres, and its presence suggests an area of light scrub or cleared farm land.

To the south at Llanymynech in the valley of the river Vyrnwy is the outline of a more common double ditched rectilinear enclosure, Fig.9.94, indicative of settlement in the area. In the valley of the Tanat, a tributary of the Vyrnwy, are two large circles compass scribed and of unknown function, Fig.9.95. Similar monuments of comparable size have been recorded by the writer in the lower region of the river Wye. One of the most important sites is at Four Crosses near Llandysilio, one mile to the south of Llanymynech, in the form of a lattice of pit alignments constituting a system of fields as given in

Fig.9.96; the site extends over an area of some 50 acres and the arrangement is unique in the West Midlands. The presence of ring ditches and other crop-marks in the area, signifies settlement of another period.

At this point the course of the Severn originates from the southwest through a narrow valley flanked by high ground. To the west in the area of Guilsfield Cegidfa are the remains of a triple ditched rectilinear enclosure at Varchoel, Fig.9.97. The site is contained in a small field with well defined control points, and the resultant sketch plan compares favourably with a computer plot of the feature. In the same area crop-marks revealed the remains of an extensive pattern of settlement, as given in Fig.9.98. In the area of Whitley to the southeast of Forden and adjacent to the remains of Offa's Dyke, are the multiple defensive ditches of an enclosed settlement, Fig.9.99(a). In this instance there are significant differences in configuration between the computer plot with its reliability factor, and the sketch plot, but depending on the quality of the photographs selected from different sources for the computer plot, and bearing in mind the seasonal variations in crop response, some differences can be anticipated. Even so the appearance of what may be a ring ditch in both plots indicates more than one period of occupation.

The multiple defences of this feature suggests a particular type of fortified site, compared for example with the double ditched configuration of a farmstead. A similar arrangement can be seen at Collfryn near Welshpool as given in Fig.9.99(b), where settlement began after C 900 BC and continued into the Roman period, reflecting an agrarian society with local industrial activity, (Britnell, 1989). The complex site at Varchoel in the same area (Fig.9.97) may perhaps be included in the same category. Although it has been has postulated that the population was largely confined to the hill-forts, (Stanford, 1980), sites of this nature tend to lend credence to the existance of late Iron Age settlement in the lowlands of east Shropshire.

Complex settlement sites are also in evidence adjacent to, and in the area of the Roman auxiliary fort at Forden Gaer, Fig.9.100. These remains are of particular interest in that they lie on soil series 811(b), deep silty and clayey river alluvium affected by ground water and local flooding from the Severn. The appearance of crop-marks under these conditions is exceptional, as is the presence of the settlements themselves situated in such an environment. Whether or not they have a close affinity with the auxiliary fort is a matter of speculation. The rectilinear double ditched feature at Site 246 is an enigma with its sharply defined profile and the absence of entrances.

9.4 Summary

a) Mapping

The results are presented in the form of sketch maps in order to include the evidence accumulated on individual sites over the whole period of reconnaissance. There are of course limitations in producing plans of this nature, and these have been set out in a paper by (Hampton, et al, 1985). Apart from interpretation which inevitably is a matter of personal judgement, the method adopted is influenced by the presentation and quality of the aerial photographs. Plotting by Mobius or paper strip is tedious, but it is considered that such methods are adequate for the purpose of site identification, initial classification and field work. Where a computer plot is included for comparison purposes, the sketch plans in general show acceptable agreement taking into consideration the computer reliability factor. From the variations in crop-marks due to weather, time and season in which the air photographs were taken, some differences in detail are to be expected. However, it would not be prudent to attempt to select specific areas or individual features for excavation using a sketch plan, and a computer plot and/or geophysical survey would be a prerequisite for this purpose, unless of course the whole site is to be stripped, which is often the case when the overburden is removed prior to quarrying.

b) Survey results

The crop-mark evidence selected from the writer's collection constitutes approximately 40% of the data acquired, and is considered representative of the wide variation in settlement patterns to be found in the valley of the river Severn. The remains are not confined to the well drained soils of the river terraces, or those of its tributaries, but extend over the considerable areas of glaciofluvial drift and other soils that are slowly permeable. From the writer's point of view the areas of settlement presented are to a certain extent a function of the sortie patterns adopted, and the obvious difficulty in achieving a comprehensive coverage over other areas further afield, in view of the limitations in aircraft performance. This is reflected in the wide scatter of sites recorded in the middle and upper Severn, to the north and west of Shrewsbury, as compared to the relatively dense settlement in the region of Viroconium and Worcester for example.

In the valley of the Severn and its watershed, casual finds from Neolithic to Roman are distributed over the area, (Stanford, 1980: Chitty, 1963: Smith, 1957), and provide evidence for widespread settlement. From the complexity of sites recovered by the writer in the valley of the Warwickshire Avon, (Webster, Hobley, 1965), and the Severn, it is no longer tenable to regard the Jurassic ridge of the Cotswolds as a demarcation line between settlement to the southeast and that to the northwest, and although the configurations may differ there are viable comparisons to be made.

c) Enclosures and settlement

Apart from ring ditches and pit alignments, the majority of the crop-mark evidence for settlement is in the form of enclosures, distributed in simple and complex form. Multiple ditches however do suggest a defensive system compared with the single ditch of a compound, which may only serve as an enclosure for animals and dwellings. But a single ditch does not necessarily signify one period of occupation, for it may have been subsequently recut. Neither does the presence of multiple ditches imply a unified construction, for they could well have developed over a period. The identification of associated field systems presents problems in that some alignments may constitute periglacial remains, and do not appear to form a regular pattern of fields such as may be seen in Yorkshire and Nottinghamshire, (Riley, 1980), and Wessex, (Hampton, Palmer, 1977). From the results however, there is sufficient evidence to support a widespread pattern of prehistoric farming in the Severn valley as demonstrated in other areas, (Fowler, 1983; Pickering, Hartley, 1985).

The sites as presented in the sketch plans are of a recognisable form, but there are many areas where ditch alignments have been recorded in isolation, unrepresentative of periglacial remains or the effects of present day agricultural activity. Such features could be the remains of early field systems, and merit continuity of observation with the prospect of recovering additional crop-mark profiles, more readily identified as reminiscent of occupation. Compared with sites on a relatively flat landscape, the evidence for settlement on sloping ground may be more difficult to recover due to an accumulation of soil from the effects of erosion.

Some sites are fragmented, as for example in the crop-marks at Rock Green, east of Ludlow as given in Fig.9.104, where the evidence in the form of incomplete enclosures and linear ditches, is only sufficient to indicate an area of occupation. The site was under threat from the proposed alignment of the Ludlow bypass, and a rescue excavation was carried out by Birmingham University Field Archaeology Unit, (Carver, Hummler, 1975). The finds suggested occupation of unknown form in the Beaker period, possible Iron Age, and evidence for a Romano-British presence; the excavation was confined to that part of the site under threat. Nonetheless, the findings do contribute to the prospect of early settlement in the area. Further, the soil type is 571b a typical Argillic Brown earth, in this instance sandy with a high clay content over sandstone, and the results from excavation provide supporting evidence for occupation on the less amenable soils as compared with that expected on the well drained loams over a river terrace.

d) Circles and Pit Alignments

The general distribution of these features is given in Fig.9.102.

Circles

Apart from the extant remains of barrows situated on high ground, (Fig.9.16) and scattered in the valleys, crop-marks reveal a wide distribution of burial sites in the form of ring ditches in the valley of the Severn. They are to be found in isolation or in groups and vary in diameter from 10 to 50 metres, and have a marked affinity to other sites in the region as for example in Gloucestershire. (Grinsell, O'Neil, 1961). From excavation, a large percentage are assigned to the Bronze Age, but this is not the only culture to construct round barrows, and some may well constitute the remains of Saxon or Roman interments. From the distribution given in Fig.9.102 there is evidence for cemeteries at Brooms Green, Grimley, Morville, Cross Houses, Gravelhill, Four Crosses, Bromfield, Craven Arms, Buckton and Mortimers Cross; from the results of Stanford's excavation at Bromfield, the remains of other forms of burial also testify to the existence of substantial areas of settlement.

The notation adopted in terms of multiple ditched barrows does not necessarily infer a particular form of construction, but represents use over a period in which the feature is subsequently enlarged by the addition of further ditches with secondary burials, (Donaldson, 1977; Field, 1985). Leaving aside small ring ditches or penannular rings associated with enclosures, the distribution in the area of the Severn is given at Fig.9.103, in terms of ring diameters, and compares favourably with a graph of the distribution of circles in Gloucestershire (Darvill, 1987(a);97). The remains of Henge monuments in the form circular ditches and entrances are not so evident in the Severn valley. There are only four possible sites, Craven Arms Site 259, Fig.9.87; Holt Site 50, Fig.9.30 (excavated); Perry Farm Site 215, Fig.9.101; and part of a feature at Cotwall Fig.9.57. A similar situation exists on the Warwickshire Avon.

Pit Alignments

The distribution of pit alignments is similar to that recorded by the writer and J Pickering in the valley of the Warwickshire Avon, (Webster, Hobley, 1965;Fig.4). Both the Severn and the Avon exhibit pits in round or rectangular form, but there are significant differences in arrangement, whereas double alignments are to be found in the Avon valley, no similar configurations appeared in the area of the Severn; the same comment applies to offset pits which possibly represent some form of entrance. That many of the remains constitute land boundaries there is no doubt, (Wilson, 1978). Although they appear to be part of a prehistoric landscape, such features according to Wilson may be of any period from Neolithic to the Middle Ages. Not all the alignments are straight, (Fig.9.49) and may have been influenced by the environment, for example through a wooded area, or to avoid other remains or variations in the landscape.

An example excavated at Eskbank Nurseries, near Dalkeith, Scotland, (Barber, 1985), consisted of a linear series of oval pits infilled by the process of gradual weathering. There was no evidence to indicate that the holes had ever held posts, and in conclusion it was agreed that the remains were quarry pits to provide material for the bank of a linear earthwork, with a radiocarbon date of 110 + 70BC. This may be so for this particular site, but the sharply defined rectangular pits of some alignments in the Severn and Avon valleys are too neat for quarry pits. Further evidence for pit alignments on the lines of a dyke is given by (Spratt, 1982). There are other variants, at Long Bennington in Lincolnshire multiple ditches representing land divisions also include an alignment of pits, (Wilson, 1982:Fig.60). The existence of an extensive pattern of linear earthworks in the form of multiple - ditched boundaries in eastern England and the midlands, has been established from aerial reconnaissance, (Pickering, 1979). But the field system bounded by pit alignments at Four Crosses in the Severn valley (Fig.9.96) falls into a different category, a similar orderly arrangement is to be found at King's Bromley in Staffordshire; there appear to be no offset pits to indicate any form of entrance. These features are now well known and are to be found in most river valleys, (R.C.H.M., 1960), and it is surprising that only a few examples of pit alignments have so far been revealed in Wiltshire and the upper Thames, particularly in view of the wealth of evidence for settlement in these areas.

There have been various suggestions as to the function of these features. including the planting of young trees, this would of course delineate a boundary and provide a wind break against crop damage and soil erosion, but would not necessarily constitute an effective barrier. There is also the question of a bank associated with a pit alignment, and any evidence for it would have been ploughed out on cultivated fields. If the pits are of the order of one metre in depth. spaced by two metres with a diameter of 1.5 metres. which is a reasonable assumption from excavation, the available material would not form a continuous bank of much more than say 2 ft in height. That is providing no soil was scraped up from the adjacent land surface. But such a bank with a palisade would form an effective protection, it is of interest that when the overburden was removed from an alignment at Butler's field. Lechlade (Darvill, 1987(a):122). what appear to be a line of post-holes was visible adjacent to the pits. If a bank existed on this side of the pit alignment together with a palisade. it would constitute an effective game trap if they were driven against it, with a 50% chance of falling into a pit particularly if the pits were screened by loose vegetation. But an enclosed field system in the arrangement at Four Crosses (Fig.9.96) requires a more plausible explanation. There are as many possibilities as there are variations in pit alignments, and it is for excavation to solve the problem.

e) Cursus Monuments

The features are prominent in the upper Thames and usually associated with groups of ring ditches. and datable to the Neolithic period. The shape usually takes the form of a long rectangular single ditched enclosure with square ends. but in some examples one end may be elliptical. Similar configurations were recorded on the gravels in the valley of the Warwickshire Avon (Webster, Hobley, 1965;PL.1). Such monuments are notably absent in the area of the Severn, except for one crop-mark northeast of Worcester at Hindlip, Fig.9.40. This arrangement bears a strong resemblance to a feature recorded by the writer in the upper Thames, a similar outline also appears at Thornborough in Yorkshire, (R.C.H.M., 1960:PL10(b)).

There are however ditch systems in the Severn valley which have a marked affinity to those of the upper Thames, and consist of an alignment of double ditches which may qualify as a Cursus monument. The ditches are too wide for a trackway, and their form suggests other than extended land boundaries. Such a feature at Cross Houses, south of Shrewsbury, Fig.9.70 Site 168, appears in conjunction with a number of ring ditches, and terminates to the south in a large irregular rectilinear enclosure, continuity of the system to the north is unknown. Another alignment at Berwick Wharf, Fig.9.62 Site 165, exhibits a similar arrangement of parallel ditches but there is no evidence for ring ditches in the vicinity. It is possible that these monuments may be of some ritual significance, and as such would have a place in the prehistory of the area.

9.5 Conclusions

a) It is evident from the crop-mark sites presented, that the results from aerial reconnaissance in the valley of the river Severn are commensurate with those of other midland rivers. Such an archaeological potential was unsuspected when the writer initiated survey over the area in 1952. Only a very few settlement sites have been investigated, compared with the work on hill-forts and Roman military installations, and of these it is unfortunate that excavation has been confined to rescue, in some instances with insufficient time available to conduct an overall detailed investigation, so necessary to put the features revealed into proper perspective. Where for example unusual configurations have no parallels with sites investigated in other river valleys, selective research excavation would constitute a viable contribution to the development of cultures in the valley of the Severn and its watershed.

b) There is sufficient data from the limited number of excavations of settlement sites in the Severn valley to support the existence of an indigenous culture, but insufficient to place the development of similar unexcavated sites into any form of chronological sequence. If the evidence suggests that an Iron Age way of life continued into the Roman period, assuming that it is not totally derived from the hill-fort population, the settlement sites recorded in the Severn valley must reflect a potentially rich lowland development. Obviously the fabric of rural settlement must have been influenced by a Roman presence, in the form of trade and improved agricultural practices, particularly on the heavier soils. A programme of site classification and morphological studies is already in progress, initiated by the National Monuments Record Air Photographs Unit under R Whimster, but this is only a beginning. Crop-mark evidence in itself will not provide a detailed account of the ancient landscape, it will however constitute a basis for exploration, and sorting the various rectilinear sites into some form of mapped sequence.

c) A substantial number of new sites have subsequently been recorded in recent years through the activity of other practitioners, particularly in conditions of drought, and it is clear that the archaeological potential of the area has yet to be fully exploited. Sand and gravel extraction, together with other development, is making extensive inroads into archaeological remains, but a balanced investigation of other selected sites is long overdue and constitutes a scientific challenge.

d) The advent of site destruction is a mixed blessing, although it does provide archaeology with the prospect of uncovering unknown features, and the opportunity to investigate known sites as revealed through aerial reconnaissance. Under such circumstances, if sufficient time is made available, depending on the nature of the proposed development, a reasonable assessment of the sites may prove feasible. But in general such features are not revealed in detail until the overburden is removed, as is the case prior to gravel extraction, in this event any upper layers of stratification are irrevocably lost, and the speed at which development proceeds very often only permits what is virtually a salvage operation. But there is no doubt that in the absence of such opportunities, it would be difficult to establish a framework in which to formulate any future excavation policy, in terms of rescue or indeed research. Bearing in mind also, the wide distribution of complex sites already known through aerial reconnaissance, and the prospects of more to be revealed in future years.

e) In reality, because of the mass of evidence recorded in the Severn valley, it is anticipated that apart from the opportunities presented through rescue, very few features will be excavated in the interests of research. In the event, Archaeology will inevitably face the difficult problem of selection, if any attempt is to be made to put the evidence for settlement into perspective. But that will be no reason to discourage or fail to support future reconnaissance over the area, for the outcome may well influence the choice at that time, either through the recording of new features or the recovery of additional detail in sites already known.

Chapter 10

ROMAN MILITARY INSTALLATIONS AND ROADS

10.1 Introduction

The distribution of Roman military installations and civil road alignments is given in Fig.10.1. From the results of the writer's aerial reconnaissance, the evidence for Roman military activity appears to be concentrated in four main areas, namely Greensforge, Wroxeter, Craven Arms and Leintwardine. J K S St.Joseph has also maintained observation over the area with an additional complex at Brompton, situated to the southeast of Forden Gaer, (St.Joseph, 1969:119), the results recorded over this site by the writer were too fragmented to justify plotting. Prior to the Roman campaigns in the region, no doubt communication between early settlements would have been maintained through a long established network of trade routes, including the use of the Severn as a waterway.

The existence of what are predominantly later civil roads were in all probability aligned on earlier military routes, serving as a direct communication between established forts and legionary bases. But it does not necessarily follow that all such roads represent a line of advance into hostile territory, determined by a particular military strategy; this would depend on the area and nature of the threat, together with the disposition of the legions and auxiliary units at the time. Because of the general lack of dating evidence, it would be inappropriate in this presentation to speculate as to the origins of individual installations in terms of known campaigns in the area, particularly in the case of temporary camps, or attempt to place the sites in the context of the overall military situation in the province; such hypotheses have already been formulated in other publications, (Frere, 1967; Webster, 1970).

In any event the situation in the Severn valley is fluid, and subject to further contributions from aerial reconnaissance. On the Ordnance Survey Map of Roman Britain, 1956, the only known military installations in the area of the Severn consisted of one temporary camp and seven forts, including the sites at Tedstone Wafer and Grimley, both of which are of doubtful military origin. Subsequently, from the writer's limited survey, no fewer than 38 installations have been recorded in the region. The excavations to date however are minimal, and in the main confined to a few auxiliary forts, with the exception of a supply base established within an Iron Age fort on Brandon Hill to the south of Leintwardine, and assigned to the Neronian period AD 55-60 for the main occupation (Frere, 1987). As a consequence, the outcome of such investigations together with the results of aerial reconnaissance can only provide a tentative basis for considered archaeological opinion. For the purpose of this presentation therefore, leaving aside the legionary fortress at Wroxeter, the evidence for military sites in the region will be confined to an assessment of the installations as they appear in the three basic configurations, that is to say, temporary camps, auxiliary forts and the possibility of small camps or fortlets. Many of the features were photographed initially or in the same season by J K S St.Joseph and published, but additional detail and other forts were observed and recorded by the writer.

10.2 Military Installations

As in the distribution of settlement sites presented in Chapter 9 the Roman military installations are given in the form of sketch plans, and represent the total data acquired over the whole period of reconnaissance.

10.2.1 Temporary Camps

Temporary or Marching camps are indicative of legions or detachments on campaign, and vary in size accordingly. They were constructed at the end of a days' march to serve as temporary accommodation. The forward area would no doubt be reconnoitred by an advance party, selecting a relatively cleared site in a situation least likely to pose a threat, and also fulfil the requirement for water and forage. The layout of a camp is distinguished by its rounded corners and a profile usually in the form of a playing card in shape; the defences consist of a single V shaped ditch of up to 5 ft wide and 3 ft in depth. Behind this would be a bank of earth or turf to support a palisade. The entrances are protected by a Titulum consisting of a short length of ditch and bank parallel to and spaced away from the entrance, or alternatively a Clavicula, which is an extension of the defensive ditch and bank to form a curve across the entrance, the arrangement may be external or internal with respect to the camp defences, (Johnson, 1983:51). There are other variants of Clavicula form, (Frere & St.Joseph 1983:131). The features were intended to prevent an attacker from rushing an open gate, and forced an oblique approach restricting the entrance and exposing the attacker's unprotected sword arm to defenders on the rampart.

Where an area has been subjected to continuous cultivation, the evidence for the banks of such features would have been swept away by the plough, leaving only the remains of the defensive ditches to be recovered through crop-marks. There are no timber gates, and the open entrance would be defended by a troop detail. It is remarkable that no evidence survives for the ditches of a Titulum or Clavicula in any of the 20 camps recorded by the writer in the region; but examples are to be found in other areas, both on cultivated and undisturbed land; troops were accommodated in leather tents and there is little prospect of crop-marks revealing any evidence for occupation, except perhaps for a scatter or an alignment of rubbish pits, (Frere & St.Joseph, 1983:42,27).

a) Wroxeter Area

Situated on the south side of the Watling Street at Burlington, 21 miles east of Viroconium are the remains of a small camp of 7½ acres recorded in 1970, J K S St.Joseph has shown that this camp is contained in the northeast corner of a much larger camp occupying an area of 43 acres, (St.Joseph, 1973:Fig.18).

In the area between the villages of Eaton Constantine and Leighton, 4 miles to the southeast of Viroconium and west of the Wrekin, is the outline of a triple ditched Vexillation fortress enclosing an area of 20 acres, an unusual feature in the valley of the river Severn, Fig.10.2, Site 194. The gates on the north and south aspect are centrally placed, but those on the east and west boundaries are less certain. The site is positioned for the most part on relatively level ground, but the defences to the south extend over a downward slope facing the river Severn. A camp of this size would accommodate half a legion and it is inferred that they were constructed for battle groups engaged in campaigns, (Webster, 1985:175). The defences were sectioned by A W J Houghton and considered to have been constructed in haste and badly excavated. Some pottery was recovered including Samian ware, but it was all in such poor condition that it could not be dated, (excavation data unpublished). In the area to the south between the fortress and the river are the remains of two single ditched temporary camps, Site 208, but insufficient is known of the profiles to determine the size; from their relative position it is doubtful that the camps are associated with the fortress. In the vicinity isolated ditches suggest other camps in the area. This is a complex site, and in the absence of excavation it is open to speculation as to whether the temporary camps preceeded the fortress, or constitute later incursions into the area.

North of Viroconium are the remains of two temporary installations, Fig.10.3, the profile of both camps is incomplete but sufficient is known to give a minimum area. At Site 325 the northeast corner and east alignment of 1000 ft is established, the defences to the north extend over 1500 ft, but nothing is known of the west boundary. The southeast corner lies under the outer defences of Viroconium, however a short section considered to be part of the south alignment defined an area for the camp of at least 35 acres.

To the northeast a camp at Site 326 lies on the remains of Atcham airfield, the northeast and southeast corners are evident together with the east alignment of approximately 950 ft and that to the south 800 ft; from these dimensions the camp occupies at least 20 acres. It would not be unreasonable to postulate 35 acres, if it is accepted that the overall profile may compare with that of Site 325. Camps of this size will accommodate a full legion with auxiliaries. The configuration of Site 326 is unusual in that the entrance on the south alignment is staggered and sited near a corner; the arrangement is not inconsistent with the purpose of a Titulum. A similar offset feature appears in the military complex at Rhyn Park 35 miles to the northwest, (Frere & St.Joseph, 1983:52), although in this instance it forms part of an additional outer defence work protecting another military installation. The enclosures at Site 151 and 142 indicate the remains of settlement in the area.

It was not until the drought of 1976 that the defences of another camp appeared as parch marks in pasture at Attingham Park to the northwest of Viroconium, Fig.10.4, Site 324, prior to this only fragmented evidence had been observed. Some 650 ft of the north alignment, the northeast corner and 800 ft of the east defences were recorded. From these dimensions the area occupied by the camp cannot have been less then 13 acres. J K S St.Joseph also photographed the site and postulates a minimum area of 22 acres, (St.Joseph, 1977:145). To the south in a field adjacent to the A5, Site 149, crop-marks revealed the northeast corner of what appears to be a further camp of which only some 150 ft of the north side, and 80 ft of the east side was visible. The site lies at the confluence of the river Tern and the Severn and is screened to a large extent by woodland, from the orientation of the ditches, the camp cannot have been very large, the ring ditch in the vicinity is in all probability the remains of a barrow. An enclosure to the west, Site 167, is representative of a farmstead, and Roman-British pottery has been found in the locality.

In the drought of 1976, in an area east of the Severn and 4 miles to the northwest at Uffington, crop-marks revealed a temporary camp of some 37 acres with an annexe on the northwest aspect of the order of 4 acres, Fig.10.5. Most of the field boundaries in the area have been removed, allowing the site to be revealed under a single crop. From the evidence for the remains of field boundaries the sketch plan shows good agreement with the results recorded by J K S St.Joseph, in 1975, of 38 acres and $3\frac{3}{4}$ acres respectively, (St Joseph, 1977:Fig.13). All the temporary camps in the area of Viroconium are situated north of the Severn with the exception of an installation near the village of Cound, and the confluence of the Cound Brook with the Severn, Fig.10.6, Site 321; 270 ft of the northeast axis, the northeast corner and 800 ft of the southeast axis was visible, however the profile and dimensions are insufficient to determine the area occupied by the camp, but it could not be less than 10 acres. The site is of some significance, in that it is the only military installation in the area south of the Severn.

The elongated enclosure at Site 156 is an unusual configuration for a settlement, and strongly suggests the remains of a mortuary enclosure, a similar feature was recorded by P Everson at West Ashby, Lincolnshire (Marsac, Riley & Scarre, 1982:Fig.11).

On the north bank of the river Perry at Perry Farm near Whittington, 5 miles east of Oswestry and 23 miles northwest from Uffington another camp was observed and recorded, (Fig. 9.101, Site 327). From the sketch plan the east/west axis was 1650 ft, and the north/south axis 1050 ft. The east alignment changes direction beyond the mid point at an entrance, and an area of some 40 acres compares favourably with the temporary camp at Uffington, (Baker, 1969:Fig.11,Pl.4).

b) Craven Arms - Bromfield area

The Watling Street is aligned south from Viroconium to pass through a narrow valley flanked by the high ground of the Long Mynd and Caer Caradoc Hill, to continue in a more open landscape south to Craven Arms in the valley of the river Onny. In this area there is evidence for a complex of temporary camps of varying size. At Upper Affcot, (Fig.9.87, Site 356), a well rounded corner to the southeast and two sides of a camp were recorded, continued reconnaissance failed to extend the north/south axis of 370 ft, but the east/west axis was subsequently increased to 1100 ft, from these dimensions the area of the camp could be no less than 10 acres; if however the north/south axis is increased by a factor of 2, which is not unreasonable in view of the extended length of the east/west defences, a camp of at least 20 acres may be anticipated.

A short distance to the southwest in the vicinity of Newington at Craven Arms are the remains of three camps as given in Fig.10.7. At Site 316, two of the camps intersect each other and cut across the line of the later Watling street, of these the larger camp exhibits two well defined rounded corners and a north/south axis of 1170 ft, and with a south alignment of some 1150 ft gives a minimum area of 31 acres. Parallel ditches and part of the northwest corner confirmed the existence of a small camp set at an angle in the southeast quadrant of the larger camp at A, the dimensions give a minimum area of 6 acres. A third camp lies to the south, Site 317, where two rounded corners were eventually recorded on the west aspect, and from the dimensions of the ditches the area is at least 3 acres. The configuration of the enclosure at Site 265 suggests other than a settlement and may be considered in the category of a mortuary enclosure, the feature is similar to the crop-marks of a long barrow or mortuary enclosure at Dorchester, Oxfordshire, (Wilson, 1982:80).

Following the course of the Onny to the southeast and 7 miles from the complex at Newington, there is a camp at Bromfield, situated near the confluence of the Onny with the river Teme, (Fig.9.80, Site 357). The evidence for this camp was recorded by J K S St.Joseph in 1943, not all the profile was visible at that time and excavation fixed the alignment of the NW, NE and SW sides, to give dimensions of 1060 ft by 945 ft representing an area of 20.5 acres. The sections confirmed the ditch to be 5 ft wide and 3 ft deep, (Stanford, 1967-68). Unfortunately there were no finds to indicate a date for the camp. There are other ditch alignments in the area of Craven Arms and Bromfield which offer the prospect of further temporary camps.

c) Leintwardine

Leintwardine lies 9 miles to the southwest from Newington on the line of the Roman road, and at the confluence of the Clun with the river Teme. To the west of Leintwardine and south of the Teme, are the remains of a temporary camp sited near Walford, and close to the defences of Brandon hill-fort, Fig.10.8, Site 330. The dimensions of the defensive ditches are 1210 ft by 860 ft, enclosing an area of some 24 acres, the camp is of legionary size and would accommodate a force of 5,000 on the basis of 210 men per acre. Adjacent to the southeast corner is the incomplete outline of a small enclosure of not less than ¾ acres, Site 331. From its position and profile it may have some relationship with the temporary camp, but it is for excavation to determine its origin and function.

Near the village of Brampton Bryan, and one mile west of the camp at Walford, is one of the largest temporary camps recovered so far in the Severn valley area, Fig.10.9, Site 263. Because the remains are distributed over a number of cultivated fields, the crop-mark evidence for the defensive ditches was fragmented, and necessitated several seasons of observation by the writer to complete the circuit, (St.Joseph, 1969:120). From this data the north/south axis extended over 1520 ft, and that of the east/west axis 1760 ft, enclosing a total area of 64 acres. A campaign camp of this size would accommodate at least two legions with auxiliaries, a force of some 13,000 men. Two gates were recorded, one sited at the centre of the west alignment and the other offset on the south alignment. The regular profile of a small enclosure at Site 220 suggests a Roman origin, and it would be of interest to know if it was associated with the camp, although it is some distance away. A small group of ring ditches, Site 304, is also evident close to the west alignment, and the area must have been reasonably clear of vegetation to allow the construction of a camp of this size. In the absence of similar camps to the east, and bearing in mind the legionary dispositions at Gloucester and Wroxeter, this site may well constitute an assembly point for separate forces from different areas, prior to an assault on the objectives. Whether the provision of a supply base in the form of a large granary within Brandon Hill-fort, has any connection with such a force is an interesting hypothesis. Site 307 gives the outline of a small farmstead or pound.

d) Greensforge

Greensforge lies on Smestow Brook, a tributary of the river Stour, and is positioned between Droitwich to the south and the fort complex north on the Watling Street at Stretford. J K S St.Joseph has recorded evidence for six temporary camps in the area of Greensforge, (St.Joseph, 1969, 1973). From the writer's reconnaissance two of these appeared to the west of Smestow Brook, Fig.10.10, Site 322 and 323. The remains were insufficient to determine the area of either camp, a small D-shaped enclosure at Site 81 is of unknown origin. At Greensforge itself two distinct corners with short lengths of ditch were recorded, Fig.10.12, Site 82, from the orientation of the remains with respect to the Smestow Brook, the camps cannot have been very large. To the north at Site 83 are the remains of a more substantial camp, defined by a well rounded corner to the west together with a northwest ditch alignment of at least 600 ft, and a short section to the southwest of approximately 300 ft extending to the modern road. The two outer ditches of a Roman road can be seen to cut across the corner.

10.2.2 Auxiliary Forts

Auxiliary forts are of a more permanent nature, occupied by single units, the auxilia are irregular troops mostly consisting of non-Roman forces serving in three primary roles, a) Cavalry (Alae) b) Infantry (Cohortes) and c) mixed Infantry and Horsemen (Cohortes Equitatae). The strength varied from a small force of less than 500 men up to a larger contingent of a 1000, and occupied areas from 3 to 6 acres depending on the nature of the garrison and requirement. The layout of auxiliary forts closely followed that of a legionary fortress. Some, but not all, have an annexe consisting of a fortified enclosure attached to one side of the fort, usually facing a stream or river to serve as a park for equipment and animals, and on occasions a Bath-House. The early 1st century installations would be in timber, for it was not until after AD100 that forts were built in stone. Sites were carefully selected with commanding viewpoints in a position of strategic importance, such as a river confluence or the junction of a road system. In effect they constitute an occupation force spaced at suitable intervals, to deal with any local insurgency following subjugation of the area by regular forces, (Webster, 1985:213-30 & Johnson, 1983).

a) Alcester

At Alcester an auxiliary fort is sited south of the town on relatively high ground at Primrose Hill overlooking the confluence of the Alne with the river Arrow, the alignment of the Ryknild street also crosses the Arrow at this point, Fig.10.11, Site 328. Only the east corner was visible together with short sections of the two defensive ditches. From its orientation with respect to the sloping ground to the north, an area of some 5 acres may be anticipated, and with the exception of the north corner which lies under the farm buildings, there is every prospect of recovering the remainder of the circuit in the adjacent cultivated fields to the west. The ditches of an enclosure cut through the northeast defences, but the date of the two features awaits the outcome of excavation.

b) Greensforge

In addition to the evidence for a number of temporary camps in the area, there are also two well known auxiliary forts, Fig.10.12, Site 82 and 183, (St.Joseph,1966:300).

The sketch plan includes all the writer's results over the whole period of reconnaissance. Excavation of both forts has produced evidence for occupation in the Claudian period, (Webster, 1970). The fort at Site 82 is the larger with an area of some 5 acres, and from the remains of Site 183, 3.5 acres; St.Joseph gives an area within the ditches of 4.3 and 3.1 acres respectively.

The larger fort has an annexe with a well defined entrance, extending round the east defences and part of the south alignment, with a sharp change in profile at the southeast corner. Due to a modern road intersecting the fort, only three entrances are identified, one of which exhibits well rounded interns at the east gate, Fig.10.13. Within the annexe is a small rectangular feature with an outflow which extends across the annexe ditch; St.Joseph suggests this may be the remains of a tank or latrine pit. External to the north defences is a section of ditch, unrelated to the annexe and in all probability constitutes part of an additional outer defence work.

The smaller fort at Site 183 shows considerable detail of interest. From the position of the gates the fort faced to the north, and crop-marks also revealed some of the construction details, Fig.10.14. The two defensive ditches are only visible in part, but without doubt are representative of the whole circuit. Of the internal features an alignment of pits define the extent of the rampart at the intervallum, it has been suggested that these may be the remains of demolition pits, (Webster, 1965:83), but such features as in other Roman forts could be attributed to latrines or cooking-pits; but it is the distribution of smaller pits indicative of post-holes that are of some significance. At the west gate two parallel rows of post-holes are clearly visible suggesting the existence of timber towers flush with the rampart. At the southwest corner there is also evidence for a configuration of post-holes which constitute the remains of an angle tower, (Johnson, 1983:76). The remains are substantial and it has been argued that the fort was dismantled and the timbers removed. Other features of interest are the two ditches of an outer defence work arranged to form a staggered entrance across the east gate (Fig.10.12), continuity of the alignment is visible along the fort defences to the north; a case has been made for varying forms of such defence works associated with other forts, (Wilson, 1984).

At Site 83, crop-marks revealed the two parallel outer ditches of an approach road leading to the complex, sections of a pit alignment can also be seen to cross the area from northwest to southeast, and if the feature is continuous it would represent a land boundary extending for some 850 metres. The alignment runs parallel to a ditch across the area which appears to maintain continuity along the southwest defensive ditch of the temporary camp. An excavation at the point of intersection with the Roman road would hopefully determine whether the pit alignment is pre-Roman or later. The remains of a large regular enclosure in the area to the west are insufficiently defined for comment. Surface finds and evidence for buildings have indicated a possible area of settlement to the west of Smestow Brook and the fort complex.

c) Wall Town

This particular fort is situated approximately 4 miles west of the Severn on the outskirts of the present day Wyre Forest, in a variable landscape away from any other known military complex. The ramparts are upstanding, particularly to the east and the profile of the fort is clearly identified by the typical rounded corners, Fig.10.15. A farm and its outbuildings occupy the northwest quadrant of the fort, and a modern road intersects the area, the site was identified as a fort from the aerial viewpoint (St.Joseph, 1953:Pl.IX).

Prior to this event, Roman pottery and tiles were recovered from the site during road widening, giving a date from the late 1st to the early 2nd century. The site occupies an area of 4½ acres within the ramparts and when excavated, revealed evidence for the presence of a sequence of permanent forts dating from the late 1st century, with a possible final abandonment in the third quarter of the 2nd century, (Walker, 1965). This is obviously an important installation in the area, the excavator also commented on the fact that the fort was not dismantled at the end of its useful life, as one would expect.

d) Wroxeter

In the vicinity of Wroxeter and to the south are the remains of a permanent auxiliary fort on the east bank of the Severn, Fig.10.16. Evidence for the site was initially recorded by J K S St.Joseph and from excavation proved to be of early 1st century origin, the area of occupation within the ramparts was considered to be 4¾ acres, (St.Joseph, 1951:54). Although the fields have been under continuous cultivation, the outline of the fort has only appeared in any detail once in a decade, but continual reconnaissance by the writer has revealed additional features. Crop-marks have produced fragmented evidence for a system of roads within the confines of the fort to the west, Fig.10.17 Site 314. The existence of timber buildings was inferred from excavation, but none have as yet been identified through aerial reconnaissance.

Adjacent to the south defences however, is an outer ditch serving a similar purpose to the features observed at Greensforge and other auxiliary forts. In an area external to the north defences is a series of pits of unknown function, although the distribution does suggest a pattern rather than a random scatter. There is also a ditch alignment spaced away from the fort defences, with a rounded corner to the northwest. This was at first thought to be the remains of a temporary camp in the area, but to the east the ditch exhibits a slight curve near the field boundary and suggests that the general arrangement is that of an annexe to the fort, and not a temporary camp or part of an outer defensive system as is evident on the south defences. To the east the enclosure at Site 130 suggest some form of settlement.

Two miles to the northeast of Viroconium and on the south bank of the river Tern at Duncote Farm is the outline of a double ditched elongated enclosure, Fig.10.18, Site 329. The corners are rounded with a long axis of 860 ft and a short axis of 220 ft, and from the dimensions of the inner ditches encloses an area of some 4 acres. Because of the very unusual configuration it has been argued that the feature is not a fort, and indeed may not even be of Roman origin. Only two gates have been identified, positioned in the centre of the short axis on the north and south aspect. It is confirmed from aerial reconnaissance that no other gates exist round the perimeter. There is however an additional feature in the form of a small regular enclosure attached to the outer ditch on the south alignment, with an entrance adjacent to the south gate.

An exploratory excavation across the defences by A W J Houghton revealed the ditches to be V shaped in profile, with a slot in the bottom in places suggesting a Roman military style of defence system. There was also evidence for post-holes internally and the pottery recovered has not, to the best of the writer's knowledge, been dated to other than the 2nd century AD. There are various options as to the purpose of this installation, a temporary camp is not in question in view of the double ditch arrangement, and the internal area is far too small to accommodate two cohorts back to back. Clearly the feature is of some military significance, and from the writer's point of view may constitute a storage facility, or supply depot. The construction of forts in the approaches to Wales would no doubt require maintenance and supplies, and it would not be unreasonable to postulate a small military base for that purpose. From its situation it lies near the focal point of a system of roads to the north, south, east and west, and in view of the very limited data acquired so far, such an unusual site justifies further detailed investigation.

In the vicinity to the southeast is evidence for an area of settlement at Site 135. From its position, the remains were under threat from the proposed construction of the Shrewsbury bypass, and a rescue excavation was conducted by Birmingham University Field Archaeology Unit, (Jones, 1990). An initial assessment of the results established five phases of development, including the field systems of an agrarian society extending from the Iron Age into the Romano-British period, with a major change of site use in the 2nd and 3rd centuries. The remains are complex, but there is no doubt that in the final appraisal the changing functions at Duncote Farm, and Meole Brace to the south of Shrewsbury, will have an important bearing on the nature of rural development over a wider area, possibly associated with the site of Viroconium at Wroxeter. The fragmented evidence for a small enclosure is shown at Site 121.

e) Craven Arms

To the north of Craven Arms near Wistanstow crop-marks revealed the outline of an auxiliary fort, sited on relatively high ground overlooking the confluence of the Byne Brook with the river Onny, and the crossing point of the Roman road south from Viroconium, Fig.10.19. From the position of the gates the fort faced east, the profile was readily identified due to the removal of field boundaries in the vicinity, allowing the cultivation of a single crop over most of the area occupied by the fort. On the north alignment where the ground slopes down to the Onny, only the inner ditch was visible in pasture. The remainder of the defences are double ditched, and it is reasonable to assume the same configuration existed to the north. It is considered that the sloping ground does not constitute a steep enough scarp to justify only one defensive ditch. The area enclosed within the inner ditches is some 3½ acres.

f) Leintwardine

The Roman site of Bravonium at Leintwardine lies on the Watling street alignment south from Wistanstow, overlooking the confluence of the Clun with the river Teme and the Roman road crossing to the south. This situation also allows a viewpoint along the valley of the Clun to the north, and that of the Teme to the west and its course as it turns south at this point. Concealed under the village of Leintwardine is a sequence of occupation dating from a vicus in C.60-160 and an auxiliary fort C.160-196, (Stanford, 1968). The lack of aerial evidence for an earlier military installation in such an important position was surprising, and continued reconnaissance eventually revealed the outline of an auxiliary fort at Jay Lane in the vicinity of Leintwardine to the northwest, overlooking the river Clun, Fig.10.20. From Stanford's excavation the area within the ditches was 5.6 acres with a probable date of C.50-78. Subsequently evidence for an annexe appeared on the west defences facing the Clun as one would expect, the profile was incomplete but sufficient to give an area of at least 2 acres.

During reconnaissance in the valley of the Teme to the west, another auxiliary fort was recorded at Buckton Park Farm situated on the north bank of the river above the flood plain, Fig.10.21, Site 214; the detail of the installation has been discussed in Chapter 6, PP:95-99. There is an additional feature in the form of a temporary camp northwest of the fort enclosing an area of some 3½ acres, and it is tempting to regard this as a labour camp for the construction of the period 2 stone fort. The building foundations to the east have been referred to by the writer as the remains of a Bath-House, but in view of the size of the building J K S St.Joseph is of the opinion that it may be a Mansio, however there is some indication for an outflow channel to the south, and the structure may well accommodate a Bath-House and Mansio. Other crop-marks in the area include a ring ditch at Site 299 and the remains of a possible native settlement at Site 301. From his excavation of the known auxiliary forts in the area S C Stanford has postulated the following dating sequence,

Jay Lane	C.50-78	(Fort)
Buckton 1	C.90(?)-120	(Fort)
Buckton 11	C.120-130	(Fort)
Leintwardine 1	C.70-160	(Vicus)
Leintwardine 2	C.160-196	(Fort)

g) Stretton Grandison

The line of a Roman Road to the north from Dymock (Gloucestershire) is well attested, and where it crosses the river Frome the remains of an auxiliary fort were recorded 500 metres east of the alignment, Fig.10.22, Site 332. The area has long been down to pasture, and the evidence only appeared in the form of crop-marks when the land was brought under cultivation. The outline of the defences is incomplete, but sufficient to recover the four rounded corners in a double ditched configuration, together with the whole length of the west alignment, (Baker, 1970). From the dimensions within the ditches the area enclosed is some 4 acres, There are also faint indications for the ditches of an outer defensive system protecting the west gate, the ends of the ditches are staggered and similar to the arrangement associated with a 1st century auxiliary fort at Greensforge (Fig.10.12, Site 183). The fort is well placed, not only to cover a river crossing point, but also close to the junction of two Roman roads revealed through negative crop-marks, Site 11, one to the north from the settlement at Dymock and the other aligned west toward the Romano-British town at Kenchester in the Wye valley. At the road junction there is evidence for disturbed ground, the remains in the area are diffuse but suggest the possibility of a Mansio sited at this point.

h) Forden Gaer

To the northwest of Craven Arms at a distance of some 25 miles, is the well known auxiliary fort at Forden Gaer on the east bank of the Severn, (Fig.9.100, Site 273). The fort occupies an area of some 8 acres on the river flood plain, and appears to have its origin in the Flavian period, with occupation continuing into the 4th century. The course of the road leading to the fort from the Long Mountain to the northeast, is well in evidence from negative crop-marks. At least two periods of fort reconstruction are identified from the divided termination of the approach road at the north defences. In each case coincident with the alignment of a north/south street through the fort, and continuity is suggested from the remains of road metalling external to the south defences. From the photographs taken by the writer there is nothing further to add to what is already known of its complex history from excavation and aerial reconnaissance, (Frere & St.Joseph, 1983:103 & Crew, 1980).

10.2.3 Fortlets

Apart from the evidence for temporary camps and auxiliary forts, there are smaller enclosures of possible military origin worthy of comment, and in the absence of a better description appear under the heading of Fortlets.

a) <u>Redhill</u>

At Redhill is a double ditched irregular feature near Oakengates on the Watling street, some 16 miles east of Wroxeter, Fig.10.23, Site 318. The site lies 650 ft north of the Roman road on relatively high ground, with its long axis aligned northwest/southeast, the inner ditch encloses an area of some 1¾ acres subdivided by an additional ditch across the narrow dimension, part of the inner compound is obscured by a reservoir. The only visible entrances are to the southeast directly in line through the three defensive ditches, although in this area the ditches exhibit rounded corners of military form, the configuration of the north profile is unusual. The site is unexcavated, but in an adjacent field to the west, two metal objects were found suggesting 1st century military presence in the area, (Webster, 1962-63). From its position the site may have accommodated a small unit, or perhaps a signal station with its compatible viewpoint. Site 113 constitutes part of a regular enclosure adjacent to the Watling Street.

b) <u>Wigmore</u>

On the alignment of the Roman Road 5 miles south of Leintwardine, crop-marks revealed the defences of an enclosure adjacent to, and on the east side of the road Fig.10.24. The axis of the ditch to the east extends for some 300 ft with an entrance offset from the centre and two rounded corners, the configuration is similar to the southeast outer defences at Redhill. The evidence for internal structures is diffuse, but sufficient to suggest the presence of buildings. Whether or not the ditches extend across the Roman road is unknown, but from the remains it is, in the writer's opinion a possible Roman military installation; it has been suggested that it may constitute a labour camp for the purpose of road construction. However, its identity must await the outcome of field walking and further investigation through aerial reconnaissance and excavation. From a military point of view, the site has no obvious strategic advantage in that it overlooks sensitive areas such as a road junction or river crossing, but it is positioned to the south of an open landscape in the valley of the river Teme, bounded by high ground to the east and west at a point where the road passes through the Aymestrey gap to cross the river Lugg. The alignment then continues south to the Romano-British town at Kenchester.

c) Tedstone Wafer

In an open undulating landscape 5 miles to the northeast from Bromyard are the remains of a regular double ditched enclosure, Fig.10.25. The site was considered to be military, and excavation has recovered fragments of a single bowl dated to the early 2nd Century, (Webster, 1954). Although the north perimeter of the site is obscured by modern buildings, from the known configuration the area within the ditches is estimated at 1½ acres, sufficient for a small garrison of up to 200 men, assuming they would have been accommodated in tents. The ditches were back filled and there are no surface remains for the site, no doubt due to erosion from continued cultivation.

d) Clifton-on-Teme

Evidence for another small site exists near Clifton-on-Teme some 4 miles to the northeast of Tedstone Wafer, situated on relatively high ground above the valley of the river Teme, Fig.10.26(a). The site has been known for some time and excavated in 1933 with no satisfactory dating evidence. Subsequent excavation has revealed three phases of Roman occupation, and occupies an area of up to 1½ acres within the ditches, comparable with that of Tedstone Wafer, (Stanford, 1959), the finds indicate intermittent occupation from AD 125. The remains of earthworks are visible on the surface and the profile is evident in pasture, Fig.10.27, under cultivation however, crop-marks define more clearly the outline of the defences, Fig.10.28. S C Stanford has suggested that such a military post would have little value for a civilian settlement, and there would be no need in prehistoric and Roman times to take over such marginal land. But this is not necessarily the case, as evidence has appeared for an area of settlement 1½ miles to the north of Tedstone Wafer, in the form of enclosures and penannular gullies indicative of Iron Age circular houses, Fig.10.26(b), Site 55.

10.3 Roman road Alignments

The alignment of Roman roads in the West Midlands is well attested and consolidated through ground observation, (Margary, 1957), for the most part the remains constitute later civil roads, necessary to maintain communication, not only for the occupation forces but also to serve as trade routes between areas of settlement following the conquest. From the evidence for military activity associated with the alignments, the main trunk routes no doubt had their origins in earlier military campaigns, but evidence is sadly lacking for the network of minor interconnecting roads which must have existed.

The remains appear in various forms, from two outer ditches to the hard core of a road surface, and in some instances the raised profile of an Agger. Other indications for an alignment have been recorded by J K S St.Joseph through the crop-marks of pits providing material for an Agger. Where a modern road is coincident with a Roman alignment it is relatively easy to record, but where discontinuities occur and in the absence of any surface remains, an alignment may only be observed through a sequence of country lanes, hedgerows or crop-marks.

10.3.1 Photography

To achieve an acceptable presentation there are many variables to be taken into consideration, of these weather is the limiting factor in terms of visibility, particularly in the presence of haze. Under such conditions an aspect into sun is virtually useless, and depending on the intensity of scattered light other viewpoints will need to be assessed, or await the prospect of unlimited visibility which may be anticipated following the passage of a cold front. Aircraft height is also of importance, too high and the feature is integrated with the landscape, too low and the far view will be constrained through perspective distortion, the balance between height and aspect is a matter of personal judgement in the prevailing conditions. It is as well to remember that raising the camera to include the horizon will result in a significant increase in light, and in the absence of autocoupling the aperture must be reduced accordingly. Aspect is important, and a selection of photographs is presented to serve as a guideline. If the horizon is to be included it is desirable to keep it level, and in any event it should only occupy a small portion of the negative.

a) Illustrations

The alignment of the Ryknild street to the south of Bidford-on-Avon is traced by a modern road, Fig.10.29(a). The photograph was taken in line with the road and the far view is too compressed, but with an offset angle as given in Fig.10.29(b) a compromise is achieved in terms of perspective distortion, resulting in an improved presentation of the alignment. The horizon is still too dominant and a small increase in height would have been to advantage, maintaining the same aspect and adjusting the angle of oblique accordingly.

Continuity of the Fosse Way to the southwest of Cirencester is accentuated by hedgerows and trees, Fig.10.29(c). The aspect directly in line is acceptable as the alignment changes direction in the far view reducing the foreshortening effect. Where an alignment changes direction more than once, as in the course of the Roman road to the south of Kenchester Fig.10.29(d), an offset viewpoint looking into the curve in the middle distance improves the presentation. The line of the road is revealed through the continuity of field boundaries and modern road, with a highlight where it crosses an airfield. The far view is accentuated by a hedgerow through fields of ripe corn on rising ground, a fortunate circumstance.

Where an alignment is well defined, as is the course of the Ermine street northwest from Cirencester to the Cotswold ridge in the form of a modern road, a more dramatic effect may be achieved through an angled oblique. Comparative viewpoints are given in Figs.10.29(e) and (f). If visibility is adequate, extended alignments may be recorded. An example is illustrated in Fig.10.30, and shows some nine miles of the Fosse Way north from Stretton-under-Fosse. Continuity in the form of a modern road in the foreground is emphasised by a tree line in the middle distance. Beyond this the alignment changes direction to the northeast, where it intersects the Watling street at High Cross. With sufficient height it was possible to exclude the horizon, which was indeterminate due to the effects of haze. The slightly offset aspect produced a more convincing presentation.

The Roman road alignment south from Viroconium is a more difficult subject, as it approaches the gap through the high ground of the Long Mynd to the west and the range at Caer Caradoc to the east, Fig.10.31. Continuity is visible initially through the alignment of hedgerows and lanes. It was observed to the best advantage from a viewpoint in line with the gap to present the high ground as a backdrop, with the alignment at a sufficient angle to emphasise its course and reduce the effects of perspective distortion. Unfortunately the lighting conditions were variable along the alignment due to the presence of cloud cover.

10.3.2 Results

In some instances where Roman road alignments have been substantiated, there are significant areas of discontinuity where its course is inferred. Apart from the contributions from field work, an alignment may also be verified through crop-marks, and the sections of road confirmed through this medium are given in Fig.10.1.

a) Shuthonger Common

The general line of a Roman road between Worcester and the legionary fortress at Gloucester is known in part, but its approach to a crossing point over the Warwickshire Avon at Tewkesbury was unknown. From aerial reconnaissance two outer ditches were observed across Shuthonger Common, and continuity traced south through an alignment of field hedgerows to the high ground of the Mythe Tute, overlooking the confluence of the Avon with the river Severn, Fig.10.32, Site 9, in a view south. Subsequently the road across the common was sectioned to reveal three distinct features, consisting of the remains of an Agger 32 ft wide with ditches on either side, in the form of scoops 14 ft wide and 2 ft into the subsoil, intended to provide material for the Agger the upper surface of which has been swept away by the plough. The excavation also revealed additional well surfaced roads of compacted gravel on each side of the Agger, (Webster & Sanders, 1960). The Mythe overlooks a flood plain, and a raised causeway would have been necessary to a bridging point across the Avon before the road turns south on a ridgeway to Gloucester. To the south of Worcester, the alignment was confirmed by the crop-marks of two outer ditches at Clerkenleap Farm on the east bank of the Severn, Fig.10.33, Site 26.

b) Droitwich

The important settlement and fort at Droitwich is served by a network of roads from Greensforge, Alcester, Worcester and Metchley, but as yet there is no known road to the west. In the grounds of Westwood House across the river Salwarpe from Droitwich, two parallel ditches were recorded in pasture, extending for 650 ft and aligned to the northwest, suggesting a possible route across the Severn in the direction of Wall Town or Bromfield, Fig.10.34, Site 170. The ditches are almost in line with a driveway to Westwood House, but the characteristics are not the same and the remains are sufficiently offset to suggest a possible Roman road alignment. From the Ordnance Survey map at the beginning of the 18th century, there has been no change in the driveway to the house, or any other feature which may suggest a reason for the two parallel ditches.

c) Greensforge

The road from Droitwich to Greensforge is well attested, and is visible through crop-marks for a distance of some two miles, passing to the west of Stourbridge; the alignment is shown in Fig.10.35, Site 78 and Fig.10.36 (a), Site 110. Only the metalled surface was revealed in the form of negative crop-marks, with no evidence for any outer ditches. At Fig.10.36(b) a lighter line in the foreground identifies the road alignment continuing to a hedgerow in the far view. It is perhaps not surprising that the only building plot left vacant in a local housing development, is in area B coincident with the line of the Roman road. Continuity to the southeast in area A is visible through parch marks in pasture and crop-marks, Fig.10.36(c).

A road alignment is also postulated to the northwest from Greensforge, its course and destination is uncertain, but negative crop-marks confirm 170 ft of metalling on that heading south of Chasepool Farm and one mile from Greensforge, Fig.10.37, Site 53. Part of an enclosure with an entrance to the west was recorded at Site 86. From Pennocrucium on the Watling street, Margary traces a road south for 4½ miles to Pendeford Hall on the outskirts of Wolverhampton, in the direction of Greensforge. Crop-marks have confirmed the outer ditches of a road to the north from the forts at Greensforge (Fig.10.12, Site 83). A further section of this road was subsequently recovered 2 miles north of Greensforge near Himley, south of Wombourne, in the form of two parallel ditches extending for 500 ft, Fig.10.38, Site 27. The alignment of the two sections is in good agreement with the projection south from Pennocrucium.

d) Pennocrucium

Three miles southwest of the settlement at Pennocrucium on the Watling Street,two parallel ditches were recorded across Ackbury Heath, Fig.10.39(a) Site 144. The ditches are spaced by some 35 ft and extend over a distance of 1300 ft. From Fig.10.39(b) they appear in the foreground as crop-marks and continue northeast in pasture, where a short length of hedgerow defines the east ditch alignment. If the course of the road is projected to the northeast, it would intercept the Watling street at Pennocrucium coincident with the termination of the road north from Greensforge. In the writer's opinion this constitutes a hitherto unknown alignment, and if projected to the southwest would cross the road northwest from Greensforge in the area of Rudge Heath. The heading to the southwest is in the general direction of the fort at Wall Town, and if maintained would cross the Severn to the south of Bridgnorth.

e) Viroconium

The course of the Watling street from the east to Viroconium is well known, for the most part in line with the present day A5. Four miles from the city the modern road diverges to the north from the Roman alignment at Overley Hill, and continuity of the Watling street is identified by negative crop-marks and hedgerows for a distance of two miles before rejoining the A5, Fig.10.40, Site 164. The line of the Watling street and divergence of the A5 trunk road is illustrated at Fig.10.41 in a view west, and Fig.10.42 with a view to the east. Although negative crop-marks reveal the presence of a metalled road surface under the topsoil, in this instance it is not that of a Roman road but the remains of an early 19th century coach road, consisting of soil and clay packed with fragments of stone. The alignment was sectioned in 1962 at point A, Fig.10.40, and established a series of road levels with the Roman remains some five feet below the surface, (Meeson, 1965-68). Four phases were assigned to the Roman period with a total width of metalling in the region of 20 ft, it was not possible to date the Roman remains.

It is of interest that the lowest levels show evidence for four wheel ruts, and because of their proximity the excavator suggests that two lane traffic was not common; this would fit in very well with the concept of an early military road. From excavation no effective outer ditch was associated with the Roman road or any of the structures prior to the 18th century. It would appear that this road has been in continuous use in one form or another from Roman times to the 19th century, when Telford recommended a realignment following the course of the present day A5.

At the site of a disused airfield on Uckington Common to the north of Viroconium, crop-marks revealed the parallel outer ditches of two roads intersecting at 90 degrees, Fig.10.43(a). The ditches are well defined and spaced some 25 ft apart, the alignments appear convincing in terms of Roman roads as illustrated in Fig.10.43(b) in a view southwest. The road to the northwest at A lies in the direction of the temporary camp at Uffington and in line with the military installations at Perry Farm and Rhyn Park. Continuity to the southeast would join the Watling street just beyond Uckington village. With a projection to the northeast, the road at B would intercept the known Roman alignment south from Whitchurch, in the vicinity of the military site and settlement near Duncote. Its course to the southwest would probably join the Watling street to cross the Severn at a point downstream from its confluence with the river Tern.

In a general view of the area to the west as given in Fig.10.43(c), the alignment at A continues southeast in the form of crop-marks at C where it joins a modern road. To the northwest there appears to be continuity with an existing road beyond Black Coppice at point D. The parallel ditches at B are also in line with a road at E, it is not unusual for a Roman road when aligned with a modern road, to show evidence for its continuity where the modern alignment deviates from its course. This is evident at F where the modern road deviates from the alignment at B.

Having presented a reasonable argument for the existence of two Roman roads and a crossing point, all is not what it appears to be. In the first instance a modern road 25 ft wide would not be expected to terminate abruptly as at C for example (Fig.10.43(c)), and the deviation of the road E to the south is later than the disused airfield as it can be seen to cut across the remains of a runway. An earlier plan of the area detail and road system is given at Fig.10.43(d), with the airfield runways superimposed. On comparing the points A to E with the previous figures, it is clear that the crop-marks of the outer ditches derive from the remains of grubbed up hedgerows, defining the boundaries of modern roads which existed in the area before the land was cleared, and the wood at New Plantation disappeared. The point to be made is that misinterpretation of a feature can arise in the absence of supporting evidence, even though a good case can be made for its authenticity.

In this instance to postulate a military route from the camps in the vicinity of Viroconium to those at Perry Farm and Rhyn Park is plausible, introducing a tendency for interpretation to be influenced by believing what one wants to believe. It also emphasises the limitations in the use of a single photograph with a restricted viewpoint (Fig.10.43(b). The Roman road south from Whitchurch is traced by Margary (route 6a), to a crossing of the river Tern just west of Duncote Farm. From this point the alignment to Norton and thence to Viroconium, would intersect the airfield east of Black Coppice and across the trading estate. It is clear that the features under discussion bear no relationship to the Roman road alignment.

The crop-marks are identical with those of two intersecting Roman Roads north of Badbury Rings in Dorset, (Frere & St.Joseph, 1983:11), and demonstrates the uncertainties that can arise in making a qualitative assessment of crop-mark features in the absence of more definitive information.

f) Leintwardine

On occasions interesting features appear along an alignment, as for example on the road south from Leintwardine to Kenchester (Margary route 6c). Two miles to the south of Leintwardine beyond Paytoe Hall, the road follows a rough lane across Wigmore Moor for a distance of one mile, Fig.10.44; Margary comments on the remains of an Agger 30 ft wide and 2 ft high along the west side of the lane. Beyond the lane negative crop-marks confirm its continuity to a point where it appears to intersect the remains of a stream. The meanders are also clearly identified by crop-marks, Fig.10.45. From the evidence the bed of the stream at A does not appear to cut into the road and must have been in existence in Roman times, for at B to the south the road can be seen to deviate slightly to avoid its course, perhaps the result of a small error in surveying. The ground is too disturbed in the area to determine a similar deviation at this point in the alignment to the north. From the general arrangement it is possible that the road was planned from the south, the line of the Agger is also clearly visible in pasture at C.

g) Dymock

A road alignment to the north of the Roman settlement at Dymock is well known (Margary route 610). Presumably there would have been an alignment to Dymock from the fortress at Gloucester, of which no obvious traces remain. From aerial reconnaissance there is evidence for a road tending to the southeast from Dymock, Fig.10.46, the initial heading however is not in a direct line to Gloucester. The alignment is in the form of a negative crop-mark extending across two fields, with continuity established by hedgerow and modern lane as far as the M50, a distance of approximately one mile. The general layout is given in Fig.10.47.

h) Kenchester

On the road north from Dymock an alignment west to Kenchester would appear to originate from a junction at Stretton Grandison (Fig.10.22, Site 11), comment by

Margary indicates that the origin and first two miles of this route as far as Yarkhill is unknown. The line of a road south from Kenchester in the direction of Abergavenny is given at Fig.10.29(d). Where this road approaches and crosses the river Wye one mile from Kenchester, the metalling is traced by parch marks in pasture at A, Fig.10.48(a), the outline of the Romano-British town is visible at B. From the deposits on the north bank, the river meander at this point has no doubt progressed east since Roman times, and the bridging point must now lie under the pasture. Across the river the alignment is confirmed by negative crop-marks at B, adjacent to and in parallel with the field boundary, Fig.10.48(b), this indicates a change in the direction of the road to the southwest. An alignment north from Kenchester to Mortimers Cross and Leintwardine is well attested, (Margary route 6c). In a view south from Arrow Green, Fig.10.49(a), four miles of the alignment can be traced for the most part by hedgerows and trees emphasised by the long shadows particularly over the first two miles before it joins the A4110 to Hereford in the far view. Although traces of the Agger have been noted in places, crop-marks also confirm a section of the road metalling in area A near Stretford. On this section of the road as given in Fig.10.49(b), the marks at B confirm its continuity to the south from a hedgerow alignment.

10.4 Conclusions

a) The purpose of the military installations recovered through aerial reconnaissance in the Severn valley area cannot be considered in isolation, and may only be assessed in conjunction with the military works in adjacent regions, (Webster, 1970 & 1974). A knowledge of the forts in the area is poorly served from excavation, and it is only through S C Stanford's investigations of the fort complex at Leintwardine that a chronological sequence of these particular remains has been established.

To date nothing is known of the forts at Alcester, Stretton Grandison, Wistanstow, Leighton and Duncote. The situation with regard to the number of temporary camps in the area is such that no installation has yet been dated, and it is only through their relative positions spaced by a day's march, including the size and alignment, that lines of campaign may be postulated. Their very size is a deterrent, and short of stripping an area, it may be considered that field walking together with the use of sophisticated detectors may offer an opportunity to recover any artifacts. But in the event of other than military finds - the results could be misleading, for there is always the possibility of settlement within the area, as is evident at Craven Arms for example (Fig.10.7, Site 265). However, the prospect of troops losing coins on campaign is hardly tenable, as is the possibility of recovering discarded pottery. In all probability the larger camps in the area represent advances into Welsh territory over the period AD40 to AD80, and the dating of finds within such a short period may be unreliable. On the other hand, a study of the characteristics of the defensive ditches and gates by section, may offer a more viable guideline. So far excavation has only confirmed the military nature of the camp defensive ditch at Bromfield, and recognition is for the most part derived from a camp profile.

Apart from the auxiliary fort at Stretton Grandison, there is no evidence for military activity between Leintwardine and Gloucester, Wall Town also stands in isolation, and the concentration of temporary camps in the area of Greensforge, Viroconium, Craven Arms and Leintwardine does not necessarily imply forces solely directed from the east. Other military installations must surely await discovery in the area to the south, away from the known road alignments, particularly in view of the proximity of the legionary base at Gloucester.

b) Early military routes in the area in the form of road systems are equally difficult to establish from aerial reconnaissance, and the evidence for most of the known alignments in all probability represent a later phase of civil development. Aerial reconnaissance may however substantiate the course of a road where continuity of its alignment has not been traced, the junction at Stretton Grandison is a good example. A previously unknown road to the southeast from the settlement at Dymock is certain, but the prospect of an alignment west from Droitwich, and a section recovered southwest from Pennocrucium, have yet to be verified, and may only be regarded as tentative.

Most of the known alignments are attested through ground survey as recorded by Margary, and apart from the prospect of new alignments arising from aerial reconnaissance, the results of continued field work also need to be supplemented from the aerial viewpoint where feasible.

CHAPTER 11

THE ROMANO-BRITISH TOWN OF VIROCONIUM AT WROXETER

11.1 Introduction

In addition to the prospect of early settlement in the Severn valley and its implications in archaeological studies, emphasis was placed on the evidence for Roman occupation. From this work a complete pattern of military installations emerged, as presented in Chapter 10. The presence of a number of temporary camps in the vicinity of Viroconium, bear witness to the strategic importance of the area as a gateway into mid-Wales, and is also reflected in the establishment of a legionary base on the site. Following the campaigns into Wales and towards the end of the 1st century, the fortress ceased to have any further military significance and was left to be dismantled, and the area made available to a civil authority. Its subsequent development and function as a Romano-British town, has yet to be fully investigated and understood.

Although a series of excavations on the site (Wright, 1872; Bushe-Fox, 1913-6; Atkinson, 1923-7; Kenyon, 1936-7) were instrumental in highlighting the complex history of the town, the guidelines for their investigations were of necessity based on an appreciation of the surface remains; unfortunately during this period there was no prospect of aerial reconnaissance to enhance the work and assist in the choice of site to solve specific problems through excavation, as is the case in present day archaeological research. It was only after 1955 when the Birmingham University Department of Extra-Mural studies initiated a training school based on excavations on the Baths site, that the significance of a contribution from aerial reconnaissance by the writer was to be recognised.

Over a period of some 25 years, a dedicated surveillance programme was conducted over the site of Viroconium and its environs. Invariably as with many other sites, it has raised problems which are the subject of speculation, awaiting to be solved by excavation. The site encloses an area of 180 acres comprising some 16 open fields which have been subjected to continuous cultivation, with the exception of the Baths site. The acquisition of detailed information with regard to concealed remains, was achieved through the medium of crop marks and the effects of parching in pasture. This has been a slow process due to the variable conditions over successive seasons, compounded by the limitations imposed through the agricultural practice of crop rotation. The evidence from aerial reconnaissance over Viroconium also emphasised the problem of continuous erosion of the remains by the plough, and the pressing need to restrict unauthorised casual excavation on the site; as a consequence a requirement was raised to provide protection, which was ultimately achieved when it became a scheduled monument. Because agricultural activity is now severely restricted, further discoveries within the confines of the town may only be anticipated under exceptional conditions of drought, through parching effects in pasture.

It is the writers intention to analyse and attempt to put into perspective the results of this work, from a collection of over 500 photographs. It is not intended to refer to the detailed excavations conducted within the town area, except where they are relevant to the interpretation of the results from aerial reconnaissance.

Apart from independent excavation directed toward the town defence systems, investigations have for the most part been confined to the town centre, that is to say an area associated with the Baths site and the Forum, from which most of the knowledge appertaining to its origins and history has been established. The results from reconnaissance over other parts of the town have on occasions been misunderstood, and subject to current archaeological opinion. This demonstrates the inherent problems in the interpretation and evaluation of the information in terms of what it reveals, rather than attempting to make it fit a particular hypothesis. As a consequence the interpretation offered by the writer is a matter of personal opinion, based on experience of the medium through which it has been derived, and is subject to verification or otherwise by excavation.

11.2 The Site of Viroconium

The town of Viroconium at Wroxeter, Shropshire, lies on the east bank of the Severn, ¾ of a mile southeast of the confluence with the river Tern. It is situated on a high terrace of glacial sand and gravel overlaying boulder clay, and from its size constitutes one of the largest towns in the province. At a bend in the river a steep cliff rises to a height of 40 ft, and from this point the town lies on a plateau with rising ground to the northeast, the area then extends north across the valley of the Bell Brook intersecting the town on an east/west course before turning southwest to join the Severn. Within the town area, including the defences, there are two distinct soil types, for the most part comprising type 514r, deep well drained coarse loams and sandy soils, locally over gravel, but to the east and south type 572m predominates, consisting of deep reddish fine loamy soils with slowly permeable subsoils and slight seasonal waterlogging. These characteristics are important in terms of recovering concealed features through changes in the growth of vegetation.

From its situation the view north extends across the river Tern and embraces the open fertile Shropshire plain, a relatively flat landscape with the exception of Haughmond Hill three miles to the northwest. The viewpoint east is dominated by the high ground of the Wrekin, but to the south the town overlooks the Severn floodplain, and in conditions of good visibility affords a splendid panoramic view west to the Breidden and the Welsh mountains, with the Long Mynd and Caer Caradoc southwest; the high ground of the Clee Hills may also be seen beyond the ridge of Wenlock Edge to the south.

11.2.1 History

The geographical position of Viroconium is of some importance in that it controlled access to the west, and south through the valleys of the Welsh Marches. From an historical point of view it is generally accepted that the site was first occupied by Legio XIV in C.AD 60 following the campaigns by Ostorius Scapula, AD 48-52, Didius Gallus, AD 52-57, and in the context of the subjugation of Wales under Quintus Veranius, AD 57-58, (Webster & Stanley, 1962-63). Prior to this the only military occupation in the area was in an auxiliary fort immediately south of the site on the east bank of the Severn, and assigned to the Claudian period, (Fig.10.16 and 10.17). Legio XIV remained on the site until it was withdrawn from the province in AD 66, in the subsequent period the history of the fortress is open to debate, although a case has been made for the transfer of Legio XX from its base at Kingsholme (Gloucester) to the site at Viroconium, until Agricola took it north to Scotland. Whether or not this legion returned to the site, its eventual establishment at Chester rendered the fortress at Viroconium obsolete resulting in its demolition C.AD 90. From this date the site was available for civil development, to eventually become the civitas capital of the Cornovii, (Webster, 1975:41).

During the period of military occupation a substantial civil presence would have evolved in the vicinity of the fortress, in the form of a Vicus. With the departure of the legion it is highly improbable that the inhabitants would have dispersed completely, for a number of reasons. Scotland was a considerable distance away in hostile territory, and must have been a deterrent even for the most ardent of camp followers. Nor would it be known how long such a campaign would take, and assuming the fortress was subsequently placed on a care and maintenance basis, implies a return to the base or possible replacement by another garrison. Although there were uncertainties for the future, there would be sufficient incentive for the core of a Vicus to remain. In addition there may also have been a supportive civil presence within the legionary Canabae, under the control of the fortress commander.

In this context it is not necessarily the Cornovii providing extramural facilities for the garrison, but also perhaps retired legionary veterans with specialised services, or involved in trade and local area development, bearing in mind also the needs of a continued military presence in the region. It is reasonable therefore to postulate a pattern of settlement, capable of initiating civil development on the site when it became available. Some consideration will be given later in the chapter as to whether demolition was in fact total, in terms of levelling the site and its defences. It is also of some significance that it did not become a Coloniae for retired legionaries as was the case in other abandoned military bases such as Colchester, Lincoln and Gloucester, (Wacher, 1975).

11.2.2. Evidence for occupation

A general outline plan of the site (Corbett Anderson, 1867) is given in Fig.11.1, and apart from the line of the defences to the north and northeast, is reasonably representative. From the same source Fig.11.2 is a woodcut of a view south across the centre of the town with the Long Mynd and Caer Caradoc in the distance, including the imposing remains of the Basilica on the Baths Site. The feature at that time stood 21 ft high, 72 ft in length and 3 ft thick, and is referred to as the 'Old Work'. Structures on the site had been extensively robbed down to ground level in Medieval times to provide material for ecclesiastical and lay building projects in the region, this is reflected for example in the stonework of the churches at Wroxeter and Atcham.

As early as 1701 a hypocaust and tessellated pavement was recorded at B, Fig.11.1, many other remains and artifacts were recovered in the intervening period to 1859, when a committee was appointed to initiate a more systematic excavation under the direction of Thomas Wright (Wright, 1872). It was evident that the remains of structures existed under the topsoil over much of the town area, and some had even been observed through the advanced ripeness of corn over the walls. Crop-marks then, were well in evidence, but nearly a century was to elapse before aerial reconnaissance began to make its impact on the city.

There is little advantage to be gained in attempting to analyse the results of reconnaissance as recorded in each successive season. The information contained in the majority of the writer's aerial photographs appears in fragmented form, and it is only in the fortunate circumstances of very dry conditions coincident with responsive vegetation, that individual features may be seen to integrate and form a more comprehensive pattern. This does not necessarily imply that all the information previously recorded will appear under such conditions, and cross reference to what is in effect fragmented detail in other seasons, before or after the event, is often of value in substantiating the findings.

11.3 Town plan from aerial reconnaissance

The area occupied by the town is shown in Fig.11.3 in a high oblique looking north, at the centre are the remains of the excavated baths site and the 'Old Work', the course of the Bell Brook is defined by an alignment of trees and vegetation at A. The position of the town on the east bank of the Severn is more readily appreciated in Fig.11.4, in the context of the surrounding landscape; the village of Wroxeter occupies the southwest corner, with farm buildings in an area northwest of the baths site. The early auxiliary fort is situated ½ mile to the south in a field at A, and in this particular season was not visible as a crop-mark.

Leaving aside the military aspects of the town, the remains of streets and buildings are for the most part revealed in the form of negative crop-marks, or parching effects in pasture. Although the evidence under the topsoil suggests the last phase of construction, the relationship of one feature to another is not necessarily contemporary. Further, the detail of buildings and streets may themselves conceal evidence for earlier structures, and what is revealed in effect constitutes a cross section or slice through the town plan at the point where stone robbing ceased. With regard to the nature of the structures that previously existed above ground level, there are few indications from the results of aerial reconnaissance to suggest their individual architectural form, although collectively the remains may indicate its function. The limitations in the recovery of features through aerial reconnaissance are obvious, particularly where remains lie too deep under overlaying deposits to induce changes in the growth of vegetation, and ultimately it is for excavation to elucidate.

11.3.1 Street layout and buildings

In view of the extensive area occupied by the town with its modern field boundaries, roads and lanes superimposed, it is difficult in a descriptive sense to appreciate the Roman layout from individual photographs in the context of the overall area. For this purpose vertical cover over the town is given in Fig.11.5, and discrete areas numbered where relevant for identification and cross reference. The areas are bounded by lanes and roads including the course of the Bell Brook, rather than attempting to identify individual insula. The focal point in this respect is the Baths site in the town centre, a view of the initial excavations by Birmingham University in 1961 is shown in Fig.11.6, and from this it will be appreciated how little of the site was left open to public view from earlier activities. This may be compared with the more substantial remains as they appeared in 1976, Fig.11.7. The hypercaust pattern of the baths suite is detailed, including an open baths site and the outline of the Macellum or market place, excavated when the Keeper's house and site museum were demolished. A new museum and car park is now situated adjacent to the site, opposite the farm buildings.

a) Remains in Areas 1, 2 & 3 (Fig.11.5)

The street pattern in areas 1 & 2 south and east of the baths site represents the initial layout in the form of a regular insula pattern, Fig.11.8, unlike the strip development which may be seen in the Romano-British town of Magna (Kenchester), (Baker, 1962). There is no evidence for continuity of the streets east to join an additional north/south alignment at A, Fig.11.9. It may appear from Fig.11.8 that the streets are in alignment, but this is not necessarily true for in a view south the street at B (Fig.11.9) is offset and curves to join the alignment south. A similar effect may be seen in a street at A, Fig.11.10, this offset alignment terminates at the corner of the baths site, for beyond this point are the faint traces of a building complex. There are other anomalies, for example in area 2 crop-marks in 1975 detailed an arrangement of building foundations which appear to lie adjacent to the street at A, Fig.11.11. The crop has been harvested for silage, but sufficient of the marks remain to reveal the building and part of the street plan. There is an apparent discontinuity in the line of the street where the remains of a wall can be identified at B, this suggests that in all probability the building extended across the alignment. The lighter line at C is considered to be a short section of a secondary street.

In the dry summer of 1976 crop-marks revealed the building more clearly, Fig.11.12, the wall in line with the street is still visible but is easily confused with striations in the crop due to agriculture. The remains of other buildings in the field are also difficult to resolve because of this interference pattern. It is of interest to compare the two obliques and the effect of perspective distortion on the building dimensions. The relationship of the building to the street is not readily apparent, and may only be resolved through excavation. The streets in the insula plan can be seen to continue south into area 3, Fig.11.13, with a short section at A and an extended section B which terminates near the line of the town defences C.

Due to variations in agricultural practice difficulties may arise in interpretation from season to season, for example in 1965 the street system in area 2 appeared as given in Fig.11.14. The lighter lines of open furrows at A produce an interference pattern, but are unmistakable as they extend across the town defences D. The remainder constitute Roman street alignments and may be compared with those in Fig.11.9; the dark spots are not pits but blemishes on the negative or print. The distribution of buildings in area 1 is given in Chapter 5, Figs.35 & 36, D R Wilson has demonstrated the detail and complexity of buildings in areas 2 & 3, (Wilson, 1984:Fig.1). So much depends on the timing of sorties in any particular season, and toward the end of an intensive dry period a few days can make a significant difference in the results achieved, particularly where soils are slowly permeable as is the case in areas 2 & 3.

b) Remains in Area 4 (Fig.11.5)

Weather and crops vary considerably from year to year, in 1965 for example there was little to be seen in the south aspect of area 4, except a street alignment adjacent to the forum and faint indications for buildings in the field, Fig.11.15. The lighter line at A is spurious and not indicative of a street, as it intercepts buildings near the modern road and extends across the site of the forum. For a decade after 1965 the results over the town were fragmented, and it was not until the drought of 1975/76 that the situation was transformed, particularly in Area 4.

The response in the field to the south of the forum is shown in Fig.11.16, from this it is readily apparent that the regular insula plan in area 1 does not extend across the town main street, which is partly in line with the modern road and separates the two areas. A series of stone buildings replacing earlier timber structures are set at right angles to the main street behind a continuous portico, with side streets in places. An unusual feature at A is the circular outline of a Gyrus. The most significant structure however, is a regular enclosure bounded by two concentric walls and rounded corners, its function is at present unknown although several possibilities have been suggested, (Webster, 1975:62). Within the enclosure and in the vicinity to the north, the remains of some buildings appear as positive crop-marks.

In an oblique to the north, Fig.11.17, negative crop-marks delineate the street plan and the layout of the reconstructed forum at A, following the conflagration which destroyed it between AD 165-68 together with the timber shops and houses to the south. On the west side of the feature are the remains of the Basilica, and spaced away from the east wall appear three substantial foundations in line at B, indicative of column bases. In all probability these represent the remains of a colonnade, a similar arrangement is known to exist on the other three sides of the courtyard. To the east is a range of rooms, situated between an inner portico and the exposed remains of the outer colonnade C. The central area is divided by two parallel walls, with an unusual curved feature extending across the area to the east. The north boundary of the forum lies under pasture, and is defined by continuity of the street at D as a parch mark. The forum and the unfinished bath-house which lies beneath it have been excavated (Atkinson, 1923-7).

The ditches at E define the course of the main drainage system leading to an outfall in the river Severn, because the stone covers have been removed the channels appear as positive crop-marks. An additional curved ditch or channel is just visible at F, but whether or not this forms part of the overall system is a matter of conjecture. The remainder of area 4 to the west and north of the forum is given in Fig.11.18, the principal street to the north is well defined, with a range of complex dwellings predominantly to the west. Particularly impressive is the extensive plan of a winged corridor house A at the termination of a side street. From its situation the house commands an unparalleled panoramic view across the flood plain of the Severn. To the northeast of this building is a long rectangular ditched feature of unknown origin B, because it is not understood and does not appear to form a recognisable part of the town plan it has not been included in previous assessments, but its presence cannot be ignored until its function has been determined.

This feature intersects two parallel ditches which extend across the area and the street alignment C. From the crop-marks the ditches appear to have been cut across the street and therefore of a later date. Within a week the situation was reversed, and the street could be seen to cross the ditches. The effect arises from the street foundations subsiding into the ditches, resulting in a build up of humus above the road metalling producing a positive crop-mark. As dry conditions persist and the moisture content of the humus is reduced, penetration of the plant rooting system increases in order to remedy the deficit at a lower level where it encounters the road metalling, inhibiting growth and producing a negative mark. The effect has been observed in previous seasons and has important implications in other areas; the street can be seen to cross the ditches in Fig.11.19. The feature was initially recorded by J K S St.Joseph and considered by him to be military, (St.Joseph, 1955:88,Pl.xix).

To the west the ditches turn south to a point where they are obscured by the winged corridor house, and to the east they also appear to turn south at the hedgerow near the farm buildings. There is no evidence for an entrance along the alignment, indeed the anomaly which arises at the street intersection confirms their continuity. From the orientation they could not possibly constitute the defences of a legionary fortress, for if the west alignment is extended south it would inevitably lie across the cliff and the river Severn. This may be more readily appreciated from Fig.11.20, there is also another unusual feature in that the ditches are not symmetrical at the northwest corner. The theory that a significant part of the town area had been eroded away by the Severn, together with any evidence for the ditches, was discounted by

D Pannett, in a detailed exposition of the river characteristics at that point. (Pannett, 1989). Apart from continuity of the street plan in area 4 (Fig.11.20), there is a dearth of crop-marks in the surrounding fields, indicative of the problems involved in deriving a town plan over successive seasons. That the installation is early there is no doubt, as it pre-dates the buildings and street which lie over its ditches. A section excavated during a training school at Wroxeter in 1958 proved inconclusive due to other disturbances in the profile, although pottery attributed to the Flavian period was recovered from the lower filling of the inner ditch, (Webster & Stanley, 1962-3:113). The function and purpose of the feature in the sequence of events, awaits an opportunity for further investigation.

A viewpoint from the northwest in 1975 is more informative, Fig.11.21. The elongated ditched feature at A is clearly defined, and it is tempting to interpret the remains as representing initial foundation ditches for a building similar to the winged corridor house at B, but the overall dimensions appear to be excessive when compared with other town dwellings (Fig.11.18). At the northwest corner of the two parallel ditches is another anomaly where they appear to terminate in a loop at C, but on closer inspection continuity of the inner ditch is just visible at D; in the very dry conditions the appearance of other ditched features have introduced a more complex and diffuse background. There is a divergence in the alignment of the principal street where it intersects a complex pattern of streets at E, the general arrangement appears to be influenced by the presence of a parallel ditch and street system extending across the field. This is better illustrated in Fig.11.22, and exhibits a number of important variables in interpretation.

At the junction, the metalling of the street A appears to be inordinately wide, perhaps deliberately so to accommodate the additional streets arising from subsequent town development, continuity of the alignment is erratic and also curves against the line of another street in area B. A secondary street C crosses the parallel system to join an alignment D in the adjacent field. There appears to be another divergence at E, but the evidence is diffuse and may be due to the integration of random features in the area, this effect often occurs in low obliques. The principal street can be seen to continue at F in the next field. A discontinuity as it crosses the line of the ditch G is the result of the street subsiding into the ditch, but the crop-mark effect has never been observed to reverse as in the case of the two parallel ditches, and reflects an increase in the depth of humus above the metalling. Subsidence is obviously more extensive due to the increased width of the ditch, compared with that of the parallel ditches. A short length of hardcore surface at H terminates at the ditch and appears to have some affinity with street B, apart from the apparent discontinuity. A series of positive crop-marks in the area between the ditch and modern road are more regular in shape compared to a scatter of pits, their origin is unknown but may represent the remains of timber buildings. With reference to the two parallel ditches, negative crop-marks of building foundations at J are seen to lie across them, the remains have not subsided into the ditches because of the small area and lighter bonded structure, compared with street metalling. One further point of interest concerns the ditch characteristics, a line of metalling along the inner lip is clearly visible at I. Continuity of this system and its implications will become more apparent later in the analysis.

<u>c) Remains in Areas 4, 5 & 7 (Fig.11.5)</u>

The features in area 5 are predominantly in the form of a street system, the response over successive seasons has been variable presenting uncertainties in interpretation, as for example in Fig.11.23,, (1975). Negative crop-marks indicate continuity of the street pattern from area 4, and although they appear to have some form of symmetry, there is a singular lack of evidence for a formal building layout to the north of the ditch at A; the whole area is a complex of pits and other ditched features which strongly suggest the presence of timber structures. The lighter lines at B are spurious and derive from agricultural activities, the remainder of the negative marks are representative of the Roman street layout. At C the response is particularly confusing, but the street alignment at D can be seen to continue on the other side of the modern road, where it curves inward for no apparent reason. In a view west the street pattern is more clearly defined, Fig.11.24 (1976), continuity of the street and parallel ditch from area 4 is traced at A with the course of the ditch given by the subsidence of the streets at B. Other details of interest are the side streets which appear along the west boundary of the modern road C. They are also evident in isolation in area 7 at D, faint traces of building foundations are associated with the side streets. In a view south, Fig.11.25, some of the buildings are visible at A including the outline of a temple B. Together with the evidence for the site of a temple recovered during the excavations by J P Bushe-Fox south of the forum, the two features represent the only known sites of this nature within the confines of the town.

The presence of side streets implies continuity of the town main street to the north, the alignment was already known to exist between the baths site and the forum. Immediately to the north evidence for its continuity proved elusive, indeed on the occasion when a water main was laid along the west side the modern road in 1958, there was no indication of street metalling. The initial results from aerial reconnaissance proved inconclusive, as the negative crop-marks suggesting street metalling were consistent with the response from the 'land' introduced by the plough round the field boundary. In 1960 however the result was positive, Fig.11.26, in the form of a drainage channel associated with negative crop-marks of the street metalling at A. The modern road is seen to diverge in the area, and offers an explanation for the lack of evidence from the excavation of the water main. On this occasion there were no confusing marks from the effects of the plough.

The layout of the street system in areas 4 & 5 is given in Fig.11.27, and with a low oblique the pattern in area 5 is well defined and appears to be symmetrical with the alignment of the parallel ditch and street, A. To the north near the Bell Brook is the outline of an additional boundary ditch B, extending across the field, with a well rounded corner where it turns south at C. Nothing is known concerning its origins and function, but it is a substantial ditch and in the opinion of the writer undoubtedly forms part of the town plan; from the crop response and its configuration, it is highly improbable that the remains constitute a grubbed up modern field hedgerow.

d) Remains in Area 6 (Fig.11.5)

In this area north of the Bell Brook and within the town defences, Fig.11.28, positive crop-marks reveal a complex distribution of pits, many of them rectilinear suggesting the existence of timber buildings. There is no evidence for a formal layout of metalled streets or the foundations of stone buildings, but a pattern of rectilinear gullies A can be seen in the area, overlain by the remains of parallel ditches associated with subsequent ridge and furrow cultivation B. The pattern of ditched features in area C bears no obvious relationship to the remains within the town defences, and will be discussed later in chapter 13. Taking into consideration that crop-marks in general may only reveal a small percentage of any concealed remains, the intensity of occupation in this area of the town must have been considerable.

e) Remains in Area 9 (Fig.11.5)

To recapitulate in areas 4 & 5, crop-marks confirm continuity of the parallel ditch and street system in Fig.11.29 in this oblique in 1964 there is an unusual feature at A, where there is a change in the ditch characteristics. The width is abruptly reduced to a narrow configuration for which there is no obvious reason. It is possible that an entrance existed at this point, and the narrow apparent interconnecting ditch may represent a land drain, introduced by the farmer to reduce the effect of any excessive accumulation of moisture in the area, also the feature is not in alignment with the main ditch. This is a matter of conjecture in the absence of a more plausible explanation. The parallel street is continuous at this point, and although crop-marks fail to show it in this instance, it can be seen at Fig.11.25 where the line of the narrow ditch is just discernible, and by inference the main ditch is earlier than the adjacent building. The street at B, Fig.11.29, continues into areas 7 & 9.

From the point of view of interpretation, crop-marks in area 9 present the most complex pattern of features within the town, Fig.11.30(a). Continuity of the street from area 4 is well defined at A, as is also the street B associated with the parallel ditch. Of the ditch itself there are no positive marks to indicate its course, but subsidence of the streets at C clearly testify as to its continuity. Crop-marks at D are diffuse, but sufficient to suggest that the street alignment (B) continues to the far hedgerow coincident with the line of the town east defences. Data to support this will be the subject of subsequent analysis. On street B where the alignment changes direction there is evidence for a section of metalling E, terminating at the line of the ditch, foundations of unknown form are also visible adjacent to this feature. At F is another apparent alignment extending east across the field, where it appears to continue down the slope in the form of a ditch toward the Bell Brook. The mark is very direct and nearly in line with the plough, it has no obvious affinity with the Roman layout, nevertheless even as a dubious feature it merits comment.

The field lies on rising ground leading to a plateau, where on the north aspect it slopes steeply into the valley of the Bell Brook. Initially there was evidence for a bank along the ridge, this has been bulldozed by the farmer to ease the problem for the plough, hence the diffuse nature of the crop-mark evidence in this area. A lighter band of what appears to be poor soil continues along the ridge, where it curves in the far view to terminate parallel with the hedgerow. Other evidence for the ridge can also be seen to continue into the next field across the east defences, (Fig.11.30(b)). The two effects do not necessarily derive from the same source, and introduces an element of uncertainty in this area. The remains of buildings are distributed throughout the field and from their orientation do not suggest a formal planned layout, Fig.11.30(a). A central street G is aligned south from the Bell Brook across the field. The feature at H appears to enclose a particular area of interest, but this is illusory for it represents the course of a channel through the complex leading to the Baths site, and is considered by the writer to be the remains of the town aqueduct; there is also evidence for stonework in places which has no obvious relevance to buildings in the vicinity, its origin and alignment along the ridge is not readily apparent from the existing crop-marks. The interpretation of the feature itself is not obvious, for the crop-marks suggest a wide channel, but the alignment where it intersects the main street is perhaps more representative in terms of dimensions. Any superficial assessment of the results from aerial reconnaissance often leads to misunderstanding in archaeological terms, and the maxim of look and look again cannot be overemphasised.

A viewpoint to the northeast, Fig.11.30(c), shows the details of buildings and other features in the south area of the field. Along the central street is the line of a drain A, revealed as a positive crop-mark in the absence of stone covers. The channel intersects the course of the aqueduct at B and terminates on the ridge. It is positioned approximately down the centre and not at the side of the street, as is generally the case. A similar feature is visible along the main street at Kenchester, (Baker, 1962:PL.1). Of particular note are the remains of a fine house situated on the high ground at C, with an enclosed courtyard or garden and a colonnaded portico, the heating system is identified from the positive crop-marks of a collapsed Y shaped hypercaust. The main feature in the area is a large walled enclosure at D, of unknown origin and function. A parallel inner wall is also visible in places, E.

There are no indications within the enclosure for a formal layout of streets or buildings, its south boundary is not visible and may be in line with the lane at F. There is certainly no evidence for it to the north of area 2, nor are there any obvious entrances along its known boundary, the whole edifice is an enigma and its function is currently the subject of speculation. There are a number of features within the enclosure, in all probability unrelated to its purpose, and representing different periods in the town development. From reconnaissance over the area by the Cambridge Committee for Aerial Photography, at a later period during the drought in 1975 than the writer, parch marks in the pasture confirmed the detail of a granary with another building to the south, (Wilson, 1984:PL.XVI); faint indications for its existence are also visible at C, Fig.11.9. The metalling of a street at G (Fig.11.30(c)) terminates between the structures, evidence for another street H originating from the east, enters the enclosure intersecting the remains of the granary to the north. The foundations of buildings were also recorded in the northeast corner of the enclosure in area I, but not in alignment with the boundary wall, the street at H also cuts through these remains. This implies at least four periods of occupation in the town development, the granary, enclosure, buildings and the street at H. Another dominant feature is the ditch at J, and it would be more appropriate at this juncture to defer comment, pending the discussion relating to the evidence for a legionary fortress.

f) Remains in Areas 8 & 10 (Fig.11.5)

Over many seasons of observation there was little indication of occupation in area 8, with the exception of the town defensive system. In view of this, the area north of the Bell Brook has been regarded as devoid of stone buildings. It was not until 1975 that dry conditions were sufficiently prolonged to give an unprecedented response in area 8. Crop-marks in Barley, Fig.11.31, revealed in detail the impressive remains of the town defences in the form of the robber trench of the wall A, together with the dark band of a wide outer ditch. To the rear of the defences the area is complicated by pereglacial features, but there is evidence for a substantial building at B, of particular interest are the remains of at least four column bases set in a curve C, there is also some evidence for an outer wall at D. To the north of the building is an alignment of streets E leading to a corner on the defences. In the area to the south are a number of positive crop-marks delineating small rectangular features suggesting the remains of graves. There is also a scatter of pits over the area, reminiscent of occupation similar to the distribution in area 6, but not with the same apparent density.

From his excavations in the area, T Wright postulated an entrance through the defences in line with the Watling Street and coincident with a modern lane, A, Fig.11.32. Continuity of the street within the defences, prior to crossing the Bell Brook, is identified by crop-marks at B. Side streets from the alignment also extend into area 8 as given at C, but do not constitute a regular pattern. Apart from the line of the town defensive ditch which lies along the higher ground north of the Bell Brook, there is a lack of evidence for occupation in area 10, except for a side street A, Fig.11.33, extending east from the Watling Street for a short distance, and terminating at what can only be described as a series of lighter bands on rising ground B. Evidence for the side street was a rare occurrence but indisputable, and in the absence of excavation its purpose remains a matter of conjecture. The Watling Street C crosses the Bell Brook to continue south at D as the main street in area 9. There is no crop-mark evidence for an alignment of the Watling Street from the civil defences to the town centre, as it changes course to cross the Bell Brook through relatively low ground.

11.3.2 Summary

This concludes the review of the crop-mark evidence from aerial reconnaissance by the writer, over the area within the town defences. In view of the number of photographs taken during the period of observation, it has only been possible to include a representative selection to support the assessment, and demonstrates the complexity of the town layout derived from occupation over at least three centuries. Leaving aside the excavations associated with the forum and baths site, and in the vicinity, little is known of the overall town development in other areas.

Aerial reconnaissance alone cannot provide definitive answers, nor have the limited excavations conducted within the confines of the town, away from the public buildings. But an assessment of the individual investigations where relevant, together with aerial photography, may provide a more viable guideline than through speculation based solely on the results from aerial photography, each new feature recovered appears to initiate a degree of conjecture, in some instances entirely unsubstantiated, and irrespective of a considered interpretation. Finally it is for excavation to elucidate, but it is only through the results of aerial reconnaissance that specific problem areas may be identified, and hopefully contribute to a realistic future policy on the site.

By 1958 a preliminary plan of the town was feasible, Fig.11.34, the use of oblique photographs reflected a significant lack of control points resulting in inaccuracies, but it did serve a useful purpose as an initial attempt to put the results into perspective. Subsequently at the conclusion of the survey, sufficient detail had been recovered to produce a more comprehensive plan. For the purpose of specific analysis an updated layout is given at Fig.11.35, and to simplify the argument the details of buildings have been omitted, except where they are relevant to the discussion. As so little is known concerning their individual function and sequence in the town development, to include them would not materially assist in the proposed interpretation with respect to the parallel ditch and street alignment, legionary fortress, town civil defences and aqueduct.

11.4 Early Defences (Fig.11.35)

The course of a parallel ditch and street alignment across the town in the form of crop-marks, has been identified in section 11.3.1. Its configuration at A in Fig.11.35 suggests some form of defensive system with the parallel metalling as an intervallum road, spaced away from the ditch to allow for a rampart, (Baker, 1967-8). The evidence for it originated from a section excavated by (Dame) Kathleen Kenyon. In terms of early defences at Viroconium, an analogy was drawn with the arrangement at Verulamium, where the line of the Watling Street approaches its 1st century defences at an angle. By inference a section was excavated across the alignment at B, (Kenyon, 1936-7), in the absence of evidence from aerial reconnaissance it was a remarkable deduction. Unfortunately the section did not extend far enough to the south to recover evidence for the associated road, which would not have been anticipated at that time. The section did however reveal the remains of a rampart with 1st century pottery embedded in it, together with the profile of a substantial ditch. In her summary K Kenyon considered that the filling of the ditch was late, probably 4th century which would negate its function as an early defensive system; on the other hand to quote "There were indications that this ditch had been re-cut as the original lip of the ditch was overlapped by some layers of metalling which had been cut by a later ditch". The excavator concluded that the ditch and bank at Viroconium had its origins in the 1st century, and that the extended town area enclosed by the late 2nd century defences had subsequently been reduced, and the line of the original 1st century defences refortified.

The alignment to the east was sectioned (Johnson, 1975:17) revealing a platform of worn cobbles 3½m wide terraced into the slope at C, Fig.11.36, two other sections D & E confirmed its continuity. At a distance of 12 m down the slope from this feature the long section exposed the remains of a V shaped ditch F, which in the opinion of the excavator had probably silted very rapidly after its original opening. The two features C and F are also identified on a sketch plan drawn by S Johnson, Fig.11.37(a). Excavation was based on aerial photographs by the writer indicating a number of unusual crop-marks in the area, including the possible alignment of a defensive system east/west across the town, (Baker, 1967-8), but the investigations were discontinued due to the excessively dry conditions, and it was considered by the excavator that the results so far, had failed to establish that the features on the hill-slope were ever defensive in nature, and the ditch may have been dug to mark out some feature along the slope. This implies that it was not associated with the alignment as sectioned by K Kenyon.

It would be appropriate at this juncture to examine in more detail the combined evidence for continuity of the alignment from aerial photography and excavation results, bearing in mind that the only positive data is reflected in the excavations by K Kenyon and S Johnson. The aspect of the sketch plan by S Johnson (Fig.11.37(a)), has been reversed to provide a viewpoint west, and the scale expanded to match that of K Kenyon's section, Fig.11.37 (b) & (c) respectively to allow a direct comparison between the two sections. In the absence of evidence for the road metalling in K Kenyon's section, a data base is given by the ditch and a slot at G which appears in both sections. The match derived from the sketch plan is not perfect, but sufficient to establish a relationship between the two profiles. The width of the road metalling and the spacing from the ditch of 3½m and 12m respectively (Fig.11.36) is in good agreement with the crop-marks of the known alignment.

Additional evidence may also be derived from the writer's aerial photographs of the excavation. In a view west, Fig.11.38(a), the only indication for the ditch is given at H through a discontinuity in the Roman street alignment, but the line of the road metalling is clearly defined by a parch mark at I. Continuity in area J is diffuse due to the effects of agriculture, but the alignment can be seen as a crop-mark in the far field at

K. To simplify the discussion the photographic evidence is considered in conjunction with the section identification as given in Fig.11.36. From Fig.11.38(a) continuity of the road alignment I, intersects the long section at C, later in the excavation other sections were added. With the parch mark of the metalling I as a datum, its continuity was confirmed by the cobbled surface recovered in two other parallel sections at D and E, Fig.38(b). The remaining sections were not completed. It will be appreciated from the contours on the slope that the line of the metalling is approaching the crest of the ridge, where it may have been affected by the farmers activity in reducing the land profile in this area. In sections D and E the excavator found the surface to be only one stone deep, implying that at C the foundations were more substantial. Parch marks show no evidence for the ditch, but its relative position is given at F.

It is for archaeology to resolve the apparent anomaly in the ditch profile through further investigation along its alignment. If the ditch was re-cut as K Kenyon suggests, its position on the sloping ground may well have determined the nature of the profile. From the evidence presented, the writer is of the opinion that a case has been made for continuity of the road and ditch system in this area. It is also apparent that the system is beginning to deviate away from the ridge, and not in line with the crop-mark anomaly at this point, (Figs.11.30(a) and 11.36). This assessment is not intended in any way as a criticism of the excavation, but to reconsider the findings in the light of other relevant detail from aerial reconnaissance. The position of the sections is given in Fig.11.35 in the context of the overall town plan.

11.4.1 Summary

Having established the existence of a ditch and bank system across the town, it merits further consideration as to its function, and may be conveniently discussed under the following headings.

a) Origins
b) Early town defences
c) Subsequent town development

a) Origins

That it constitutes some form of defensive system there is no doubt, although there is no evidence for a gate or entrance along the whole alignment, apart from the anomaly in the ditch to the west. There must have been at least one, but if the ditch was bridged there would be little evidence for it if any from crop-marks, or obscured from view, as for example at the point where it intersects a Y shaped modern road junction. The town main street to the north would also cross the alignment in this area. K Kenyon interpreted the section as evidence for early town defences in the 1st century, but her findings were subsequently considered to be inconclusive. There is other evidence from aerial reconnaissance however to support the hypothesis, but not necessarily in the form of civil defences. The metalling parallel with the ditch suggests an intervallum road of military style, there is an additional feature to support this in the form of a line of metalling on the inner lip of the ditch A Fig.11.35, also confirmed by K Kenyon, the evidence for it appears as a negative crop-mark (Fig.11.21). This is consistent with military practice as a foundation to stop the rampart slipping forwards, (Johnson, 1983:56-65). The profile of the ditch in K Kenyon's section is not what is normally expected of a military work, but there was evidence for a re-cut which may have destroyed the original ditch profile. On this basis the early alignment has been provisionally assigned to the military phase at Viroconium, associated with the establishment of a legionary base on the site, and considered to be representative of an outer defensive system for the fortress Canabae, (Webster, 1990). This will be more readily appreciated in a later discussion appertaining to the legionary fortress.

b) Early town defences

It is generally accepted that the early legionary fortress on the site was dismantled in C. AD90, and in accordance with military practice the fortress accommodation together with the defences would have been reduced to a level site. Presumably this included the suggested line of defence enclosing the Canabae. Apart from the prospect of a military presence remaining in the area to assist the external resident population in planning the town centre, it is doubtful that civil defences would have had a priority, for in itself the associated Vicus would have been unprotected except for the facilities within the confines of the Canabae. However there is no evidence for back filling of the ditch recovered by S Johnson, nor is there more than one rampart indicated in the section by K Kenyon, but she considered that the ditch had been recut, and this implies that it was enlarged at some period in the town development. Refurbishment of the Canabae defences would only account for the north circuit, but there is no reason why the fortress defences to the east and south should not have been adopted, or reopened. The situation is not unknown, for at Exeter the defences of an earlier legionary fortress were retained by the new city, (Frere, 1984:66). No doubt much would depend on the status and strategic importance of the site.

Pending further excavation, aerial reconnaissance can only confirm the existence of a defence work across the town. S S Frere and J K S St.Joseph place this system in the 2nd century, with a much larger area enclosed by a wall, bank and ditch in the 3rd century, (Frere & St.Joseph, 1983; 162-166). However a section across the defences on the south perimeter established a date in the late 2nd century for the outer bank and ditch, with a town wall inserted into the bank at some later period, (Webster, 1962). This does not materially assist the argument, but does serve to highlight the inherent problems in the interpretation of evidence from aerial reconnaissance.

c) Subsequent town development

It is suggested by K Kenyon that the town area may have been reduced and the earlier defences refortified. The results from aerial reconnaissance do not support the hypothesis, for example at A, Fig.11.39, building foundations extend over the ditch infill and also lie across the intervallum road at B. The incomplete remains of the structure at C are situated very close to the line of the ditch and there is some evidence for stonework over it, if an entrance existed at this point in the defences as suggested from the last phase of construction, it must be earlier than the building. The erratic behaviour of the street at D as it changes direction in line with the intervallum road, probably belongs to an early phase in the overall town development, for its continuity east is in alignment with the central street plan. The divergence cannot be ignored, and in the absence of a more plausible explanation suggests that the original intention was to continue the alignment west. This implies that, prior to the development of the street layout to the north, the parallel ditch and road system was still functional.

Subsequent development in the layout of streets external to the defensive system is not perhaps as haphazard as it first appears to be. Part of the outer street E is aligned with the intervallum road, and changes direction to continue east parallel with the central insula plan to join the intervallum road at F, and is not necessarily all of one period. A refortification of the inner defences implies reconstruction of the rampart, and to some extent the remains would tend to screen the earlier streets across its alignment, and there is no evidence for this. Further, there was no comment by K Kenyon on rampart reconstruction and no obvious evidence for it in her section. The most convincing argument against a reduction in the town area is at G, where streets cross the ditch and subsidence of the metalling has occurred through consolidation of the infill over the centuries.

From the evidence presented, it is concluded that some form of defensive system across the town originated during the early military phase, and was subsequently adopted for the initial town civil defences, although it is generally accepted that the majority of Romano-British towns did not receive any defences before the late 2nd century, (Frere, 1984;66). Taking into account the unique situation of Viroconium as a frontier town in the approaches to Wales, it may have been a special case. In view of the crop-mark evidence for the width of the ditch, the recut appears to extend across the town as far as the ridge in area 9, where the profile changes due to the sloping ground, as given in the section by S Johnson. Beyond this point there is unfortunately no crop-mark evidence for the termination of the defensive system, at or in the vicinity of the later town east defences.

There remains the question of 3rd century pottery recovered from the upper silt of the ditch in K Kenyon's section, and also above the original rampart. This suggests that the ditch had fallen out of use and allowed to silt up over an indeterminate period, prior to the 3rd century deposits. There is no indication that the ditch had been back-filled, nor is it evident in the section by S Johnson, this implies that it only occurred in areas where it became necessary to accommodate street metalling or building foundations, and the latter is only apparent from aerial reconnaissance in two places on the alignment. The excavator considered that the ditch on the sloping ground to the east had silted rapidly after its original opening, equally well it may have been cleaned out over a considerable period, and only allowed to silt up when it was no longer functional. It was also postulated that the intervallum road in Fig.11.36 constitutes a foundation for the town aqueduct, and will be the subject of analysis in Chapter 13.

From the argument, it is the opinion of the writer that some form of defensive system existed round the early nucleus of the town, before the advent of the late 2nd century defences. There is no convincing evidence from aerial reconnaissance for a reduction in the town area, by refortification of the early defences. In the event, it could not have occurred before the 4th century reconstruction of the civil defences on the north perimeter. Apart from the guidelines from the results of aerial reconnaissance and limited excavation, there is an obvious requirement for several substantial sections across the alignment, to derive sufficient statistical data in order to establish a realistic time sequence for the system.

The results of the excavations at Viroconium by S Johnson in 1975-76 await formal publication, and the excavator has kindly allowed the writer to include a copy of his provisional findings for reference, as given in Appendix 2.

CHAPTER 12

VIROCONIUM: LEGIONARY FORTRESS AND CIVIL DEFENCES

12.1 Legionary Fortress

The existence of a military base on or near the site of Viroconium was postulated through tombstones dedicated to soldiers of the XIVth legion, and found in a Roman cemetery in the vicinity of the Watling Street outside the northeast defences of the town, items of military equipment and coins of Claudius I have also appeared in excavations, (Webster & Stanley, 1962-3). As given in Chapter 10 there is ample evidence for military activity in the area, but despite a thorough search from the air there were no indications for a legionary fortress.

It was at first suggested that the parallel ditches of a military work northwest of the forum may represent part of the fortress, but this was discounted for the reasons given in Chapter 11. It was not until the drought in 1969 that crop-marks revealed a substantial ditch A, Fig.12.1(a), some 4 metres wide on an east/west alignment in the area northeast of the baths site. From the crop-mark evidence its course is obscured by the street B and there is a well defined discontinuity at C. The alignment continues east and clearly lies under the negative crop-marks of buildings and the walled enclosure in area D. Beyond this point the ditch turns south in a well rounded corner, with no further evidence for its continuity. In this area the feature is coincident with the town east defences, and lies under the remains of the rampart and wall. A lighter response in the crop at E adjacent to the ditch appears to suggest some form of metalling, but could equally well represent other remains as it follows the contour of the ditch at the corner, this is more clearly defined in Fig.12.1(b).

At the intersection of the ditch with the proposed aqueduct channel at F, Fig.12.1(a) the evidence is clear in terms of two ditches crossing, but the relationship of one to the other is indeterminate. However from the interpretation so far the ditch is obviously early, and it can be safely assumed that the aqueduct channel cuts through or lies above the ditch. An additional feature of interest (Fig.12.1(b)) is a street alignment at G, this crosses the walls of the enclosure and the ditch, and continues across the line of the rampart; it is important to note that the feature is not in alignment with the ditch. and there is also some indication for side streets at H. Earlier in the season the crop-mark across the rampart and ditch was clearly defined, but in this photograph it was beginning to disintegrate in the dry conditions as the plant roots penetrated the metalling for moisture to sustain growth, and implies a semi-permeable surface in this area. Another street joins the alignment at I and continues south into the next field, parallel with the town east defences. The writer considered these remains to be representative of the fortress defences, but this was only a single ditch and archaeological opinion was uncertain in the absence of a second ditch. In the event, later that year (1969) excavation revealed the remains of a military style rampart in the north/west corner of the Macellum on the baths site, this was adjacent to the modern road and precluded further investigation regarding any outer defences; behind the rampart were the remains of an intervallum road. Subsequently excavation revealed evidence for a timber gate southwest of the Macellum, and in line with the rampart. In view of this evidence, and from the configuration of the ditch to the northeast, it was concluded that it represented the north defences of a legionary fortress. Interpretation of the excavations by K Kenyon near the northeast corner, established the east defences of the fortress.

Earlier excavations on the baths site had already revealed the foundation slots of two timber barrack blocks in an east/west alignment, but were not consistent with the orientation of the double ditch north of the forum, (Webster, 1966-80). Further, aerial reconnaissance confirmed that these ditches were some 10 degrees off alignment with that of the single ditch northeast of the baths site. It was concluded that the double ditches were not associated with the legionary fortress, and represented the remains of another military installation whose function has yet to be determined.

Other evidence from aerial reconnaissance in 1975 consolidated the general outline of the fortress, but so far no attempt has been made to detail and put into perspective the results from individual excavations external to the baths site, together with aerial reconnaissance.

12.2 Excavations on the fortress defences

The object of this discussion is to detail the characteristics of the fortress defences as revealed through excavation, and attempt to coordinate the findings with the results of aerial reconnaissance.

12.2.1 Excavations by K Kenyon

In 1936 K Kenyon cut three sections across the town east defences, A B and C as given in Fig.12.2, the results from aerial reconnaissance appertaining to the fortress north defensive ditch are also included on this plan. The sections are detailed in Fig.12.3 and are dealt with in reverse order, section C north of the modern lane revealed two ditches spaced some 34 ft between centres with the inner ditch partly under the town wall, to the east are the remains of the later town civil defences. Both ditches were assigned to the 1st century. At section B south of the lane the inner ditch is in the same relative position, but the outer ditch with the same spacing as in section C was considered by the excavator to be 2nd century. Presumably if it is of that period its construction has destroyed any evidence for the 1st century ditch. Section A was cut some 250 ft south of section B and revealed evidence for two distinct phases of rampart construction, the inner termed the 1st bank was cut into by the town wall, and considered by the excavator to be early from the 1st century pottery recovered on the original turf beneath it. Because of the arrangement of the turf facing adjacent to the wall, archaeological opinion considered this rampart to be military in origin. In this section there was no evidence for ditches associated with the rampart as in Section B and C, only the profile of the inner 2nd century ditch and the overall 4th century reconstruction. Although at this stage the results from aerial reconnaissance, and excavations by K Kenyon with respect to the fortress east defences supported the hypothesis, it was not until excavations in the area, (Johnson, 1975:17), that more convincing evidence was forthcoming, as given in Fig.12.2, sections D, E, F and G.

12.2.2 Excavations by S Johnson

Excavations associated with the fortress on the north and east defences were conducted in 1975-76, and an aerial view of the sections in 1975 is given at Fig.12.4(a). A cut at A represents the reopened section of K Kenyon, the remainder of the sections B were initiated by S Johnson. To relate the sections to the town plan, a hedgerow at C defines the line of the east civil defences. Parch marks in the pasture reveal the outline of the walled enclosure D, together with the remains of buildings in area E. There is also evidence for part of a street alignment at F, subsequently identified as the fortress via Sagularis.

From a viewpoint south as given Fig.12.4(b), the sections appear in more detail, together with the ground contours.

a) East defences (Fig.12.5)

The section by K Kenyon at C was reopened on an exploratory basis, and from this a new section D cut in parallel 6 m to the north. This section profile is given at Fig.12.6 together with the excavators comments, only 17 metres of this section are shown, the remainder was not fully excavated. The results confirmed an inner ditch partly under the town wall, V shaped and only 1.2 m deep representative of that in the adjacent section by K Kenyon (C.Fig.12.3). Because of local constraints, the section did not extend far enough east to recover Kenyon's second ditch. Of particular relevance in Fig.12.6 is a rampart (A) found with turf in military style, and a gully (D) spaced some 20 ft from the ditch centre, this compares favourably with the gully visible in Kenyon's section B, Fig.12.3. A further cut was made through the east defences, at E, (Fig.12.5) but the section was not completed.

b) North defences (Fig.12.5)

A third section F was cut to locate the ditch and street on the north alignment. The ditch was V shaped, 3.6 m wide and 1.6 m deep, and from the crop-mark evidence is the same ditch as given in section D. Fig.12.6. In this area the street had been resurfaced several times, and to the south were the beam slots of rectilinear buildings. With a spacing of some 10 m from the ditch, the street at this point could be interpreted as the remains of the fortress via Sagularis. The street was also confirmed in section E, Fig.12.5. Clearly the street alignment west from the town civil defences is not parallel with the military ditch (G.Fig.12.1(b)), but is coincident with the via Sagularis for part of its course. In 1976 a section at G, Fig.12.5, revealed a short length of ditch parallel with the fortress defensive ditch, but all that remained was a small discontinuous V shaped slot, 0.5 m deep. It was spaced some 34 ft from the ditch centre, and compares favourablv with the dimension of 33 ft between the centres of the two ditches in K Kenyon's section C, Fig.12.3, where it was assigned to the 1st century.

12.2.3 Further aerial evidence

In 1976 a parch mark of the street A, Fig.12.7(a), suggests continuity south and is confirmed as a negative crop-mark in the adjacent field at B. The alignment is almost parallel with the town east civil defences C, and extends south as far as the site of Finger Post Cottage at D. Its relationship with the town street layout to the south and east of the central baths site, is given at Fig.12.7(b) in a view west. It is clear that there is no extension of the town street plan to the east, to join the alignment E. This may now be confidently interpreted as the fortress via Sagularis or intervallum road, for at F is a series of long narrow stone buildings situated between the rear of the fortress rampart and the intervallum road, representing the remains of cook-houses and other buildings. Similar features are to be found in legionary bases elsewhere, (Webster, 1985; Johnson, 1983). Another feature of interest is an apparent gap in the intervallum road at G, this is unusual in that the road round the defences is normally continuous. A plan of the detail and associated sections so far is given at Fig.12.8.

12.2.4 Analysis of the fortress north and east defences

To support the analysis, the section by S Johnson as given in Fig.12.6, has been adopted by the writer as a data base. The first item of interest is the fortress ditch and rampart A, together with the evidence for a gully at D. From the results presented, the inner fortress defensive ditch is identified on the north and east alignment as given in Fig.12.5. The spacing between the ditch centres of the short length at G and the fortress inner ditch, is in good agreement with the spacing between the two 1st century ditches at section C, Fig.12.3, and is close enough to be disregarded as a coincidence. In the opinion of the writer there are two defensive ditches associated with the fortress. In section A however there is no evidence for either ditch, which may have been destroyed by the inner 2nd century defences. It is apparent from the section drawing that K Kenyon did not excavate under the wall and berm, and in view of the rampart characteristics there is no doubt that the dimensions given by the wall and berm would allow sufficient space to accommodate the fortress inner ditch. Because the line of the later civil defences in this area deviates to the west by some 4 degrees, this ditch would lie partly under the wall and to the east compared with its position in sections B and C, (Fig.12.3); the outer fortress ditch would then have been in line with and subsequently destroyed by the 2nd century ditch. The architecture of the rampart compares favourably with that in section D. Fig.12.6.

From section F in Fig.12.5 there is a distance of some 35ft between the fortress ditch and the intervallum road, sufficient to accommodate a rampart of at least 15 ft leaving space to the intervallum road for the cook-houses and other buildings. Consideration is now given to the gully as revealed in section D, Fig.12.6 and section B, Fig.12.3, with approximately the same spacing from the centre of the fortress inner ditch, of 21 ft, and 19 ft respectively. From the following dimensions there appears to be a relationship between the fortress defences and those postulated for the Canabae.

Sections	Ditch to Gully (Centres)	Rampart
D, Fig.12.6 (fortress) S Johnson	21 ft	15 ft
B, Fig.12.3 (fortress) K Kenyon	19 ft	12 ft
Fig.11.37 (a & b) (early defences) S Johnson (CHAPTER 11)	22 ft	14 ft
Fig.11.37 (c) (early defences) K Kenyon (CHAPTER 11)	19 ft	13 ft

Taking into consideration the possibility of small errors in the excavation interpretation and drawing of the features from the individual sections there is reasonable agreement, and suggests that the gully represents a drain at the tail of an early rampart. If the data from the fortress section is considered to be consistent with military practice, then the early defences are also of military origin and support the hypothesis that they are associated with the fortress as a defensive system for the Canabae; it is noteworthy that the spacing between the ditch and intervallum road of the early defences is similar to that of the fortress. It follows therefore that the recut in K Kenyon's section must be later, possibly in terms of an early civil defence system. The evidence for successive ramparts in S Johnson's section D, Fig.12.6 is also reflected in the sections cut by K Kenyon, and will be pertinent to a later discussion regarding the town civil defences.

12.2.5 Fortress south defences

The outline of the fortress defences on the west, north and east alignment has now been established, and there remains the question of the south boundary. In this area there are no guidelines from aerial reconnaissance in terms of the defensive ditches, but the alignment of the intervallum road on the east boundary has been shown to project as far as the site of Finger Post Cottage, (D,

Fig.12.7.(a)). When this cottage was demolished in 1970 A W J Houghton cut a section across the site, as given in Fig.12.9(a). The information is unpublished and in the form of provisional plans, but sufficiently representative to identify the principal features of interest. The ditches at C and D derive from the town 2nd century civil defences on the south perimeter, and from the section terminate in a butt end, suggesting some form of entrance through the town defences from the southeast. Ditch E was initially considered by the excavator to be part of a large intrusion, although it is continuous through the section. For the most part the ditch was infilled with Roman building stone, to the east is another ditch F with a more shallow profile, also continuous; the two ditches are spaced 45 ft between centres, and there is no evidence for a 4th century reconstruction of the civil defences at this point.

The profiles of the ditches at E and F exhibit a marked similarity with the fortress ditches on the east alignment (Section C, Fig.12.3). and are considered by the writer as evidence for continuity of the defences in this area. A comparative increase of some 12 ft in the spacing between them is explained, if the section intersects the ditches at an angle on the corner of the fortress defences. The section is illustrated in a viewpoint east at Fig.12.9(c), and shows the outer 2nd century ditch D in relation to the stone infill of ditch E. The latter is better illustrated in Fig.12.9(d). and reveals the dark silt in the lower part of the ditch contrasting with the upper stone infill. If this is the fortress ditch, it has remained open for a considerable period. As the silt is confined to the slot, it suggests that if the ditch was backfilled at the time of the fortress demolition it has subsequently been cleaned out and reused, a point to be taken into consideration with regard to the prospect of an early civil defensive system prior to that of the late 2nd century.

Further investigation on the site of the cottage revealed a substantial cobbled road surface. Fig.12.9(b), considered by the excavator to be early in view of the finds sealed on its surface, this data is also unpublished. A section cut across it at G to H is given in Fig.12.9(a) and reveals more than one period of construction, with part of the surface concealed under the rampart of the 2nd century defences. From the width, form and orientation of the lower surface, it is the opinion of the writer that it is representative of the fortress intervallum road on the south alignment. The upper surface appears to be much later as it diverges to the west, and also extends east through the town defences. It is clear from aerial photographs that the line of the intervallum road from the north, if projected across the modern road, would terminate at the site of the cottage, (Fig.12.7(a)).

If the upper remains constitute an early civil road west into the town, it was subsequently to be partially obscured by the butt end of the late 2nd century rampart, Fig.12.9(b). From the section in Fig.12.9(a) it is evident that some 10 ft of the road between the rampart and the remains of the intervallum road had been resurfaced. If the excavator is right in his interpretation, the foundation trench for the town wall represents an intrusion into the road surface at some later date, reducing the entrance even further. The remains suggest that the situation is similar to that on the fortress north alignment, where a later civil road is coincident with the intervallum road for part of its length. The excavation results have only been considered in the light of the fortress defences, and there are other aspects which merit further investigation.

To a certain extent the finds are considered to be inconclusive. Beneath the tail of the rampart a coin of Vespasian lay on the upper road surface, but away from the rampart and beneath the earlier road in natural sand, a sherd of South Gaulish Samian was recovered and considered by Brian Hartley to be early Flavian, (A W J Houghton). On the upper road surface clear of the rampart, two broaches of 1st century origin had been trodden into the surface. The finds are of interest but do not materially assist the argument, with the exception of the Samian sealed under the lower road. Although excavation has revealed a complex of roads of more than one period, it is concluded that the argument for the existence of an intervallum road in the area is valid, and substantiated by aerial reconnaissance.

12.2.6 Summary

a) From the data presented, the outline of the fortress defences has been established on the north, east and south alignment as given in Fig.12.10, sections A, B and C are those of K Kenyon, D, E, F and G, S Johnson and I, A W J Houghton. The termination of the 2nd century ditches on the south perimeter is given at J, and in addition there is some evidence from aerial reconnaissance for post-holes at H in the via Decumana gate position. Continuity of the fortress south defences is also in alignment with a sequence of narrow buildings to the west, similar to those associated with the intervallum road on the east alignment, it should be noted that the line of a town street, adjacent to the those buildings is offset. The defences to the west are confirmed by the excavations of G Webster on the baths site, in the recovery of evidence for the Porta Praetoria and the fortress rampart. This completes the circuit enclosing an area inside the ditches of some 15.5 Hectares (38 acres), as given in Fig.12.11.

b) Having established the outline of the fortress, it is now possible to consider the internal arrangement in conjunction with a simplified town street plan, as illustrated in Fig.12.12, where the central street layout has to some extent been influenced by that of the fortress. The via principalis is identified from the gate on the north defences, and a town street in a north/south alignment is closely associated with it as far as the baths site. Following a discontinuity, there is a further alignment in a street to the south which extends beyond the central insulae to the town civil defences, if this is projected it would lead to the early auxiliary fort situated on the east bank of the river Severn. The discovery of the fortress west gate determined the line of the via praetoria to its junction with the via principalis, and a town street is coincident for part of its length. Directly to the east a section of street is also in alignment with the via decumana, but does not extend to the east gate. Whether or not other elements of the street plan are associated with the fortress layout, is a matter of conjecture. The remains of a granary to the north has been assigned to the fortress, in view of the typical military style of buttress and pilae to support the floor. The principia or headquarters building, is assumed to occupy an area east of the junction of the via praetoria with the via principalis.

To the south crop-marks have revealed a line of 6 column bases of a colonnade in alignment with the via principalis, there are also two more bases in parallel to the east and set on a wall or plinth A, Fig.12.13(a). It is considered that the features are associated with the fortress, and represent the remains of a substantial building in stone. The relationship of the colonnade to the town plan is shown in Fig.12.13(b), the via praetoria is aligned with the boundary on the south aspect of the baths site, and would give a position for the principia in area A. The colonnade lies to the south at B, and from the crop-marks the bases are much larger than would be expected of a town house, and compare with the remains of the colonnade on the east alignment of the town forum. The crop is barley and sensitive to lighting and angle of approach, and from the viewpoint in Fig.12.13(b) there are faint indications for an extension of the colonnade to the south at C, this would given an axial dimension approaching that of the existing forum. The prospect of an early town forum is a possibility, but this is conjectural opinion. There have been various suggestions as to its function including the praetorium or a bath-house, but the relative position of such structures varies in a fortress layout and it is for excavation to elucidate. The overall plan in Fig.12.12 is considered to be representative of the fortress on the site of Viroconium, as derived from excavations round the perimeter and the results of aerial reconnaissance. The fortress faced west, and the line of the Watling Street into the area terminates at the gate on the north defences.

c) From the sections of S Johnson and the associated analysis, it is suggested that the defensive alignment across the town is of military origin, with the possibility of its later use in the form of early civil defences. There is insufficient information to determine precisely how and where the outer military defence work joins that of the fortress, and persistent aerial reconnaissance has nothing to offer in this respect. If it indeed represents the enclosure of a Canabae, there must be some form of termination in the area. From the relationship of the sections on the outer defences as given in Fig.12.5, there is very little space for a conventional corner to integrate this system with that of the fortress. This is a critical area for future investigation, and as the excavator comments, is much disturbed. Clearly the action in removing the bank which existed on the high ground above the Bell Brook has had a detrimental effect on the remains, but not apparently on the metalling of the road and its associated ditch, which lies on sloping ground.

12.3 Viroconium civil defences

Following the fortress demolition nothing is known concerning the organisation and work involved in the early stages of town planning, to take advantage of the area made available from the military evacuation. The population of the Vicus associated with the fortress must have been considerable, including perhaps artisans in the various trades, such as masons, carpenters and a knowledge of civil engineering in general. Whether or not military assistance was forthcoming in the early stages, there is the possibility of retired soldiers with such skills, quite apart from any involvement in the conduct of external trade and extensive agriculture in the area. If demolition took place in C.90 it would not be unreasonable to postulate that town development per se, did not really get under way until the early years of the 2nd century. The population of the Vicus itself would also need to readjust to the prospect of survival following the departure of some 5000 soldiers, as is readily apparent in the present day when a military base is disestablished. This may have made its impact during the period prior to demolition, when the fortress was placed on a care and maintenance basis, or serving as a depot, resulting in a degree of social stability. It also begs the question in respect of money and facilities, together with an organised authority to control and supervise the initial planning and conduct of the work. The period of time between C.90 and the visit of Hadrian to the province in AD 120, in terms of town development, has yet to be accounted for. It is hardly credible for example, that the forum was designed and built during the ten years following Hadrian's visit, to the dedication in AD 130.

In the event, town development as a whole was sufficiently advanced to justify the construction of a substantial defensive system in the late 2nd century, enclosing an increased area to give a total of 180 acres with a perimeter of some 2 miles. This system of ditch, rampart and palisade was to continue until the addition of a wall at some later date, yet to be determined. It was not until the 4th century that the defences were reorganised as in other Romano-British towns, to allow for the provision of an added facility in the form of bastions. It is not intended in this discussion to examine the politics or events which influenced this sequence of town defences, for it has been eloquently dealt with elsewhere, (Frere, 1984). A case has already been made by the writer to support the possibility of a defensive system enclosing the nucleus of the town in the early 2nd century, and it is the evidence from excavation for defensive systems attributed to the late 2nd century and 4th century reconstruction, which is the subject of the following discussion.

12.3.1 Defences of Viroconium from excavation

A plan of the various sections round the town perimeter is given in Fig.12.14, and identified accordingly for reference in the text. The findings of the excavations are outlined to a certain extent, sufficient to provide a data base prior to an assessment of the results from aerial reconnaissance. The discussion is centred on the construction and profile of the defensive systems, rather than introduce the contentious subject of pottery which may be inconclusive, and does not materially assist the argument.

a) Excavation by T Wright

It was T Wright who traced the line of the defences round the town perimeter in 1872. At that time the alignment of the town wall could be seen in the form of a continuous bank, and no doubt included the remains of the rampart. His excavations on the south boundary in area WR(A), Fig.12.14, revealed evidence for a ditch, as given in

Fig.12.15, from this section the excavator considered that the ditch had a flat bottom and a width of 95 ft. The inner face of the rampart and ditch appears continuous and inclined at an angle of 45 degrees, the outer face more perpendicular; there was no trace of a wall associated with the rampart. Further excavation in the vicinity however, did reveal the cobble foundation for a wall set in clay, with an average width of 6 ft, Fig.12.16.

In search of an entrance at the Watling street gate his excavations on the northeast perimeter (WR(B), Fig.12.14), revealed part of the wall standing to a height of 4 ft, the transverse trench established a complete section of the wall. There was no evidence for facing stones, but the comments are of interest in that the remains were tolerably perfect with the sides even and smoothed, Fig.12.17. There was also evidence for discontinuity of the wall, and no indication for a ditch at this point adjacent to the modern road, but a further section to the west revealed the existence of a wide ditch together with the wall foundations, and confirmed the findings on the south perimeter. The excavator concluded that an entrance existed at this point, and whatever structure protected it was probably of timber. There was no comment on the lack of mortar in the construction of the wall.

b) Excavations by D Atkinson

The excavations of D Atkinson in 1923-27 comprised a series of sections, also on the line of the northeast defences, between 'Horse Shoe' lane and Norton lane, (A, Fig.12.14). The course of the wall was determined across the field, only the foundations were recovered, and all the masonry had been robbed away with no evidence for worked stones, nor traces of rubble or mortar. The foundations consisted of a trench in the subsoil to a depth of 5 ft from the existing surface, 7 ft wide and filled with rammed clay and water-worn cobbles embedded within it. In places the top of this foundation was no more than 9 inches below the present surface, and where the trench was deeper the upper layer contained larger cobbles than elsewhere. A further point of interest was the difficulty experienced in tracing the foundations across patches of boulder clay, and the alignment was only determined by cross sections to identify the edge of the defensive ditch.

Additional sections were also excavated on the line of the northeast defences to determine the nature of the defensive ditches. A section A(2), Fig.12.14, revealed the wall foundation and a wide ditch of some 65 ft with an original depth of 15 ft, the profile was W shaped as given in Fig.12.18. The excavator makes no comment on the profile, other than to suggest that it provided steep scarps and counterscarps of a defensive nature, with less expenditure of labour than a conventional V shaped ditch. A further section A(1), Fig.12.14, was opened adjacent to the modern lane on the north aspect in the same area as T Wright, to reveal a V shaped ditch 13 ft wide and 4 ft deep, Fig.12.18. It was concluded that a causeway existed at this point, suggested by the conventional reduction in the dimensions of the defensive ditch, and validated the findings of T Wright.

c) Excavation by K Kenyon

The excavations of K Kenyon on the line of the town east civil defences in 1936 have already been discussed in the context of the legionary fortress, and consideration will now be given to the results in terms of the town civil defences. For this purpose the sections K (A, B and C), Fig.12.14 are rearranged with the town wall as a datum and given in Fig.12.19. In section A the defensive ditch is W shaped, and in agreement with the profile and dimensions as found by D Atkinson on the northeast circuit (A2, Fig.12.18). Although K Kenyon did not comment on the

W shape as such, subsequent investigation and interpretation has established the inner ditch profile as late 2nd century, with a recut in the 4th century to provide a wide ditch. Section B was cut adjacent to the modern lane on the south aspect and did not extend across the defensive system, but sufficient to reveal a ditch of reduced dimension in line with the inner ditch profile in section A, and assigned to the 2nd century. At Section C on the north aspect of the lane this ditch had disappeared, leaving only the remains of what is now considered to be the outer ditch of the fortress defences. All three inner ditches are in line with respect to the wall. The cut in section C did however, extend sufficiently to the east, to reveal in part the shallow profile of another ditch. Leaving aside the evidence for turf outside the town wall, clearly the inner ditch in sections A and B is of 2nd century origin.

In an earlier assessment, (Baker, 1967-1968), the writer had considered the inner ditch in section C to be 2nd century from its alignment, but in the light of subsequent excavations, K Kenyon's interpretation is accepted. The reduced dimension of the 2nd century ditch in section B is similar to that recovered by D Atkinson on the northeast circuit (A1, Fig.12.18), and suggests the possibility of a causeway at this point. From the termination of the lane there is a straight series of field boundaries and a sunk track extending over a mile to the east, the alignment continues as a modern lane for another mile as far as the village of Rushton under the Wrekin, the causeway across the defences however proved to be relatively modern. In any event at section C, although the 2nd century ditch had disappeared, the remains of what is considered to be the 4th century ditch can still be seen in part and from its profile is also shallowing out. Further, in a cut directly across the causeway K Kenyon established that the natural bottom was rising to the north, and confirms a reduction in the dimensions of the outer defensive system.

From the evidence it could be argued that an entrance existed in line with the lane prior to the 4th century recut, for there are other points to be taken into consideration. There is a change in the alignment of the defences in this area, to the south they deviate slightly west, the wall foundation is also confirmed on both sides of the lane in sections B and C, and together with the profile of the 2nd century ditch, is analogous with the sections by T Wright and D Atkinson at the Watling street gate, on the northeast defences. Hedgerow alignments are also a well established indicator along the line of many known Roman roads. There is little doubt that the 4th century recut extended across the entrance, and from the reduced dimensions suggests some form of discontinuity in the defences north of the lane. Although a case can be made for a causeway through the defences in line with the lane, and there is evidence for it from ground inspection, Kenyon's section proved it to be modern with no indication for road metalling. There is of course always the possibility that the ditches were bridged. With regard to the proposed discontinuity in the defences, aerial reconnaissance has established the existence of an aqueduct channel in pasture, crossing the line of the east defences at a point approximately 70 ft north of the lane. The final course of the channel is angled south, but the precise point and mode of entry across the line of the rampart is unknown. There is evidence for two channels into the town, and the features are included in a discussion on the aqueduct in Chapter 13.

d) Excavations by S Johnson

In 1975 apart from emptying K Kenyon's section K(c), Fig.12.14, S Johnson planned two further sections J(D) and J(E), (Fig.12.5), the latter was not completed and the remaining section J(D) is given at Fig.12.6. This cut did not extend more than 2 m outside the wall, insufficient to recover any evidence for the defensive ditches, but several ramparts were identified. Above the military rampart and ditch at B a second bank C extended beyond the wall, its front was not recovered, but similar remains can be seen in K Kenyon's section C Fig.12.19, in the form of turf as far as the line of the 1st century ditch. As the two sections are separated by only 15 ft some degree of consistency can be anticipated, particularly as the inner 1st century ditch is common to both sections. Unfortunately none of the sections in this area were of sufficient length to embrace the rampart and overall defensive system, and until this is achieved the nature of the defences in the area north and south of the lane must remain a matter of conjecture.

The results of excavations so far are tantalising from the point of view of the outer civil defences, but at least they confirm that the wall was inserted into an existing rampart and not contemporary with it. A section cut down the centre of the lane, which now exists in the form of a disused farm track, would at least establish continuity of the defences or otherwise in what is considered to be a critical 20 ft gap. In addition it will also settle the question of an entrance at this point, and provide the necessary data prior to any considered excavation to explore the possibility of a discontinuity north of the lane, particularly in view of the evidence from aerial reconnaissance for more than one aqueduct channel across the line of the defences into the town.

e) Excavation by G Webster

This particular section was cut across the south perimeter at W, Fig.12.14 and is more informative as it embraced the complete outline of the rampart and outer defensive system, including part of the 4th century counterscarp, (Webster, 1962). The area was previously known as the Glebe land and the section must be very close to the excavations conducted in this area by T Wright, but the precise location of his investigations is unknown. The section by G Webster is given at Fig.12.20, and reveals a defensive system of more than one period. The W shape is consistent with the findings of D Atkinson and K Kenyon on the northeast and east defences respectively. From the results the excavator concluded that the inner ditch was of late 2nd century origin, subsequently embodied in the 4th century reconstruction. The section extended across the ditches and into what was, in earlier sections an unexcavated feature, in the form of a counterscarp, although in this instance continuous cultivation had removed all traces of it. Here a further ditch was recovered, similar in profile to that of the inner ditch and considered by the excavator to be of the same period, and had been infilled by material from the counterscarp. The rampart 55 ft wide proved to be of one period, with the original outer face angled to form a glacis type of construction continuing into the profile of the inner ditch, as indeed found to be the case in the section by T Wright.

The foundation for the wall is in good agreement with other sections round the perimeter, but contained no cobbles only a slightly darker filling in front of the bank betrayed its existence, stone robbing and the plough had removed all solid traces. In this instance the wall foundation had been inserted into the face of the rampart, but if the glacis configuration of the rampart into the ditch is accepted, it follows that the wall is of a later construction and not contemporary with the late 2nd century defences. As the plough had removed all visible traces for the counterscarp, there would have been little point in continuing the section to determine its width. A reconstruction by G Webster of the first phase of the defences is given in Fig.12.21. From this the excavator makes two further points of interest, firstly that the material from the two ditches is insufficient for a rampart of this size, either it was smaller or there is a case for a third ditch. The spacing of 40 ft between the ditches would allow for this, but it is considered that the 4th century recut has destroyed all evidence for it. The second comment concerns the position of the wall at the edge of the ditch, and the excavation suggests that the front of the bank had eroded and the ditch partially filled before the wall was built, its height in conjunction with the rampart was estimated at 20 ft.

Although the significance of a counterscarp had not been realised in earlier excavations, a section by K Kenyon (A, Fig.12.19) obviously continued partly across it, and at the extreme of the 4th century ditch is a slight indication for the inner profile of the second ditch. If the subsurface contours in this area are interpreted as the remains of the counterscarp, it would result in a 4th century ditch 65 ft wide corresponding with the figure given by G Webster, and the spacing between the inner lip of the two ditches is the same.

f) Excavation by A W J Houghton

The section by A W J Houghton at the site of Finger Post Cottage, (H, Fig.12.14) is coincident with the termination of the civil defences on the south alignment, and is of some significance. In this section, Fig.12.9 (a), the foundation for the wall has been cut into the rampart, and it would appear that the rampart extends into the inner ditch silt, whether or not this is due to the effects of erosion as suggested by G Webster in his section on the same alignment is uncertain, but the width of the foundation is consistent with the findings elsewhere round the circuit. In this instance 2nd century pottery was recovered from the base of the wall foundation, leading the excavator to consider that the wall may be contemporary with the rampart, but this is inconclusive as 2nd century pottery was also found in the bank, and could have been in situ when the foundation was dug.

The importance of the section is reflected in the evidence for a second ditch at D. There is no indication in this section to suggest a 4th century reconstruction, and from its position and dimensions the ditch D could be accommodated in the 4th century recut between the two known ditches (Fig.12.21), and substantiates the hypothesis by G Webster for an additional ditch. The profile and dimensions of the ditches C and D in Fig.12.9(a), are influenced by two factors, firstly the section is at a angle across the defences, and secondly the ditches come to a butt end at this point, both ditches are clay lined as in the section by G Webster. If D is evidence for a third ditch, there remains the question of an outer ditch recovered under the counterscarp to the west. The ditch at F is in approximately the right position, but from the dimensions, it is too small and considered by the excavator to be continuous. The absence of an outer ditch must remain an open question, for the line of the civil defences approaching this area presents an unusual configuration, and is illustrated in the assessment of the results from aerial reconnaissance in Chapter 13.

g) Excavation on the west defences

The line of the defences to the west along the cliff above the Severn have never been substantiated, and the possibility of any significant river erosion has been discounted. As a direct result of modifications to the sewage system of the farmhouse on the bank of the Severn, the Department of the Environment funded a section in the area at F, Fig.12.14, (Brown, 1975). From this, several phases of rampart were revealed toward the edge of the cliff, as given in Fig.12.22, together with the possible remains of a wall foundation situated at the extreme west edge. It was concluded that the latest phase of the rampart may possibly be assigned to the late 3rd century, and the results imply a review of the considered effects of river erosion, in that the defended area within the town may have been reduced by as much as 10 acres.

12.3.2 Summary

a) The excavations establish a degree of consistency round the circuit, in the 2nd century and the 4th century reconstruction. There are anomalies, particularly at the southeast gate, and on the north sector of the east defences in the area of the aqueduct entry into the town. The defences have been sadly neglected, and pose problems equivalent to those associated with the town development as a whole, and a more detailed investigation of the sequence of events is long overdue. Apart from the section by G Webster on the south perimeter, there has been no attempt as yet to carry a section through the complete defensive system, to validate the structure from the rampart to the full extent of the counterscarp. The corners and assumed entrances into the town also remain unresolved. Sections are of value but limited in the information they reveal, and it will be necessary to strip areas of contention if a more comprehensive evaluation of the nature and behaviour of the defensive system is to be achieved, and as such is better appreciated in conjunction with a considered interpretation of the results from aerial reconnaissance.

b) From excavations to date, the sum total of knowledge suggests four phases of construction.

Phase 1 introduces the possibility of a defensive system to protect an early nucleus of the town.

Phase 2 involves the building of a rampart with two outer ditches enclosing an increased area of the town, and assigned to the late 2nd century. There remains the question of a third ditch.

Phase 3 consists of the insertion of a wall into the face of the rampart at some later date.

Phase 4 comprises a wide ditch and counterscarp which could not be dated with certainty; a similar style of defence work round other Romano-British towns is attributed to the 4th century, and associated with the construction of projecting bastions attached to the town wall.

c) Whereas the evidence for the ditches is definitive, that of the wall is less so and has introduced problems in interpretation. It has been argued that the defences were of timber, a hypothesis based on the lack of evidence for mortar, rubble and cut stone. If facing stones had been used and removed, the remains of an inner core would exhibit an irregular uneven surface, and not representative of the smooth face as recovered by T Wright. Unfortunately the height of the wall in Wright's section is insufficient to reveal any evidence for bonding courses.

Dry stone walls are known in other Roman structures, as at Chester for example, it is relatively easy to remove a wall of this nature, and robbing appears to have been very thorough for it is remarkable that there is no evidence for collapsed masonry in any of the excavated inner ditches, and surface residue would have been spread by the plough. It should come as no surprise that nothing remains except the cobble foundations, for indeed parts of Hadrian's wall have disappeared in their entirety. Although there is no sign of mortar, by the same token there is no evidence for a timber structure. All the sections so far indicate that a wall was inserted into the rampart, and from its position implies some deterioration in the defences at that time. The width of the wall at 7 ft is not unusual, Canterbury is 7½ ft, Verulamium 7 ft and Chichester 8 ft, the width is variable, some Romano-

British towns are greater, Winchester 9-10 ft, Caister-by-Norwich 11 ft, (Wacher, 1975). From excavation results the relationship of the wall to the bank is inconclusive, but the evidence for its insertion into the rampart suggests that it was later.

d) An unusual feature is the lack of a berm of any significance, if the rampart face and inner ditch are continuous it would suggest that the wall has been inserted at a sufficient distance from the lip of the ditch to ensure its stability, giving a berm of only a few feet. It is evident that in the 4th century reconstruction, the inner 2nd century ditch had not been backfilled to allow for an extended berm to accommodate projecting bastions, and excavation so far has not revealed any evidence for these features. Viroconium is unique in this respect, compared with the 4th century defences in many other Romano-British towns where allowance was made for the provision of bastions, (Corder, 1956).

e) The W shaped ditch profile is also unusual in that it embodies the remains of the inner 2nd century ditch, and excavation offers no obvious reasons for this particular configuration. An overall width of the order of 65 ft, compares favourably with the 4th century defensive ditch in other Romano-British towns, but the lack of a wide berm provided by infilling the inner 2nd century ditch, has led to an opinion that the defences at Viroconium were not designed to provide a facility for projecting bastions. Taken at its face value, the construction of a wide ditch in conjunction with the wall, offers no particular advantage over a conventional ditch system in terms of defence.

f) In the writer's opinion the evidence for a wall at Viroconium is indisputable, and it is relevant to compare this with the results of excavation at the Romano-British town of Kenchester, in the valley of the river Wye south of Viroconium, (Webster, 1956). Here, the wall foundation was 11 ft wide, consisting of cobbles packed in clay, and set in a trench dug into the subsoil 5 ft 6 ins below the base of the rampart. In this instance the core was bonded with mortar, and the wall adjacent to the rampart faced with masonry. Between the wall and an early ditch 13 ft wide and 8 ft deep, is a berm of approximately 10 ft, Fig.12.23. There was also evidence for an outer ditch at least 60 ft wide. The section did not extend far enough across the defences to establish any correlation between the two features, but the inner ditch had been allowed to collapse and silt up, and not backfilled. Where earth ramparts already existed the front was normally cut back to receive the wall, as at Silchester for example, where up to one-third or more of the bank was removed, (Frere, 1984).

At the northwest corner the substantial remains of a bastion were recovered, consisting of large blocks of cut stone to form a base for the outer face and contain the infill of loose stone, there was no evidence for mortar in the core or foundation stones, Fig.12.24. The relationship of the wall to the bank was not established, but the finds indicate that the rampart and inner ditch was not constructed before the mid 2nd century. In the same year, aerial reconnaissance by the writer established the line of the civil defences from crop-marks on the north perimeter, Fig.12.25. The inner ditch is identified at A, and the remains of the wide outer ditch at B; in this area the crop-marks suggest two parallel ditches. Because the ground slopes away from the rampart debris has accumulated in the ditch resulting in a relatively impermeable infill toward the centre, giving the impression of two ditches, (Baker, 1962). A previous investigation near the corner at C revealed that the ground under the top soil was covered with a layer of largish stones, some square but mostly round, probably representing debris from the wall, (Jack, 1924-1925;7). The crop-marks also show a discontinuity in the inner curve of the ditch, suggesting an accumulation of rubble from the remains of a bastion at this point.

It is considered that the berm arising from the cut back rampart, is insufficient to accommodate a projecting bastion of similar dimensions to that on the northwest corner if the inner ditch is not back filled, and suggests that such features at Kenchester were confined to the corners. Further excavation across the west defences confirmed an outer ditch 65 ft wide with a maximum depth of 9 ft, and spaced some 12 ft from the inner 2nd century ditch as suggested by crop-marks on the north perimeter. Its profile was uninterrupted as the inner defensive ditch was not included in the construction to give a W shape as at Viroconium, (Heyes & Thomas, 1956-1958). From the results of aerial reconnaissance and excavation so far, there is no evidence for a counterscarp associated with the wide ditch.

g) This serves to illustrate the variations in the design and construction of Romano-British town defences in the 2nd and 4th century, and the difficulty in establishing any degree of consistency except in basic principle. Each case is to be assessed on its individual merits, with a common origin under Roman jurisprudence.

CHAPTER 13

VIROCONIUM: CIVIL DEFENCES AND AQUEDUCT FROM AERIAL RECONNAISSANCE

13.1 Civil defences

It has only been possible for aerial reconnaissance to recover details concerning the nature of the town defences, over approximately one third of the perimeter. In areas of contention to the east, south and west, information is sadly lacking due partly to adverse soil conditions, interference by modern structures and natural vegetation. It is only on the north and northeast alignment that the response through crop-marks has revealed any detail of significance, partly as a result of the removal of field hedgerows allowing cultivation of a single crop over an increased area.

13.1.1 The town perimeter

Rather than deal with the defensive system piecemeal, the problems will be better understood by presenting the variations in sequence. For this purpose the perimeter may conveniently be divided into two areas, southwest and northeast, and from the point of view of aerial reconnaissance simplifies the assessment in terms of the results.

a) Southwest perimeter

This part of the circuit is illustrated in a vertical at Fig.13.1, and defines the town perimeter from the course of the Bell Brook near area A, south along the river Severn to the village of Wroxeter at B, where the line of the defences turns east to continue as far as the modern road junction at Finger Post Cottage C. In area A the profile of the wide outer ditch can be seen from the ground, but there has been little evidence for its existence through changes in the growth of vegetation over successive seasons. From the air the depression left by the ditch is just visible in Fig.13.2 at A, but its continuity is partly obscured by a wood as it approaches the cliff above the Severn. The parallel ditch and road system B also appears to terminate in this area, and is not resolved from aerial reconnaissance or at ground level, and represents a critical point in the defences for future investigation.

In a viewpoint southwest, Fig.13.3, the contour of the cliff is well defined at A, and although the ground between the modern lane and the cliff has been cultivated on occasions, crops have failed to show any evidence for a defence work. Subsequently an excavation in the vicinity of the farm buildings at B, revealed the remains of a rampart and possible wall foundation trench on the river bank (Fig.12.22). This has led to an opinion that the town perimeter associated with the cliff has to a certain extent been eroded by the river, D Pannett has made a good case against this assumption, but considers that following the channel cut in Medieval times between the island and the mainland, continuous erosion is evident in area B; this is substantiated by the deposits on the river bank at C, (Pannett, 1989). The alignment of the river and town perimeter is perhaps better appreciated in Fig.13.4, and shows the relationship between the defensive ditch at A and the line of the cliff B. Only excavation in the area of the cliff will determine the degree of river erosion, clearly the lowland between the cliff and the river is liable to flood, but from his assessment D Pannett is of the opinion that any realignment in the river channel is to be considered in terms of millennia rather than centuries. It is of interest that, in Fig.13.5, a change in the cliff contour suggests an outfall A in line with the town drains at B.

Continuity of the defences south along the river bank to the point where they turn east in area B, Fig.13.1, is not apparent from aerial reconnaissance. From crop-marks the course of the town main street suggests an entrance in area B, leading to a crossing of the river Severn to join the known Roman road alignment to the south. The recovery of stonework and timber across the bylet to the island, has been considered to form part of a medieval fish weir and not Roman in origin. A crossing point has yet to be established, and there is evidence for a wide ford in the river immediately south of the island. A detailed analysis of the river behaviour in the area has been eloquently presented by David Pannett, and provides a firm basis for future investigation. A turn in the defences in area B is assumed but not substantiated, for the earthworks at this point are indeterminate in terms of a Roman defence work; it has been suggested that the site also constitutes the remains of a fortified medieval Manor, (Barker, 1990).

The alignment of the defences to the east is obscured partly by Wroxeter village and the course of a stream along the wide ditch, and only becomes recognisable from crop-marks in the area where the defences approach the site of Finger Post Cottage, at a modern road junction, Fig.13.6 in a viewpoint west. In this area the remains of the rampart at A indicate a gentle curve, but crop-marks of what is taken to be the wide ditch B suggest a change in its alignment. This is better illustrated in Fig.13.7, taken during the dry conditions of 1976, and simplifies the interpretation, crop-marks at A define the outline of a platform extending slightly into the ditch B, but in line with the rampart C. In this illustration the marks are more definitive in that the wide ditch appears to curve inward at D, emphasising the outline of the platform and suggesting a discontinuity. Beyond this point to the site of Finger Post Cottage at E, there is no apparent indication for continuity of the defences. However the section by A W J Houghton at Finger Post Cottage revealed the profile of two adjacent inner defensive ditches, (Fig.12.9(a)), assigned to the 2nd century, with no evidence for a recut in the form of a wide ditch of the 4th century. The position of crop-marks at F may easily be misinterpreted as evidence for the ditches recovered by A W J Houghton as they are in line, but the marks are diffuse and appear to be in alignment with the remains of ridge and furrow over the field at G.

b) Northeast perimeter

This half of the perimeter is given in a vertical at Fig.13.8, and defines the line of the defences in the form of field boundaries, from the area of Finger Post Cottage A to the Bell Brook B where it continues up a steep slope to a corner at C. Here the defences turn sharply northwest to the Watling Street gate at D, from this point the alignment curves to the west round the north perimeter E, to cross the Bell Brook on a southwesterly heading completing the circuit.

To establish continuity a viewpoint east as given in Fig.13.9, shows the south alignment to Finger Post Cottage, A, and identifies the outline of the platform B and 4th century ditch C. An additional feature of interest lies in the crop-mark evidence for two lines of metalling at D, terminating at the platform. An entrance to the town has been postulated at Finger Post Cottage, and is supported by the evidence for road metalling from excavations by A W J Houghton (Fig.12.9(b)). At this point the defences exhibit a change in alignment to the north. The soils in this area are poorly drained, and the line of the defences difficult to resolve through changes in the growth of vegetation, except in conditions of drought. Even then, as for the south alignment, there has been no aerial evidence for the remains of a wall trench or counterscarp. North from Finger Post Cottage the depression formed by the wide ditch is clearly visible from ground level, and as such is readily identified at A, Fig.13.10. The removal of a hedgerow defining the centre line of the ditch, has at least offered a degree of continuity in the cultivation of a single crop. In area B there is a small divergence to the west on the alignment to the Bell Brook at C. Along this line, aerial reconnaissance over successive seasons has been unrewarding in revealing the behaviour of the defences in this area. The presence of a field hedgerow coincident with the alignment, formed an obstacle to the prospect of extending the excavations in the area by S Johnson, and also reduced the possibility of observing continuity from crop-marks in the individual fields, due to seasonal crop rotation. The prospect of an entrance in area B cannot be discounted, and has yet to be substantiated.

Where the defences dip to cross the Bell Brook, there is no evidence for any remains on the ground or from the air. The alignment continues up the steep slope of the valley to the first recognisable feature, in the form of a corner at A, Fig.13.11, in a view west. The wide ditch is now well in evidence from crop-marks, and a platform at the corner can be seen to extend into the remains. The alignment from this corner down to the Bell Brook is slightly offset, with respect to its continuity on the other side of the brook. From the crop-marks there is evidence for the robber trench of the town wall B, and the lighter line at C may be interpreted as the remains of a counterscarp. The defences continue on relatively high ground above the Bell Brook to area D, where the land profile dips toward the Watling Street gate at E. On the sloping ground there is an apparent reduction in the width of the ditch, and in all probability is a function of the crop response in this area as a result of soil drift, reflected in the apparent increase in width as it approaches the modern road. Continuity of the defensive system is more well defined in the next field.

The Watling Street gate is coincident with the modern lane at A, as given in Fig.13.12, and the robber trench of the wall is now clearly visible as a positive crop-mark B, together with the wide ditch C. The mark at D is considered by the writer as evidence for an outer 2nd century ditch, concealed under the remains of the counterscarp E, its existence is substantiated by crop-marks on the north perimeter and subsequently confirmed by G Webster in a section across the south alignment, (Fig.12.20). At Fig 13.13, in a view south, the defences north of the Watling Street are outlined in terms of the robber trench of the wall A, and the wide ditch B, although the evidence for an outer 2nd century ditch C is perhaps less convincing from this viewpoint. But what is emphasised is the curve of a platform on the corner at D, and crop-marks suggest that it extends into the ditch, there is also some evidence for the wall trench behind it, and a lighter band at E represents the remains of the rampart.

During the drought of 1975 the situation in this area was transformed, as given in Fig.13.14, and the line of the defences more clearly defined compared with the result in 1964 (Fig.13.13). It can also be seen that the evidence for the wall trench at A, Fig.13.14, does not extend over the whole profile of the platform. From his excavations in 1923, D Atkinson experienced some difficulty in identifying the wall foundation in this area, due to the presence of boulder clay, and does not imply that there is a discontinuity in the wall alignment at this point. The lighter lines at B are indicative of metalling, and represent the remains of an approach road leading to the corner; the detail of a building at C and its colonnade is also well defined. The alignment of the road with respect to the corner is more convincing from a viewpoint in Fig.13.15, where it turns and terminates parallel with the remains of the rampart at A.

A general view of the defences on the northeast circuit as they appeared in 1959 is given in Fig.13.16, in this illustration continuity of the alignment round the north perimeter is suggested by the configuration of the hedgerows at A, to the point where the Bell Brook leaves the town area at B. The field boundaries were eventually removed by the farmer to allow cultivation of a single crop over an increased area, and in 1962 crop-marks revealed a complete section of the defences in considerable detail, Fig.13.17. Here the evidence for an outer 2nd century ditch at A1, under the remains of a counterscarp C, is indisputable. Continuity of this ditch is visible at A2 together with evidence for a second inner ditch which is in line with, and eventually obscured by, the wide ditch. The excavations of K Kenyon and G Webster have established the existence of an inner ditch adjacent to the wall and integrated with the 4th century recut to give a W shaped profile and is not resolved by crop-marks, but in this instance there is evidence for a third ditch in the 2nd century defences, as postulated by G Webster, and indeed subsequently verified in the section by A W J Houghton at Finger Post Cottage (Fig.12.9(a)).

The robber trench of the wall D is also well defined as a positive crop-mark on this line of the defences, and associated with it is evidence for a narrow berm between the wall and the ditch. This raises three further points in the interpretation, a) unless the sides of a ditch are steeply inclined, crop-marks may not reveal its full width, b) for a wall of 7 ft wide and 20 ft in height, a berm would be necessary to maintain stability in view of its proximity to the ditch, c) if the face of the rampart constitutes a glacis construction into the inner face of the 2nd century ditch, it would have been cut back to provide a berm when the wall was inserted, and its foundation trench cut into the subsoil. The excavations of D Atkinson on the northeast defences confirm the nature of the wall foundation, and the arrangement is also evident at Kenchester where the rampart was cut back to allow for a berm when the wall was inserted, but this is not necessarily true for the whole perimeter at Viroconium.

The section on the east defences by S Johnson (Fig.12.6) indicates that the wall was inserted into the top of the rampart, and in this area K Kenyon's section implies a discontinuity in the line of the inner 2nd century ditch (Fig.12.19, section C). There are other anomalies, the section by A W J Houghton at Finger Post Cottage (Fig.12.9(a)) suggests that the wall foundation overlaps the inner face of the 2nd century ditch, and the evidence from G Webster's section on the south perimeter (Fig.12.20) shows the wall foundation to be 2 ft above the base of the rampart; the data from both sections suggests some deterioration in the defences prior to the insertion of the wall, with no attempt made to rework or clean out the ditches. One final point in respect of the two ditches at A2, Fig.13.17, they were not formed by an infill of debris into the wide ditch creating an illusion of two ditches, as is evident at Kenchester, nor are they associated with the remains of ridge and furrow in the same field, for the spacing is different, and there is no evidence for it over the remains of the counterscarp. The existence of a corner in this area is more clearly defined at Fig.13.18, in a view southwest to the Bell Brook, and also confirms continuity of the two ditches. But as a defence work the viewpoint as given in Fig.13.19 is more convincing, and also emphasises the apparent discontinuity of the 4th century ditch and counterscarp.

c) Areas of occupation

In the area between the north defences and the A5 trunk road crop-marks show evidence for early cultivation, for the most part in the form of field boundaries and enclosures, overlaid with the remains of ridge and furrow,

Fig.13,20. There is also evidence for the presence of Iron Age square barrows at A with a centre cist. The relationship of the burials to the period of cultivation is indeterminate, but undoubtedly the remains over the field are at least prior to the 4th century, as they are concealed in part by the counterscarp. Some of the features may be earlier, as the results from aerial reconnaissance have suggested continuity of field boundaries into the 2nd century defences and therefore constitute evidence for cultivation before an extension of the town area, but there is no indication for their presence in the area immediately south of the defences, and no doubt the remains have been obscured or destroyed by subsequent town development. Further detail of interest is the complex of pits at B, they are not confined within the outline of the enclosures at C, but distributed over a wide area. Some appear to be in line and in the form of slots, and has led archaeological opinion to believe that they are representative of graves. The writer is disinclined to accept this interpretation, as the slots are all in line with the effects of the plough and indicate spreading of the pit infill.

From the excavation of a number of these features, A W J Houghton informs me that they are in fact rubbish pits, albeit the remains of a cat was recovered from one pit. They may not all be contemporary and where the pits are in line could originate from a known Roman temporary camp in the area, for the linear ditch at D is considered to be the south boundary of the camp, its southeast corner concealed beneath the town defences. A similar arrangement of pits appears in a temporary camp at Glenlochar, and also within a construction camp at Inchtuthill, and considered by J K S St.Joseph to be the remains of rubbish pits, or cooking pits dug in front of the tents, (Frere & St.Joseph, 1983;27,42). The field boundaries also exhibit continuity into the area north of the A5, as given in Fig.13.21, although the remains are screened to a certain extent by variable vegetation, and the effects of subsequent ridge and furrow cultivation, some features are distinctive such as the square barrow at A, and the northeast corner of the temporary camp B; part of its defensive ditch on the north and east axis is also visible. A sketch plan of the features in the area north of the town defences is given in Fig.13.22. There is some evidence for occupation in other areas adjacent to the defences, particularly on the east alignment, but not as definitive, and because of the relatively impermeable soils in the area may only appear in conditions of drought.

13.2 The 4th century defences

By the 3rd century most Romano-British towns had received walls, which were more effective than a rampart and palisade as a deterrent against casual infiltration or a raiding party, and also offer improved access and facilities for patrols and defence by hand weapons. It was not until the latter half of the 4th century that the defences of Romano-British towns in general were reorganised, in the form of added bastions or towers projecting from the wall at intervals, including the corners, and were faced to the wall and not bonded to it. Associated with their introduction was a modification to the defensive ditches, replacing the multiple system by a single wide ditch. It is generally accepted that the function of the reorganisation was intended to provide a facility for the deployment of artillery, to supplement the normal mode of defence using hand weapons. In the late 3rd century, artillery had also been introduced in the design of the "Saxon Shore" forts in Britain and reflected in the provision of projecting bastions, (Johnson, 1976;114).

Whether or not the reorganisation of Romano-British town defences in the 4th century was military in concept, the design does not immediately suggest the nature of the threat it is intended to counter, for although the technique exhibits a degree of consistency with regard to its common purpose, that is to say the introduction of artillery, the translation of the requirement appears to have been the prerogative of individual towns. This is reflected in the wide ranging style of bastion construction with its variations in size, shape, method of construction and spacing between them, (Corder, 1956). The provision of a wide ditch and berm is a well known characteristic of the design, but as yet no consideration has been given to the existence and function of a counterscarp, other than in the form of dumped material from the ditch. The provision of projecting bastions offers distinct advantages in enfilading a wall by whatever means, with or without defensive ditches, but the significant difference in the reorganisation of Romano-British town defences lies in the introduction of a wide ditch.

Prior to analysis of the characteristics of this form of defence, it would not be out of place to give some consideration to the background. S S Frere has attributed the reorganisation to the work of Count Theodosius, resulting from the barbarian invasion of AD 367, and corroborated by the records of Ammianus, (Frere, 1967;256). Although from his comments, in the south of Britain there is little evidence in the towns and villages for damage inflicted by invaders. But what is important in the reorganisation of town defences, is the suggestion that they were manned by small military detachments as a specialist force, to provide expertise for the maintenance and operation of artillery pieces and possibly influence defence strategy. The Cornovii for example had been accustomed to raising their own militia, and by the 4th century some sections of it had been absorbed into the regular Army as Coh 1 Cornoviorum. In this sense, equipped with a more effective system of defence, the towns were to constitute a source of urban stability and administration following the actions of Theodosius in dealing with insurgency from whatever source. On the other hand, a reassessment of Ammianus by P Bartholomew has indicated the possibility of famine as a cause of insurrection among the urban poor, and the possibility of military discontent, leading to a conclusion that the actions of Theodosius were first directed against units of the Roman army, (Bartholomew, 1984). Parallels are clearly drawn today, in terms of food shortages, civil unrest and questionable military loyalties. It would appear that the reorganisation of the town defences followed the campaigns by Theodosius, in restoring a degree of stability in the province.

So far, archaeology has directed attention toward dating the reorganisation, in an endeavour to provide information which would enable the nature of the threat to be identified, and less to an assessment of the technique employed in terms of its objective and effectiveness, as a system of defence. In view of the variations in construction, there is a need to consider the evidence from other Romano-British towns, with regard to the form and disposition of artillery provided by bastions and the associated wide ditch, as an integrated defensive system.

13.2.1 Historical background

In this context some consideration is given to the function of a wide ditch and berm. Toward the end of the 3rd century and during the 4th century, it is evident in the defences of Rome and those of the "Saxon Shore" forts in the province, that artillery in the form of a spring gun or catapult was used in a defensive role, (Johnson, 1976;117). The weapon was variable in size and discharged an arrow or bolt, and functioned on the principle of torsion and not elasticity as in the case of the bow, an example is given in Fig.13.23. The arrangement was mounted on a swivel joint allowing a wide coverage in azimuth with some limited adjustment in elevation, and had an effective range of at least 200 yards and considered to be lethal at 100 yards. Although the type of construction in the weapon illustrated may not have been precisely that used in the 4th century, it is considered to be representative in principle and function (Baatz, 1978); it is of interest that in view of the high ratio between the weight of the missile and that of the weapon, the recoil would have been minimal and did not justify the provision of a resilient platform, and therefore required no special support, (Campbell, 1984).

This is quite distinct from the large stone throwing Onager, where its violent recoil, or shock when the arm hits the cushion, would need to be absorbed by a resilient platform, fixed or mobile. Such an engine has little directional capability compared with that of the catapult, and aiming is a question of range, and is more suited as an offensive weapon for a siege rather than its use in a defensive role. From the construction of the catapult its operation is more in the horizontal plane and above, with only relatively small changes in elevation below the horizontal. But depressed angles of the order of 20 degrees or more pose problems in mounting, operation and fire control, furthermore such steep angles of depression would require modification of the trestle to enable the frame to be moved down to this extent, quite apart from the possibility that the missile would not lie securely in the groove. These limitations are important in the application and use of such a weapon in the defence of Romano-British towns.

The need for a ditch and counterscarp is not immediately obvious. It was only in the siege of Rome in AD 536 that the practical necessity for such works spaced away from the wall became clear, to overcome specific problems presented by the tactical disposition of powerful artillery under Belisarius. Because the weapon platform had been increased in height to 50 ft, whilst maintaining a spacing of 100 ft between towers, there existed a considerable area in front of the wall immune from catapult fire. To conceal this weakness in defence and prevent the enemy from taking advantage of this dead ground, Belisarius dug a ditch at its edge, where concentrated fire power could be brought to bear across and in front of this obstacle, but when the stratagem was discovered the defenders were placed in a difficult situation, with heavy fighting on the wide berm; no mention is made of a counterscarp in this system of defence, (Richmond, 1928).

In AD 310 the Emperor Maxentius started to dig a ditch round the wall of Rome against an impending attack by Constantine. This work was never completed as Maxentius elected to fight outside the town and its precise nature is unknown, but it may be inferred that Belisarius adopted a similar system of defence. Sir Ian Richmond suggested a reconstruction of the wall at this time, based on the fact that Maxentius had already realised the limitations of the Aurelian defences from the invasion of Severus and Galerius in AD 307. Under the threat of attack by Constantine it would seem logical therefore for the city defences to be made more effective. The resultant 2nd-period wall needed less defenders, its increased height was also proof against the use of scaling ladders and only elaborate preparation with siege machinery could pose a threat. Hence the need to counter this by means of a ditch or ditches spaced away from the wall, and evidence for their construction is provided by the chronograph for AD 354: 'fossatum aperuit sed non perfecit Maxentius' (Maxentius dug a ditch but did not finish it), (Richmond, 1930).

Artillery was used by the Roman army in the field well before the mid-4th century, but it is unlikely that the defences adopted for Romano-British towns stemmed from this source, for the concept of a wide ditch spaced away from the wall in late Roman defence work was a strategic defence against assailants equipped with siege machinery. If the 1st period wall of Rome and its associated towers were increased in height at the time of Maxentius, as postulated by Sir Ian Richmond, the upper structure was not as substantial as the 1st period wall upon which it was built and hence more susceptible to the stroke of the ram, and it was vital therefore to contain siege machinery within artillery cover. The projecting bastions of Romano-British towns are in general more widely spaced than those of Rome, and if the height of the catapult casement is limited to the height of the wall, that is to say 20 ft, and the tower or bastions spaced by 100 ft then assuming a depressed angle of 20 degrees, dead ground would extend round the bastions over a radius of 55 ft, and could be covered by cross fire from adjacent bastions. This however requires an extensive flexible inclination in elevation, which is not readily apparent in the design of the catapult. In the defence of Rome the ditch was spaced away from the wall, not only to keep the ram at a respectable distance, but to take advantage of the catapult fire power, in so doing the limitations of the weapon created difficulty in covering the berm. It follows therefore that some other arrangement of the defences in Romano-British towns must be considered, in order to accommodate an acceptable range of adjustment in elevation.

Whether or not this form of defence derives from military experience in the field does not materially assist the argument; if the military in the province had been wholly responsible for the design and construction of Romano-British town defences, one would have expected a greater degree of consistency, which is not the case. Instead, the 4th century defences appear to be a hybrid arrangement derived from those of Rome, including the 1st period defences by Aurelian and later development in the 2nd period under Maxentius. In all probability a common defence strategy was of military origin influenced subsequently by the civil administration and economy of individual towns, which may well account for the wide variation in bastion design and spacing. The provision of a ditch and counterscarp presents advantages, but not necessarily for the same reason as in the defence of Rome, bearing in mind the limitations in weapon design.

13.2.2 The defences of Romano-British towns

a) Great Casterton

At Great Casterton the remains of two projecting bastions were recovered, one on a corner of the defences and the other spaced by 55 yards. The inner 2nd century ditch had been back filled creating a berm of 27 ft in place of the earlier berm of 7 ft, sufficient to accommodate interval bastions, (Corder, 1956). With the height of the wall at 20 ft, a variable depressed angle of the order of 5 to 13 degrees would be necessary to cover the space between the two bastions and the dead area in the foreground, this could probably be arranged by modification of the stay supporting the trough of the weapon, and there would be no difficulty in setting the missile in the groove. At the edge of the berm a wide shallow ditch was cut into the rock to a width of 60 ft, and the stone from it used to fill the earlier inner ditch, the remainder being piled on the outer scarp of the wide ditch. Its function is not readily apparent and would certainly require cross fire to cover it. Furthermore, hand weapons from the wall such as bow and arrows, hand-catapults, spear and stone throwers would be adequate to enfilade the wall, berm, and the ditch.

The comments by I A Richmond are relevant, 'A study of the ballista (catapult) reveals that without some very complicated adjustment, and particularly carefully designed arrangements for dealing with a recoil, this spring gun could not hit at close range an objective below the level of the barrel. For the normal trajectory of its missile was either straight or parabolic. Ground immediately below the tower was therefore dead, and so an isolated tower would be surrounded by a space which the ballista could not cover. But when towers were grouped close to one another the difficultly of defence thus raised could be simply solved. Two ballistae, which used the side windows, would be designed to concentrate, not only upon the short piece of ground which separated the two towers (which also would have to be covered by 'co-operation') but upon the dead ground in front of the neighbouring towers as well' (Richmond, 1930:79-80).

The question of recoil does not arise(Campbell, 1984;80), but although this confirms the limitations of the catapult it does not elucidate the purpose of the ditch, neither does it offer any solution in the absence of interval towers, and there must be other considerations in the provision of bastions and a wide ditch.

Assuming the top of the bastion is enclosed in order to protect the fibres that provide the torsion from damp, the aperture through which the missile is projected must be large enough to extend downwards to accommodate depressed angles, and Dr Baatz cannot recall the presence of apertures of this type in the defence installations which have been preserved. If on the other hand the bastion platform was open, with only a simple roof as at Caerwent, depressed angles of fire are feasible.

b) Viroconium

The presence of a wide ditch round the perimeter of Viroconium is clearly visible at ground level, with a width of 60 ft and a maximum depth of 15ft verified by excavation. The ditch extends almost to the wall leaving a berm of a few feet, no more than that provided between the wall and the inner lip of the adjacent 2nd century ditch. Its W shaped profile is not readily explained in terms of the function of the ditch, but it is derived from the spacing of the inner 2nd century ditch from the wall. The question is, was the 2nd century ditch left as an attribute to the purpose of the wide ditch, or did it arise as a consequence of an attempt to economise in labour, bearing in mind the prospect of excavating material round a circuit of at least 1½ miles, assuming the line of the existing defences overlooking the river Severn did not merit or allow a reconstruction of this form. If the inner 2nd century ditch was in a good functional condition it may well have been deliberately included in the reconstruction, as is evident in the section by K Kenyon on the east defences, (Fig.12.19). As an alternative, the section on the south alignment by G Webster (Fig.12.20) clearly indicates a continuous wide ditch profile, and would be explained if the 2nd century defensive ditches were in poor condition and had been allowed to silt up. It is considered that this is more representative of the wide ditch, but may only be resolved by further careful excavation at other points round the circuit. It may be that the W shape arises as a consequence of excavation and not necessarily a deliberate intention in construction, but the variations do suggest that the wide ditch is of secondary importance in this particular system of defence.

There is no indication for back filling of the inner ditch at Viroconium, and therefore no extended berm to allow for the construction of projecting bastions. Archaeological opinion has maintained that there is no evidence for bastions round the circuit, by the same token there would be no necessity for any change in the arrangement of the 2nd century defences, but the evidence for a reconstruction in the form of a wide ditch dictates otherwise, for there is no obvious advantage in providing such a facility in the absence of bastions in one form or another. Persistent aerial reconnaissance by the writer has shown evidence for the curved profile of a platform extending into the ditch on at least four corners round the circuit, allowing sufficient space to accommodate a bastion of similar style to that at Great Casterton, with a capability for two catapult emplacements. Doubt was still expressed, in that the crop-mark response failed to show evidence for the remains of the large stones used for bastion foundations, nor any indication of a robber trench. However, the evidence for platforms is indisputable, and implies back filling of the inner 2nd century ditch at the angles to provide a firm foundation for bastion construction. The situation at Viroconium therefore suggests a bastion sited at the corners, with no provision for the installation of interval bastions. In this case the catapult field of fire is restricted to its range capability and swivel coverage, and from the wide separation of the corners there is little prospect of providing mutual cover from cross fire.

The function of a wide ditch is still not evident, and there must be another feature in the design to be taken into consideration, in order to justify its construction. For example, the introduction of a counterscarp may also form an integral part of the defensive system, for it is difficult to believe that material from the ditch was disposed of to no purpose; although comment refers to the importance of a ditch and berm with respect to artillery cover, little reference has been made to the possible function of a counterscarp. For defence by artillery to be effective implies that dead ground must be avoided where possible, and if material from the ditch was merely dumped to form an outer scarp it would provide some limited cover behind it. But if the counterscarp was constructed in the form of a ramp or sloping platform to the top of the scarp, it would present an approaching force in full view and exposed to effective artillery fire, a suggested arrangement is given in Fig.13.24. The advantages are obvious in that only a small angle of depression would be necessary to adjust the catapult field of fire, the function of the ditch is also apparent in keeping assailants at a lethal distance and as a deterrent to scaling the wall, a further advantage is gained in that the sloping outer face of the ditch is increased by the counterscarp, presenting an obstacle to a force in retreat and exposed to fire by hand weapons from the wall and bastion. There is sufficient material from the ditch to backfill the outer 2nd century ditch, and form the counterscarp accordingly. There is no convincing evidence from crop-marks to indicate that the ditch swings away from the corners to maintain its width, and this may only be confirmed through excavation. The 4th century defences at Viroconium are meagre indeed, with stretches of the perimeter not covered by artillery fire, particularly on the east and south alignments.

The pattern of the town 4th century defences as recovered from excavation and aerial reconnaissance, is given in Fig.13.25, and the only convincing evidence for a counterscarp is revealed through crop-marks on a section of the north alignment, (Fig.13.17), but the wide ditch appeared over the whole of the north perimeter (Figs.13.13 and 13.17). The fragmented alignment of the 2nd century ditches is also shown round the circuit, and crop-marks at the northwest corner (Fig.13.19) indicate three ditches of that period, revealed in the absence of a 4th century recut at this corner, Fig.13.25, here the ground rises beyond the defences, and suggests that artillery cover would be effective without the need for a wide ditch and counterscarp. The apparent discontinuity of the 4th century defences at the southeast corner is not so well understood, except to suggest that artillery at this point would allow covering fire for the southeast gate, and to a certain extent the area south of the defences, but the reason for the discontinuity remains obscure. A similar argument applies to the bastion site at the northeast corner in that it offers protection for the Norton and Watling street gates, and well within the range of a catapult. Artillery sited on the north and northwest corner completes the cover round the north circuit. The east corner stands alone, but from its siting on relatively high ground offers a defence over an area to the north, and down the valley of the Bell Brook to a certain extent, assuming the angle of weapon depression required is feasible.

There is no evidence for a bastion site on the alignment between the Bell Brook and the southeast gate, unless an entrance to the east is proved together with gate towers.

13.2.3 Summary

a) The north sector is well provided for in terms of artillery cover from angle bastions, compared with the remainder of the circuit. However nothing is known concerning the construction of the gates, and in the event, there is the prospect of a catapult emplacement on platforms above the guard chambers, if any. It is considered that a case has been made from the results of aerial reconnaissance, for the presence of angle bastions, and further supported by the evidence for approach roads leading to the northeast and southeast corner, (Figs.13.15 and 13.9 respectively).

b) The 4th century defensive system at Viroconium compares with that of the Romano-British town of Kenchester to the south, in respect of a wide ditch and angle bastions, with no evidence or facility for the provision of interval bastions. There is little doubt that the artillery used would be in the form of a two arm arrow firing catapult, the prospect of employing large stone throwing engines in a defence mode is highly improbable, for a solid stone bastion is not a sufficiently elastic platform to absorb the shock and vibration, quite apart from its restricted mode of operation, a hollow bastion with a wood platform would be totally inadequate, but capable of accommodating a catapult.

c) The outer defences of Rome were designed to use the power of artillery to the best advantage under conditions of siege, and the creation of a berm was unavoidable. This mode of defence is not envisaged in Romano-British towns, but equally a berm is an undesirable feature, and arises from the requirement to provide a firm foundation for multiple bastions round a circuit. It is considered that the primary objective of a wide ditch is to provide material for a counterscarp, sufficiently spaced away from the wall and bastions to accommodate the limitations in bringing catapult fire to bear on an approaching force, and also allow an increase in depth on the outer face of the ditch as a deterrent. Although an arrow firing catapult is primarily designed for horizontal and elevated angles of fire, the assumptions made are based on the feasibility of achieving limited angles of depression; on the information received from Dr Baatz, his Ampurian weapon could be inclined to 14 degrees. The variation in ground profile is also a factor to be taken into consideration, when assessing the effectiveness of the 4th century defences at Viroconium.

d) It is reasonable to postulate that the 4th century defences of Viroconium derive from the strategy envisaged for the defence of Rome in AD310. Theodosius would have been well aware of the advantages and limitations in the use of artillery as a mode of defence, particularly against a more experienced and better eqipped opponent than barbarian or tribal forces.

e) Unfortunately the defences of Viroconium have been sadly neglected compared with the investigations in the town centre, and barely sufficient to substantiate the analysis given. Further excavation is long overdue to establish the form of the 2nd and 4th century defences, as suggested from the results of aerial reconnaissance, particularly in the areas of uncertainty outlined in the discussion.

13.3 Aqueduct

The source of the aqueduct originates from the course of the Bell Brook, where the valley narrows approximately three quarters of a mile to the east of the town defences. A dam in this area is not yet proved, but is a reasonable assumption. The delivery is accomplished by means of an open channel, engineered to follow the land contour to the point of entry on the alignment of the east defences. Excavation has shown that the channel was some 8 ft wide at the top, 3 ft deep and clay lined, with a gradient of 2 ft 4 ins per mile as established through levelling, (Webster & Hollingsworth, 1959). On a premise that the channel had a 2 ft wide bottom, and sides sloping at an angle of 1½:1, with a foot of water the delivery was estimated at nearly two million gallons per day.

For most of its length the channel has been ploughed out, but apart from two short sections, crop-marks have revealed its course as given at A in Fig.13.26. An additional channel B constitutes a modern drain, with the extant remains of the aqueduct in pasture at C, and clearly evident on the ground. Continuity of the channel into the next field is shown in Fig.13.27 at A. The line of the town east defences is defined by the hedgerow B, and although the course of the aqueduct is diffuse as it approaches the defences, it can be traced and seen to divide into two channels, C & D. Unfortunately after this photograph was taken in 1961, these surface remains have also been ploughed out, and subsequently proved impossible to retrieve through crop-marks. At their apparent termination the two channels deviate toward the south, and from the evidence it cannot be determined whether they were functional at the same time, but it is highly improbable, and it may be safely assumed that the two channels represent different periods of operation.

That they are identified across the line of the counterscarp and partly into the ditch is evident, that is assuming continuity of the 2nd and 4th century defences in the area. From the excavation by K Kenyon (Fig.12.19, Section C) the 2nd century ditch is not in evidence north of the farm lane, and continuity of the 4th century recut also appears to be in doubt; the section is approximately 60 ft south from channel D. This area of the east defences is in question, with no prospect of postulating the mode of entry into the town, in the absence of excavation. However, the second channel to the north at C, Fig.13.27, is perhaps more informative in that it appears to be coincident with a street alignment in the town, extending across the line of the rampart as shown in Fig.13.25, but whether or not it is associated with the aqueduct remains a matter of speculation. A sketch plan illustrating the course of the external aqueduct channel is given at Fig.13.28. In the area east of the town defences crop-marks also show evidence for occupation in the form of enclosures and ring ditches, of these the most important is a settlement at Site 128 near the source of the aqueduct. Associated with this is evidence for the remains of a villa, in the form of building foundations revealed by negative crop-marks.

The course of the aqueduct within the town has been the subject of speculation. It was suggested that the ditch recovered by K Kenyon on the alignment of a defensive system across the town may be the aqueduct channel, (Fig.11.37(c)), but from its dimension it is too large, with a bottom 8 ft wide the depth of water at full flow would only be the order of 3 ins. The section is also close to the line of the town main street, and with the bottom of the ditch at some 8 ft below it, presents a problem in channeling the water supply to the baths site. Furthermore as 3rd century pottery was found in the silt infill, the ditch could not have been an aqueduct channel as the thermae was functional during that period. From excavation on the line of the suggested defences, S Johnson considered the evidence for a cobble road along the high ground above the Bell Brook to be the platform for an aqueduct, (Fig.12.5), although there is no indication for any water conduit the road does have a gentle gradient to the west. According to the excavator the road or platform is terraced into the sloping ground, but a ridge did exist on the ground above it, and it is possible than an aqueduct channel, or conduit followed the line of the ridge instead of the road, to be subsequently destroyed when it was levelled by the farmer. Evidence for a substantial clay lined pit was also recovered near the ridge, together with a gully possibly leading to it (Fig.12.5 and Appendix 2), and from its direction points toward one of the external aqueduct channels. It was suggested that the pit may have served as a reservoir, or alternatively could be the remains of a quarry pit to supply material for a rampart, but why should it be clay lined. Finds however did confirm that the earliest infill was of the first half of the 2nd century.

The date of the external aqueduct channel is unknown, but there is evidence for an earlier bath house under the remains of the forum, and a water supply for it may have been provided as part of the initial town plan, with the pit later falling into disuse if, or when the course of the internal aqueduct was replanned to supply the present baths site. The only evidence so far for an internal channel is that suggested by crop-marks, as given in Fig.13.29, and the alignment at A is in the direction of the later bath site, with evidence for a channel B leading to an area behind the ridge, or in line with its remains. The positive crop-mark C defines the triangular outline of the pit, (Fig.12.5), and the course of the gully although not visible on the photograph, points toward the proposed aqueduct entrance at D. The use of the road at E as a platform for a water conduit over at least the initial part of its alignment cannot be discounted, but is highly improbable as there appears to be no obvious evidence for a channel emanating from any part of its course in the direction of the baths site. The line of the aqueduct from the east defences remains an enigma, and aerial reconnaissance can offer no further guidelines as to its course within the town.

13.4 Research Excavation on the civil defences

The crop-mark evidence for a platform at the corners of the town defences is of some importance, and attributed by the writer to the construction of the 4th century defences. But it was not until 1975 that an additional feature was observed at the northeast corner in the form of a series of post holes, positioned at the termination of the approach road and in alignment with the rampart, as given in Fig.13.30. The road metalling is outlined at A, and the lighter crop response C delineates the remains of the rampart, the latter is due to the relatively poor soil conditions giving a similar response to that over the road hardcore. In the area near the corner the evidence of post holes appears as darker spots in the crop, and may just be seen at B.

It is the considered opinion of the writer that the remains suggest the presence of a timber structure or tower, the evidence for it is persuasive and if it can be proved would be unique in Romano-British towns. Similar features have also been observed at other corners round the circuit, but here the evidence is ephemeral and when considered in isolation would not be sufficiently convincing to justify an investigation. It could be argued that such a structure for whatever purpose may form part of the 2nd century defences, but the approach road is still a dominant feature and in all probability the post holes are associated with the construction of the wide ditch and counterscarp. The results of excavations on the baths site have indicated a reconstruction of buildings in timber from the late 4th century, and it has been suggested that the outer civil defences may also have been in timber (Barker, 1985). However, from previous excavations the provision of a wall is convincing, but the presence of post holes may well have some relevance to the findings on the baths site, if they prove to be associated with a timber tower.

13.4.1 Site of Research excavation

This particular field is under the administration of the National Trust, and a formal application was made accordingly for a ground inspection and geophysical survey. The northeast corner is situated on relatively high ground, and a bastion or tower sited at this point would enable artillery to cover the line of the defences from the north gate extending east to the Watling street gate. Permission was granted to conduct a geophysical survey in the area, and the task was undertaken by the Birmingham University Field Archaeology Unit; the results are given at Appendix 3. Although the post holes were not identified, there was sufficient detail to reveal the robber trench of the wall, the berm and remains of hardcore on the platform. The outcome was encouraging, and a formal submission was prepared by the writer to English Heritage seeking Scheduled Monument Consent for a research excavation to test the hypothesis, and subsequently granted. Following several attempts to appeal for financial support, the project was finally accepted by Birmingham University Field Archaeology Unit on the basis of a student research dig, to which the Department of the Environment and the National Trust agreed.

The proposal to conduct an investigation on the northeast corner of the defences, was based entirely on the information derived from aerial reconnaissance. It is only at this particular corner on the town perimeter that the defence configuration is most convincing in its detail, and fortuitous in that not only is it representative of the 4th century defences but is not complicated by the integrated remains of the legionary fortress. The field in question also exhibits other important features, namely building foundations and possible burials previously unsuspected north of the Bell Brook. Although there is also evidence for side roads into the area from the Watling street, they do not constitute a regular pattern. With regard to the prospect of graves within the city boundary, it is noteworthy that the town cemetery is distributed along the line of the Watling street in a local area external to the town defences.

13.4.2. Excavation objectives

The objectives of the research excavation are defined under the following headings:-

a) Is there any evidence for a rampart and wall at this corner.
b) To establish the existence of post holes, and if confirmed do they represent the construction of a timber tower and with which defensive system are they associated.
c) Are the post holes contained within the confines of the rampart, or do they extend to the platform.
d) What is the function of the platform, was it

ever intended to accommodate a stone bastion and is there any evidence for it in the form of foundations.

e) What is the relationship of the platform with the post holes, if any.

f) To determine the form of the approach road and establish if it is of one period, or is there evidence for reconstruction.

g) What is the relationship of the approach road with the post holes.

To satisfy the above basic requirements a plan of the proposed area of excavation is detailed in Fig.13.31, it was considered that sections would be totally inadequate to solve the problems outlined, and as a consequence the area should be stripped to expose an overall plan of the features. This represents the first opportunity to conduct an excavation in depth, in order to resolve the question of a bastion form of defence in the 4th century at Viroconium.

13.4.3 Excavation results

The excavation commenced in the summer of 1991 under the direction of Dr. A S Esmonde Cleary, and an interim report of the findings is given at Appendix 4. From this it is apparent that the area is a complex of archaeological remains indicative of occupation, for which the results from aerial reconnaissance have only provided a limited response in terms of crop-mark evidence. This is to be expected as for other sites where excavation has revealed considerable detail not visible on the aerial photographs, and in general one can only anticipate that the more dominant features will appear, with a bonus in conditions of drought. From the results of this initial investigation there is no prospect of drawing any firm conclusions, and must await continued excavation in depth with a possible extension in area, to ensure that the features revealed through aerial reconnaissance are properly identified and evaluated. That the aerial evidence has justified a research excavation there is no doubt, and will ultimately constitute a viable contribution in respect of the town civil defences.

13.5 Conclusions

a) As a subject for a project oriented survey, Viroconium is without parallel in the field of air archaeology, and defines the inherent problems in the acquisition and interpretation of information derived from changes in the growth of vegetation. The interpretation presented is the opinion of the writer, and raises issues which are both controversial and currently the subject of speculation and conjecture, in the absence of excavation. The archaeology of Viroconium is complex, in that it is a synthesis of timber and stone contemporary with its development. As a frontier town it is unique in the province and justifies a more rational approach in terms of excavation, particularly in the areas of contention as presented in the discussion. Although the considered interpretation is intended to highlight the uncertainties and problem areas, it also provides a more informative basis for future assessment, than has been the case hitherto. The illustrations presented are minimal, and do not reflect the work involved over many consecutive seasons of observation, during which the results appeared in fragmented form. It was only conditions of exceptional drought, that presented a brief opportunity to observe and record the complexities and richness of the remains, within the limitations imposed by the vagaries of crop rotation and land use.

Even in such circumstances, the writer's resources and opportunities were insufficient to maintain the obvious requirement for frequent periods of observation during a season, necessary to extract the maximum amount of data so revealed. It must also be borne in mind that very dry conditions are a rare occurrence, and made demands on reconnaissance commitments elsewhere, and there is always an element of personal judgement and luck in the timing chosen. The town area is now fully protected by English Heritage and the National Trust, and maintained in pasture. In the absence of cereal crops such details as have been recorded may not appear again, and as a consequence excavation will have to rely on the existing archive, from whatever source; but no doubt there will be future guidelines through parching effects in pasture, to pinpoint particular features of interest both from the air and on the ground.

b) It is apparent that, although the results of excavation suggest three possible phases in the development of the town outer defensive system, only the first phase has been assigned a date. They have to a certain extent been repetitive, and no changes of any particular significance have appeared. It is only through aerial reconnaissance that new and unusual features have been observed, which may provide a more detailed insight into the history and construction of the town defences. There are obvious inconsistences, and there is also a need for statistical information relating to the date, function and style of the various periods of construction involved. The results from aerial reconnaissance have identified particular areas of interest, for example on the east alignment south of the Bell Brook, in the region of the aqueduct. An anomaly on the line of the south defences leading to the site of Finger Post Cottage at the southeast gate, is worthy of investigation. With regard to the defences of the 2nd century, the crop-marks of ditches on the northwest alignment present an opportunity for future excavation. Unfortunately aerial reconnaissance can offer no evidence for the existence and form of the gates round the town perimeter, in that they are coincident with a modern road or lane, nor for that matter is there any indication for the remains of roads leading to the gates.

There is however, sufficient evidence from crop-marks to justify further investigation with regard to the origin and subsequent form of the parallel ditch and road system aligned across the town; the results are tantalising and of considerable importance as a feature in the context of the town development, and excavation may also elucidate the arrangement of the town streets in that area. The 4th century defences have been dealt with in some detail, and there is every prospect that the existence of a platform at each corner is representative of a bastion site. Although a case has been made by the writer, and excavation initiated on the northeast corner, there is as yet insufficient data to prove the findings from aerial reconnaissance, and continuity of the investigation is paramount if the problems are to be resolved.

c) One of the features of significance in other Romano-British towns is the presence of an Amphitheatre, this is not in evidence at Viroconium, despite all attempts to locate it by Cambridge and the writer. It is strange that a town of this size has not been so equipped, there are one or two areas in the vicinity that look promising, but fail to reveal any convincing evidence. At some 250 metres from the southeast gate and north of the modern road is a double ring ditch, at present thought to be the remains of a barrow site, at A, Fig.13.32. From its arrangement it may well justify an investigation and ground survey, the ring is incomplete with a diameter of some 50 metres and a spacing of approximately 3 metres between the two ditches. The crop-marks also suggest the possible remains of a robbed out feature around it, but this can only be speculation in the absence of further evidence.

d) With regard to the distribution and form of the buildings recovered through crop-marks within the town perimeter, it was considered that any attempt to produce an overall detailed plan from obliques alone, would be unrepresentative and subject to unacceptable inaccuracies, in view of the paucity of control points. However, it proved feasible to outline the street plan and defences together with other features of interest, as given in Fig.13.33. To compliment this, D R Wilson has kindly allowed the writer to include a copy of his considered plot, Fig.13.34, derived from a combination of vertical and oblique photographs in the Cambridge collection, (Wilson, 1984;Fig.1). The arrangement and detail of the buildings has been agreed in principle, and it remains to collate the joint findings in order to produce a fully representative plan of the town.

e) The crop-mark evidence for occupation in the vicinity of Viroconium is substantial, particularly to the north where it extends over an area of some 500 acres, and suggests that the land was cleared for cultivation at least prior to the extension of the town defensive system. Whether or not such development may be associated with a Vicus is open to debate, but the presence of square barrows integral with the field system is indicative of early occupation. Much of the land in the area is relatively well drained, and it would seem reasonable to postulate the existence of an agrarian society prior to the construction of a legionary fortress at Viroconium. The presence of Roman temporary camps in the vicinity, of up to 30 acres, also lends support to the argument in terms of land clearance. Square barrows of Iron Age type are a rare occurrence in the valley of the river Severn, and justify investigation.

f) The problems associated with the mode of entry of the aqueduct channel into the town and its subsequent course to the baths site, remain unresolved. The possibilities have been outlined from the results of aerial reconnaissance, as an aid to excavation, there are however no indications with regard to what must have been a complex system of water distribution within the town. Only the line of the main drain from the baths site to a river outfall is in evidence.

g) The results of detailed excavations by G Webster and P A Barker on the baths site, (reports forthcoming), have demonstrated a degree of complexity in this particular area, and its impact on the archaeology of Viroconium has yet to be assessed. It is perhaps from this consideration, together with an appreciation of the results from aerial reconnaissance, that a realistic future policy in terms of excavation within the town and its defences will emerge. The marriage between aerial reconnaissance and excavation is tenuous, but an attempt has been made in this thesis to explore the potential. The value of the contribution to archaeological knowledge from aerial survey techniques is not in question, but the acquisition and subsequent interpretation of the results is complex, and comparable with the assessment of the findings from excavation, and subject to the same pitfalls. The archaeology of today is a synthesis of both disciplines, and merits a more comprehensive evaluation and analysis of the combined results, or archaeology may be the less informed.

APPENDIX 1

REPORT ON INVESTIGATIONS AT SITE OF ROMAN FORT

Location

The location of the fort is Roman Fort No. 2, Heron's Reach, Greenforge, Wall Heath, Worcs. The site was identified by aerial photographs and differences in growth of a cereal crop (winter wheat) growing in the field could be seen from the ground.

Investigations

Mr. D. Mackney and Dr. C. W. R. Smith visited the site and dug two profile pits, one adjoining a line of very good cereal growth, and the other adjoining an area of poor growth, two yards away (Fig. A1.1). Soil profile descriptions were made (Tables 1 and 2). Soil samples were taken from each distinct horizon, and chemical and mechanical analyses made, (Table 3). Plant samples were also taken and chemical analyses made, (Table 4).

Conclusions

There was no difference in the chemical analysis of the crop which would explain the difference in growth, nor was there any marked difference in the available nutrient status of the soil, to the full extent of the profile. The main points of interest in the nutrient status of the soil are the high levels of available phosphate, even in the lowest horizons, and the very low available potash, even in the top horizon.

The soil where the growth of the crop was poor did show rather lower levels of nitrogen, and more markedly lower levels of organic carbon, at each corresponding horizon, than the soil where the crop was growing well. This was in line with the observations made when describing the profiles; for example the profile where the growth of the crop was poor was very stony in the 15"-20" horizons. The differences in stoniness are also reflected in the field moisture contents. The stones would also have a diluting effect on the available plant nutrients determined on the fraction less than 2 mm.

It can be concluded that there are marked physical differences between the two profiles, in mechanical analysis, including stoniness, and in structure, which may well be affecting moisture content and nutrient uptake. These differences are a likely explanation of the differences in the growth of the crop.

The mechanical analysis of the soil where the crop was growing well was remarkably uniform throughout the depth of the profile. The mechanical analysis of the top horizon (0-15") of the soil where the crop was growing poorly was very similar to this, but mechanical analyses of the remaining horizons were markedly different from the top horizon, though similar to each other. There would thus appear to be two materials of different origin present, a finding which is in agreement with the site having been disturbed. It is possible that the area of good growth may mark the position of a ditch which has subsequently filled up. The area of poor growth alongside, which is similar to the main part of the field, would correspond to relatively undisturbed gravel.

4 March 1963 Dr. C. W. R. SMITH

Table 1

Profile No.	St. 8	General Group	Sandy acid brown soil
Grid Ref.	SO 863885	Series	Newport
O.S. Sheet	130	Type	-
Described by	D.Mackney	Date	3rd August 1932

Locality: Wall Heath - Site of Roman Fort

Elevation: 200 ft

Slope and Aspect: Flat

Relief: Flat terrace 20 ft above alluvium of the river Stour

Drainage
- Profile: Free
- Site: Satisfactory

Parent Material: Terrace and/or Glacial sand with some gravel

Vegetation or system of agriculture: Corn and sugar-beet, pit dug in gap between them

Index Date
- Map Symbol: -
- Airphoto number: -

Weather: -

Climatic Data
- Rainfall: -
- Temperature: -

General Remarks: Profile dug along side the tallest and highest yielding corn.

Table 1 continued

Layer Depth inches	Description of Horizons
0" - 15"	Dark grey (10YR 4/1.5) dry, sandy loam; stony mainly rounded Bunter pebbles (1 - 3 in.); compact - breaking easily to very weak crumb and single grain; fine inter-grain pores; friable; low mull; numerous fine roots including knotgrass; moist; some charcoal and coke fragments; earthworm; sharp boundary to:
15" - 28"	Brown (near 10YR 5/3) dry, sandy loam to loamy sand; stones as above; compact - breaking easily to very weak crumb and single grain; fine inter-grain pores; friable; very low organic matter; few roots; moist; no sec. chem; and minerals observed; earthworm channels bringing dark grey material into layer; merging boundary.
28" - 34"	Brown (10YR 5/3) dry, loamy sand; fewer stones; compact - breaking easily to very weak crumb and single grain; very low organic matter; rare roots; moist; earthworm channels; merging boundary.
34" - 38"	Brown (10YR/5/3) dry; loamy sand; rare stones; compact - breaking easily to very weak crumb and single grain; fine inter-grain pores; friable; very low organic matter; no roots; moist.

Sample	1	0 - 15	inches	5.	inches
	2	15 - 28		6.	
	3	28 - 34		7.	
	4	34 - 38		8.	

TABLE 2

Profile No.	St. 9	General Group	Sandy acid brown soil
Grid Ref.	SO 863885	Series	Newport
O.S. Sheet	130	Type	-
Described by	D.Mackney	Date	3 August 1962

Locality Wall Heath - Site of Roman Fort

Elevation 200 ft

Slope and Aspect: Flat

Relief: Flat terrace 20 ft above alluvium of the river Stour

Drainage Profile: Free

Site: Satisfactory

Parent Material Terrace and/or Glacial sand with some gravel.

Vegetation or system of agriculture Corn and sugar-beet, pit dug in gap between them.

Index Date Map Symbol: -

Airphoto number: -

Weather

Climatic Data Rainfall: -

Temperature: -

General Remarks Profile dug where corn was shortest and yield likely to be low (2 yards from St. 8).

Table 2 continued

Layer Depth inches	Description of Horizons
0" - 15"	Dark grey (10YR 4/2) dry, thin 1" band of subsoil (10YR 5.4/4) crosses horizon at about 12in., sandy loam to loamy sand; stony, mainly rounded Bunter pebbles; compact, stones leave imprint, breaks easily to crumb and single grain; abundant fine pores; friable; low mull; numerous fine roots; moist; earthworms; sharp boundary to:
15" - 20"	Yellowish brown (10YR 5.5/4) dry, pebbly sand; very stony; single grain; many fine pores; friable; very low organic matter; concentration of fine roots; dry; sharp boundary to:
20" - 33"	Yellowish brown (5YR 5/6) dry, sand; no stones; single grain; may fine pores; friable; very low organic matter; few roots below 22 in.; moist 2; merging boundary to:
33" - 36"	Yellowish red (5YR 5/6) dry, sand; no stones; single grain; many fine pores; friable; very low organic matter; no roots; moist 2.

Sample 1	0 - 15	inches	5.
2	15 - 20		6.
3	20 - 33		7.
4	33 - 36		8.

TABLE 3

Analysis of Soil Samples

Sample	CHEMICAL ANALYSIS							% Moisture in Field Sample	MECHANICAL ANALYSIS				
	pH	Available Phosphate p.p.m. P_2O_5		Available Potash p.p. 10^{-5} K_2O		% Total Nitrogen	% Organic Carbon (Tinsley)		Percentage in range				
		Fig.	Classn.	Fig.	Classn.				200µ-2mm	20µ-200µ	2µ-50µ (Amer. Silt)	2µ-20µ	Less than 2µ
Area of Good Growth													
0 - 15"	7.1	71	High	4	Very low	0.11	1.6	8.3	53	33	11	5.8	8
15"- 28"	7.2	64	"	2	" "	0.06	0.6	5.7	52	36	9	4.4	8
28"- 34"	7.2	74	"	2	" "	0.04	0.4	7.8	53	36	9	3.9	7
34"- 38"	7.2	68	"	2	" "	0.02	0.2	3.0	51	40	9	4.3	5
Area of Poor Growth													
0 - 15"	7.0	74	High	4	Very low	0.10	1.4	8.1	48	38	11	5.8	9
15"- 20"	6.8	50	"	2	" "	0.05	0.4	2.9	69	22	5	2.4	7
20"-33"	7.0	44	"	2	" "	0.02	0.1	3.6	72	24	2	1.6	3
33"- 36"	6.8	50	"	2	" "	0.02	0.1	3.2	73	23	1	1.0	4

TABLE 4

Analysis of Plant Samples

Sample	% on Dry Matter				
	N	P_2O_5	K_2O	CaO	MgO
Area of good growth	1.1	0.5	1.1	0.3	0.14
Area of poor growth	1.0	0.5	1.0	0.3	0.12

Ditches of a Roman auxiliary fort as a crop-mark at Wall Heath, Greensforge, South Staffordshire. Grid Ref. SO 863 885.

A Sugar-Beet.

B Wheat.

Fig. AI.I

APPENDIX 2

RESULTS OF EXCAVATIONS AT VIROCONIUM (WROXETER)

by

S Johnson

Inspectorate of Ancient Monuments

EXCAVATIONS ON THE EASTERN DEFENCES, WROXETER, 1975

The excavation on the eastern defences took place in order to determine the state of preservation of the remains and at the same time in an attempt to shed light on one of the most complex areas of the defences of the *civitas*.
After her excavations in 1936-7, Dr. (now Dame) Kathleen Kenyon suggested that one of the city gates might lie in the area immediately north of the sections she cut. Aerial photographs of this area, taken by Arnold Baker (lodged in the National Monuments Record Air Photographic Library, SJ 5608/242-4) show a road approaching the defences at this point. The photographs also show a ditch running roughly parallel to the road, running east-west across the field, and turning southwards under the east rampart of the city defences. Another series of features, variously interpreted as aqueduct or early defensive system, run along the crest of high ground, just south of, and roughly parallel to the Bell Brook (Baker, *Transactions of the Shropshire Archaeological Society*. 59 (1969-70) 24ff.). In addition, the aqueduct, whose course outside the defences is known from previous surveys (Webster, *Transactions of the Shropshire Archaeological Society*. 56 (1959) 133-137) enters the city in this area.

Although in intention the excavation was to have examined a wide area in detail, the excessively dry weather, coupled with the fact that this is the highest, (and therefore the best drained) part of the site, made this impossible. Accordingly, the excavation was limited to three separate sections cutting the linear features which meet actually on the line of the eastern defences. These are (a) the defences themselves, in the area sectioned by Kenyon, (b) the road and ditch approaching east-west across the field, and (c) the linear features which keep south of and follow the line of the Bell Brook.

To examine (a), a section was cut across the defences. The large outer ditch was not sectioned, nor was it possible, without obstructing access to the field, to trace both early ditches found by Kenyon (Archaeologia LXXXVIII (1940) pl. xx, C), but the wall was located. together with layers of ramparts of several periods. Kenyon's innermost ditch, underlying all other features in the section, was fully bottomed, presenting a 'V'-shaped profile, but it was still only 1.2m deep from the original Roman ground surface. On this, 1.30m inside the inner lip of the ditch, a pair of stacked turves were all that remained of the front of a rampart of military style. unfortunately its width could not be determined, since it and its ditch had been deliberately levelled after use, and later reconstruction of the rampart bank had obscured its inner face, Above this levelled rampart was more dumped material: if this was a second turf rampart, its front may have been destroyed by the insertion of the wall , or it may have lain further to the east, outside the scope of the section. Its back, or at least a stage in its construction, was marked by a line of rest marked by turves leading down to a gully (visible also on Kenyon's section Archaeologia LXXXVIII (1940) pl. xx, B). The wall itself, the latest feature on the site. survived only as footings of clay and cobbles 2.10m wide, and most of the rampart bank specifically associated with it had disappeared. There were slight indications that the facing of the Roman wall would have commenced at the base of the present ploughsoil. Remains of buildings found partially buried in the tail of the rampart were not examined.

At (b), a trench parallel to the defences but about 10m inside the tail of the rampart was dug to locate the road and the ditch approaching across the field. The ditch was 'V'-shaped, 3.6m wide and 1.6m deep: it may be the same ditch as appeared under all other features in the eastern section. Above it, the only trace of occupation was a series of rubbish pits dug into the natural sand and containing mainly second century pottery. Only in the slumped ditch fill itself was there any trace of floor surfaces of pebbles to correspond with the pits. The road was also sectioned: it had been resurfaced several times, and south of it, cut into the natural were beam slots of rectilinear timber buildings. Ploughing and erosion in this area had caused serious damage to the stratigraphy. Between the ditch and the road was a space of about 10m, sufficient for a rampart which had been completely levelled. The timber buildings may therefore have been of military origin, since they lie inside the "intervallum road".

At (c) a long section was prepared to cut the linear features along the slope overlooking the Brook. This was left unfinished because of the unexpected depth of Roman deposits encountered, but sufficient was excavated to show that on the steep slope lay at least two defensive ditches: at its crest was a clay and cobble foundation 3.7m wide, and behind this (ie <u>inside</u> the town) a deep silty hole, which may be a sump connected in some way with the aqueduct or a linear feature (possibly the aqueduct itself). It is intended to return to further examine the defences and features in this part of the site.

EXCAVATIONS AT WROXETER EASTERN DEFENCES, 1976

The aim of the 1976 excavation at Wroxeter was to clarify the discoveries of 1975, and to answer some of the more problematical questions about the Roman arrangements on the eastern side of the defences above and to the south of the Bell Brook.

Excavations were concentrated on the complex of features apparently running along the top of the slope leading down to the Brook, and in an alignment parallel to its course. What had appeared in 1975 to be a series of defences was sampled at two points, and found probably not to have been defensive in function at all, first, a large and deep pit, initially discovered in 1975, and lying almost at the top of the hill, was completely sectioned. It was found to be cut deep enough to be completely lined with red clay, the lower part of which was straight-sided. Only one corner of this large pit was identified, but from aerial photography, which shows a substantial dark rectangular mark in or around this area, it can be seen that this pit - perhaps in origin a quarry pit for rampart material - could have been some 40m by 30m in size.

North of this pit, (ie down the slope towards the brook) clay had been deliberately piled up, and into the downward slope the level platform of worn cobbles 3.42m wide had been set. This platform was encountered at two other places, with a similar width and only one stone deep. Measurements of the levels showed that it was dropping very slightly from east to west, and was terraced into the side of the slope. It was thus in an ideal position for a foundation for an aqueduct leading into the city from the eastern defences: no trace of piping or water conduit survived, but these could have been of wood or lead set on this gently graded trough.

About halfway down the slope from this aqueduct was a ditch, discovered in 1975 and now fully cleared out and recorded. It was severely 'V'-shaped and had probably silted fairly rapidly. It contained very few finds and lies in a very strange position to be considered as a defensive ditch. At the bottom of the slope, excavation continued on what had appeared to be a ditch, but this was found to be a mixture of silted layers on the valley bottom, suggesting that the Bell Brook may not always have followed its present course.

A layer of black silt covered much of the area of the upper part of the hill and within this there were no comprehensible features apart from two ditches, one of which ran closely parallel to the line of the military east-west ditch discovered and sectioned in 1975. All that remained of this ditch, however, was a small discontinuous 'V'-shaped slot, at the most 0.50m deep and containing pottery with a terminal date in the early second century, including some 'military' wares. The other ditch discovered ran at an angle to this, apparently draining into the large quarry pit. Fragmentary indications of other features were discovered, but there were no definable structures. The area has suffered badly from erosion, making much of the interpretation of any Roman buildings which may have lain on the very crest of the hill next to impossible.

WROXETER, work in Progress, 1976

Work on the Eastern Defences, 1976

A concluding season of excavation was carried out in this summer of 1976 in the area of the discoveries of 1975 in an attempt to clarify the purpose of the deep clay-lined pit and the level cobbled foundation encountered in the first year's campaign (Wroxeter, Work in Progress, 1975).

The excavation focussed on the complex of features which appeared from the aerial photographs (W A Baker, Transactions of the Shropshire Archaeological Society, lix 1969-70, 24f and PL1) to be running along the crest of the slope leading down to Bell Brook. Initial impressions in 1975 had suggested that there was at this point some form of defensive circuit running roughly east-west and forming a regular but polygonal boundary to the flat plateau of the 'East Field'. Examination of the features, however, at two points failed to establish that the arrangements at the crest of the hill-slope here were ever defensive in nature.

The main and most obvious feature of the long section down the hillside started in 1975 was a large and deep pit at the top of the hill. This was cut deep enough to have been lined completely with solid red clay, the lower part of which was straight-sided. Only one corner of this pit was identified and sectioned, but from aerial photographs of the area, which show a large rectangular mark in or around the spot, it may have been of substantial size - perhaps as much as 30 or 40 metres square. Though at first it was thought that this pit may have been something to do with the aqueduct system - a possible reservoir? - it is on balance more likely that it is no more than a quarry pit dug to produce rampart material for the civitas defences. Much of the earliest fill of the pit is of the first half of the second century. Such few finds as there were confirm this date.

Immediately north of this pit (ie towards the Brook) there was what appeared to be a deliberate bank of clay on the downward slope of which was set the level bank of worn cobbles 3.42m wide. This platform was encountered at two other places, and found to have been of similar width and only one stone deep. Else-where it lacked the bank of clay behind it. Measurements of the levels of this footing showed that it was dropping very slightly from east to west, and was at all three places terraced into the side of the slope. It can thus be safely interpreted as the foundation platform for the aqueduct leading into the city from the eastern defences. No trace of piping or water conduit survived, but these could have been of wood or lead set on this gently graded trough.

About halfway down the slope from the footing for the aqueduct was a ditch, discovered in 1975 and now fully sectioned and recorded. It was severely 'V'-shaped and had probably silted fairly rapidly after its original opening. It contained very few finds and its position, not easily explicable as a defensive ditch, suggests that it may have been dug to mark out some feature along the slope. At the very bottom, excavation revealed that what had appeared to be a further ditch was merely a mixture of silted layers on the valley bottom, suggesting that in Roman times, the Bell Brook may have been wider or on a different course within the valley floor.

In the larger area opened at the top of the slope, erosion by the elements as well as agriculture had caused serious damage to the remains. A layer of black silted material covered much of the area and within this there were few comprehensible features apart from two ditches, one of which ran closely parallel to the line of the 'military' ditch discovered and sectioned in 1975. All that remained of this ditch, however, was a small discontinuous 'V'-shaped slot, at the most 0.50m deep and containing pottery with a terminal date in the early second century. The other ditch ran at a slight angle to this, and appeared to be making for the 'quarry pit' into which it probably drained. Fragmentary indications of other features were discovered, but there were no definable buildings.

APPENDIX 3

WROXETER DEFENCES

A geophysical survey, 1989

by

Alex Jones

Birmingham University Field Archaeology Unit

1.0. INTRODUCTION

In August 1989 a team from Birmingham University Field Archaeology Unit undertook a small geophysical survey across the line of the north-east angle of the civil defences of the Roman town of Wroxeter, in Shropshire (centred on NGR. SJ 5678 0926).

The aims of the survey were:

(1) To investigate the response of resistivity survey to the anticipated man-made features in their natural surround, and

(2) To define the nature and extent of sub-surface features in this area.

Aerial photographs of the survey area appear to reveal cropmarks representing a line of small circular features immediately behind the defences, and following their alignment (Baker, 1970). These features have been interpreted as the post-holes for the timber uprights of a defensive bastion.

A small sample area (30m by 20m) was selected for survey in the plotted position of the cropmarks. Topographically the site occupies the lower part of a gentle north-east-facing slope. The area was formerly under intensive arable cultivation but reverted to pasture in 1989 under an English Heritage management agreement.

2.0. PRINCIPLES AND METHODS

2.1. Resistivity

A resistivity survey was considered to be the most appropriate technique of examination, given the nature of the subsoil and the features anticipated. Resistivity survey and crop-mark recognition alike depend on the detection of localised differences in soil constituents. These may very considerably in resistivity depending on water-content, and provide either encouragement or hindrance to crop growth. Detailed measurement of ground resistance from place to place can detect subtle changes (anomalies) in the near subsurface, caused by natural processes or man-made features, such as walls, ditches and postholes. Water-retentive materials, such as clay, are of low resistivity, whilst stone-filled features have a higher resistivity, due to their low water content which impedes the flow of electricity.

The technique cannot distinguish between differing soils of similar resistivity, and anomalies may disappear or reverse during the climatic cycle. Small anomalies may not be visible because of the coarseness of the survey; or may be caused by poor electrical contact due to bad planting of the electrodes. Slight distortion of anomalies can occur along traverse lines.

All geophysical methods of examination provide only an indirect method of site investigation. They are incapable of the same precision and complexity in recognition or interpretation as a direct method of examination, such as excavation.

2.2. Field techniques

A Geopulse resistance meter was used in conjunction with a 0.5m dimension 4-electrode square array. The square array comprises a frame in which all four electrodes are positioned at the corners of a square (modified Wenner) array. Readings of resistivity were obtained by grounding the electrodes at 0.5m intervals along contiguous traverses 0.5m apart; the same electrode orientation was maintained throughout the survey. A 1mA current was injected into the ground through two electrodes, the potential difference or ground resistivity (alpha values only) being measured across the second pair. One measurement was made per point; little gain in accuracy was achieved here when averaging four cycles of measurement per point. During each cycle twenty samples (measurements) are taken while the current is flowing into the ground (ion), and ten measurements while no current is flowing (ioff). When combined, the ion, ioff samples, and number of cycles determine the shape and duration of the pulse sent out by the meter, and therefore the sensitivity of the meter to the particular conditions of each site. Data was logged directly onto a linked micro-computer and stored on disk on completion of the survey. The effective depth of investigation depends on ground conditions, and the separation of electrodes, here 0.25m (Edwards, 1977).

2.3. DATA PROCESSING

A menu-driven graphics package on an IBM-compatible micro-computer was employed to provide on-screen interpretation of the data, and the illustrations for this report in the form of dot-density plots. These computer-generated plots highlight the areas of anomalies, represented by darker shading in areas of higher-than-average resistivity, and lighter shading in areas of lower-than-average readings. The plots discriminate sensitively between slight variations in recorded resistivity, and permit analysis of the outline, strength and spatial distribution of differing values within each anomaly. Figure 2A emphasises the areas of higher resistivity by the use of a logarithmic progression in shading. The interpretative plot (Figure 2B) is an inverse dot-density plot, where most dots occur in areas of low resistivity. Both plots depict resistivity values above the mean average of background readings for the area, and extreme high readings for the area, and extreme high readings have been partly truncated.

After recognition and definition, anomalies may be interpreted as either of natural or man-made formation. Interpretation relies on comparison with the surrounding topography and the shape, strength and sharpness of outline of the anomaly itself. Here interpretation of results was assisted by comparison with the plotted air-photographic evidence.

3.0. THE RESULTS (Figure 2A, 2B)

Readings of background resistivity in the survey area ranged between 15-35 ohm metres. In the western half of the survey a series of parallel, roughly linear bands of high resistivity (P) ca.2m wide and ca.2m apart may be defined, measuring 20% greater than background. A line of single point anomalies (A2) of low resistivity suggests the location of a quantity of buried metal or stone-free soil in these areas.

The main archaeological feature in the west area of the survey is a rectangular anomaly (A1), aligned north-south and measuring 4m across and 12m in length. A1 measures 45-60 ohm metres. It is less well defined against the linear bands of high resistance (P), but is more clearly defined against the areas of background resistivity.

To the east of the road further linear anomalies may be defined (A3, A4), in parallel alignment with the linear bands previously described (P). These eastern anomalies may be distinguished by their greater strength and markedly different outline.

A well-defined elongated anomaly (A3) measures 3m in width, containing values over 25% greater than the surrounding background. Within A3 the highest values of resistance are concentrated along its north-east edge. A4, parallel with A3, is a 2m-wide anomaly of low resistance, in the range of 30-40 ohm metres, and clearly defined outline throughout.

To the east of A4 are two anomalies of high resistivity, A5 and A6, roughly-D shaped in outline. They may be defined as areas of resistivity in the range of 40-60 ohm metres. A narrow band of higher values (A10) joins A5 and A6, but to the east values fall off gradually and its extent is difficult to define.

The most distinct anomaly in the survey is A9, aligned approximately north-south and measuring up to 7m across; it continues beyond the survey area. This is a band of low resistivity, irregular in outline, defined by values measuring 15-30 ohm metres.

Two anomalies (A7, A8), may be defined within A9. A7 is roughly oval, measuring 2m by 4m; A8 measures 2m by 3m but is more difficult to define spatially, or by its strength. A third area of higher resistivity enclosed within A9, south of A6, cannot be defined with clarity.

4.0. DISCUSSION AND INTERPRETATION

Care is required in the interpretation of results from such a limited area. A larger survey would allow the recognition and interpretation of wider archaeological and geological patterns of anomalies. The recognition of archaeological anomalies is also impeded by the comparatively narrow range of resistivity values represented here. It was not possible to auger the areas of anomalies to cross-check their physical composition.

However, it is possible to locate and define a number of archaeological features in the survey area. The pattern of alternate bands of high and low resistivity in the western area (P) may derive from ridge-and-furrow ploughing. Despite this plough pattern, also recorded in aerial photographs, a large, rectilinear stony feature (A1) has been located. This broad, stony feature may be interpreted as an area of hardstanding leading to an opening in the defences. A road has been identified from aerial photographs, but its alignment differs from A1. The anomaly A1 is located in an area where a series of post-holes has been located by aerial photography. Anomaly A2 may be interpreted as a scatter of metal, or possibly small stone-free features. Other single-point anomalies in the western area are caused by poor electrical contact, and should be disregarded.

To the east of the road the results exhibit some correlation with the evidence from aerial photography, and the plough pattern is not present. The broad, low-resistivity anomaly to the east (A9) may be interpreted as a defensive ditch, with a stone-free clay-silt fill. A7 and A8 are stonier areas within the ditch, possibly associated with the defences. A5 and A6, well-defined anomalies located on the edge of the ditch A9, and the narrow, linear anomaly (A10) may be evidence of components of a bastion platform jutting out into the line of the ditch, first located by aerial photography (Baker, 1970).

Behind A10 is an area of low resistivity (A4), possibly containing clays and silts, perhaps material from the excavation of the ditch; this may be the remains of the berm. A well-defined, broad band of higher resistivity (A3) west of A4 may be a stone-filled feature parallel with the line of the defences, an area of stone rubble, or the footings of the town wall.

5.0. IMPLICATIONS AND PROPOSALS

The results of this survey, albeit limited in scope, are of some significance to the further study of the defences and the town of Wroxeter. This exercise has demonstrated the usefulness of this rapid and non-destructive archaeological technique. Geophysics offers an exciting opportunity to investigate wider areas of the defences, town and vicus, as yet unexplored, except by aerial photography (for example Wilson, 1984).

Further, larger scale, geophysical survey, targetted initially along the line of the defences, would provide important, new and more detailed information, and allow for cross-comparison with the plotted aerial photographic evidence.

It is proposed that this further non-destructive academic study be combined with a training programme for students of archaeology, under professional supervision. Further geophysical survey of the defences should ideally be accompanied by limited excavation (for a research design see Baker 1990). This will allow the indirect evidence from the wider geophysical survey and aerial photography to be 'controlled' by the direct evidence obtainable from excavation.

6.0. ACKNOWLEDGEMENTS

We are grateful to the landowner and Mr Jeremy Milln of the National Trust for permission to carry out the survey. Mr Arnold Baker advised and assisted on site. Simon Buteux managed the project and edited this report, and Tony Clarke assisted with the fieldwork. Geophysical survey equipment was lent by Campus Geophysical Instruments, Birmingham University. We are grateful to Philip Barker, and Mike Corbishley (HBMCE) for their interest in the project.

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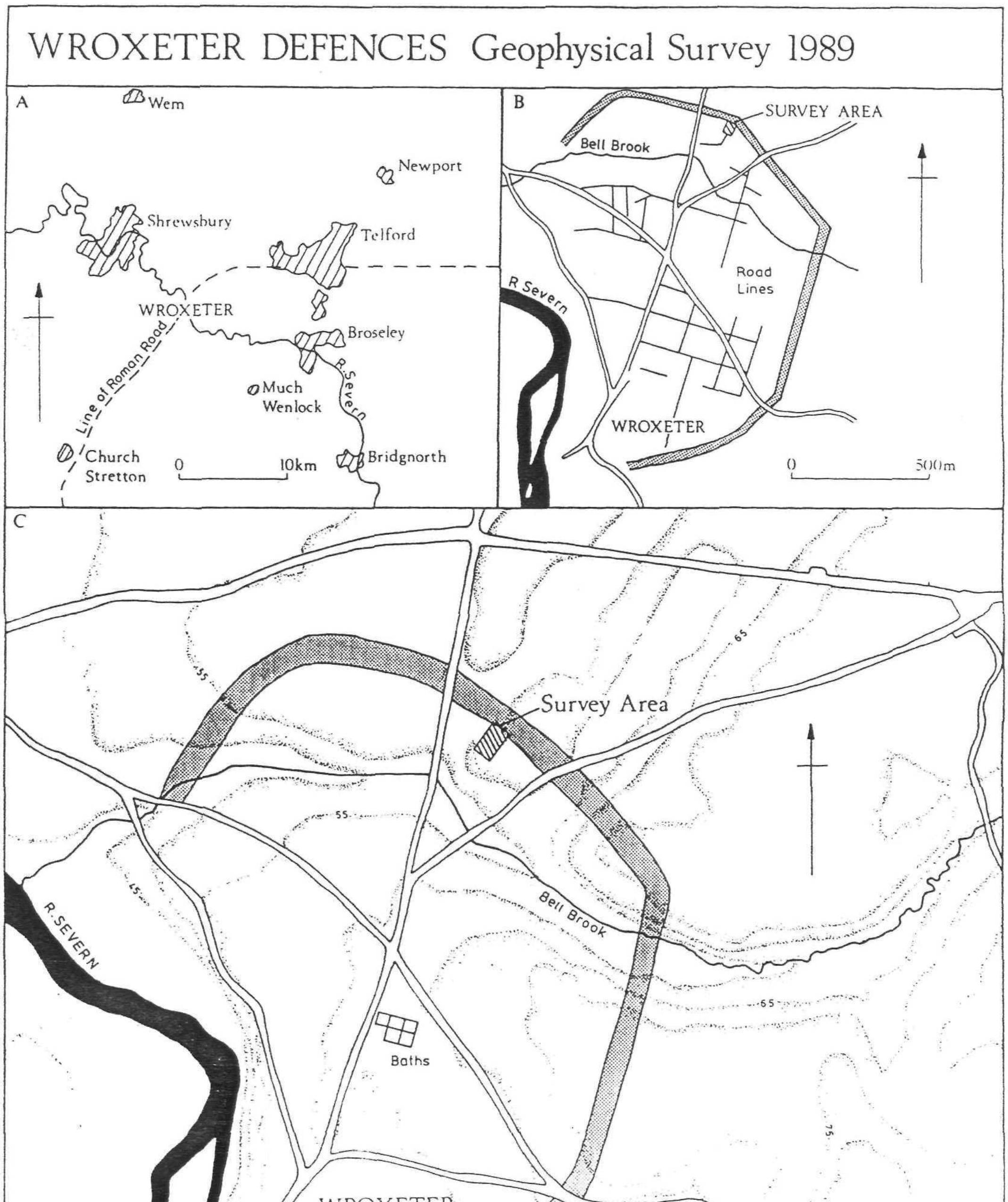
WROXETER DEFENCES Geophysical Survey 1989
A
Wem
Newport
Shrewsbury
Telford
WROXETER
Broseley
Line of Roman Road
Much Wenlock
R. Severn
Church Stretton
0
10km
Bridgnorth
B
SURVEY AREA
Bell Brook
Road Lines
R Severn
WROXETER
0
500m
C
Survey Area
55
65
Bell Brook
R. SEVERN
Baths
WROXETER
Church
75
0
250m

FIGURE 1

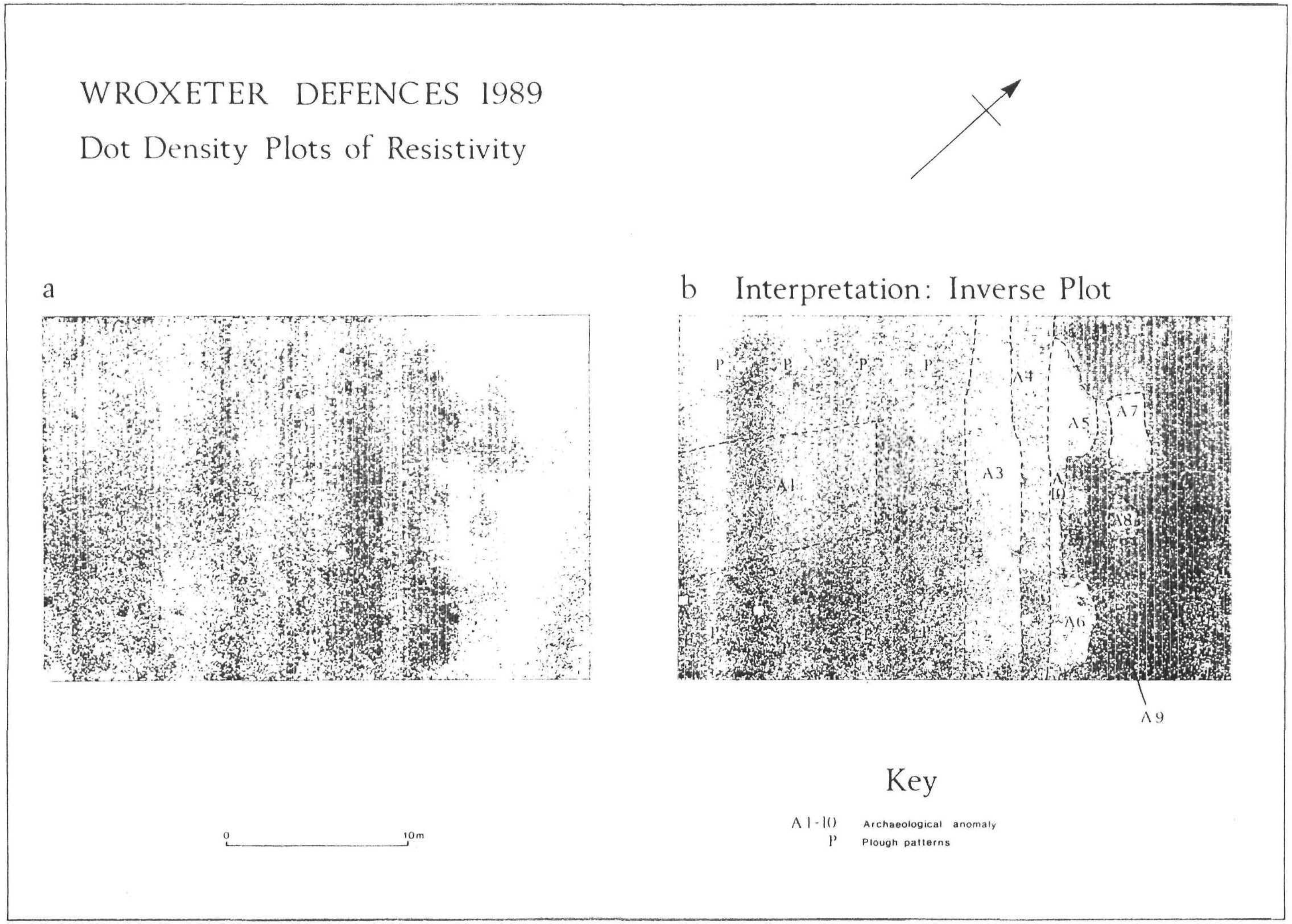
WROXETER DEFENCES 1989
Dot Density Plots of Resistivity
a
b Interpretation: Inverse Plot
P
P
P
P
A1
A3
A4
A5
A7
A10
A8
A6
A9
0
10m
Key
A 1-10 Archaeological anomaly
P Plough patterns

FIGURE 2

APPENDIX 4

EXCAVATIONS AT WROXETER 1991: AN INTERIM REPORT

by

A S Esmonde Cleary

Birmingham University Field Archaeology Unit

Introduction

In the summer of 1991 a six-week excavation was undertaken on the defences of the Romano-British city at Wroxeter (Viroconium Cornoviorum), Shropshire. The site lay on the north-eastern corner of the defences, between the modern road to Norton and the Horse Shoe Lane; the former on the line of the Roman road to Chester, the latter on the line of Watling Street to London. This interim report contains:

(i) the background to the 1991 excavation
(ii) the results of the 1991 excavation
(iii) discussion of the 1991 results

The background to the 1991 excavation

The northern, eastern and southern defences of Romano-British Wroxeter survive for almost the full circuit as a visible earthwork. They are known to have undergone degradation during the nineteenth and twentieth centuries as a result of agricultural processes, so presumably were formerly more prominent than they are now. The presence of western defences was only confirmed in 1975.

Limited archaeological work, mainly in the form of slit-trenching, has been carried out on these defences since at least the middle of the nineteenth century. They were trenched by Thomas Wright in the 1850s along both their northern and their southern extent. Wright (1872, 95-99) recorded the presence of double ditches, an earth rampart and a cobble-and-clay foundation towards the front of the rampart. Similar features were encountered by Donald Atkinson in his 1923-7 excavations at Wroxeter (Atkinson 1942, 324-32), including explorations in the field where the 1991 excavations took place. In 1936-7 Kathleen Kenyon excavated on the eastern side of the circuit, broadly confirming the features found by Wright and Atkinson, but for the first time giving some idea of sequence and date (Kenyon 1938, 175-227). She proposed that the rampart was of second-century date, and that the foundation supported a stone city wall inserted later. She also proposed the existence of an inner northern arm of the defences along the southern lip of the Bell Brook valley, which she suggested was the original line of the northern defences, later extended to the better-known line. In 1960 Graham Webster cut a trench across the southern defences (Webster, 1962), dating the rampart to the second century and the wall (represented here by a robber-trench) to the fourth, conforming to a pattern then being discerned at a number of Romano-British towns. In 1975 there were two excavations on the Wroxeter defences. Stephen Johnson dug on the eastern defences in the area of their junction with Kenyon's inner northern line. An important result of this work was the discovery of the eastern defences of the legionary fortress sealed beneath the eastern civil defences. On the western side of the city, Peter Brown dug a trench at the top of the cliff down to the Severn on the line of a projected sewer. This showed for the first time that there were defences along the river, and that the river had not cut into the area of the city. Since then Philip Barker has argued that the absence of any proven stretches of stone city wall in all these excavations must mean that there never was such a wall, but rather that the clay-and-cobble foundation carr fensive structure (Barker, 1985

The vation

The ition was two-fold. First, ther eral uncertainty over the natu of the Wroxeter defensive syst their nature: were they a 'cla ce of earth rampart later fron generally been assumed, or was correct? What was their seque ere there two successive nortl iat order? How secure was the e t be improved upon? Added to t tion of the inadequacy of slit- method on a monument so long, illied to concern over gener ata.

Secon s of specific questions relat rth-eastern corner of the defen and geophysical surveys. In th iugely productive campaign of a oxeter, Arnold Baker had ident al (cf. Baker, 1968). The first peared to be a gap in the 'robb l'. The second was that the i ditch bulged outwards at this e could detect traces of post-l n this expansion of the berm obber-trench'. Thirdly. there appeared to be a street making from the interior of absence of any proven stretches of stone city wall in all these excavations must mean that there never was such a wall, but rather that the clay-and-cobble foundation carried a timber(-framed) defensive structure (Barker, 1985, 109-14).

The background to the 1991 excavation

The impetus for the 1991 excavation was two-fold. First, there was the continuing general uncertainty over the nature, sequence and dating of the Wroxeter defensive system. Doubt has been cast on their nature: were they a 'classic' Romano-British sequence of earth rampart later fronted by a stone wall as had generally been assumed, or was Philip Barker's argument correct? What was their sequence, and in particular were there two successive northern lines, and if so in what order? How secure was the existing dating, and could it be improved upon? Added to this was a growing appreciation of the inadequacy of slit-trenching as an excavation method on a monument so long, large and complex, allied to concern over generalising from such limited data.

Secondly, there was a series of specific questions relating to the area of the north-eastern corner of the defences, arising out of aerial and geophysical surveys. In the course of his long and hugely productive campaign of aerial photography over Wroxeter, Arnold Baker had identified this corner as unusual (cf. Baker, 1968). The first problem was that there appeared to be a gap in the 'robber-trench' of the 'city wall'. The second was that the inner lip of the defensive ditch bulged outwards at this point, and Baker thought he could detect traces of post-holes and other features on this expansion of the berm and in the gap in the 'robber-trench'. Thirdly. there appeared to be a street making from the interior of the city towards the rear of the gap. Taken together these suggested something more complex than a simple change in alignment of the defences. Baker favoured a timber 'bastion' or external tower; a gate was another possibility. A preliminary geophysical survey confirmed that there were sub-surface anomalies in this area besides those explicable as rampart, ditch and 'robber-trench', and that the last of these did seem to be absent at the angle. As a result, Baker submitted an initial research design to English Heritage, proposing an excavation to examine the problems of this area. Initial reaction was favourable, and in consequence a formal application for Scheduled Monument Consent to excavate was made by the author, with supporting research design. This was accepted by English Heritage and the Department of the Environment. The five principle aims of the excavation were defined as follows:

(i) to assess the physical form of the defences and the materials used in their construction
(ii) to test for the presence of a 'bastion', gateway or other feature at the north-eastern corner
(iii) to recover dating evidence for the phases of this part of the defensive circuit
(iv) to examine the state of preservation of the monument and the effect of agricultural use on it's survival
(v) to test the excavated results against the aerial survey and, in particular, the geophysical survey as an aid to assessing their efficacy at Wroxeter

An important consideration was the fact that since the implementation in 1990 of a management agreement with the landowners, the National Trust, the area from the lip of the ditch southwards had been put down to pasture. Therefore, there is no longer the risk of further compromise of the surviving archaeological deposits from ploughing. In view of this and the status of the defences as part of a Scheduled Ancient Monument, archaeological disturbance was to be kept to a minimum consonant with the elucidation of the research aims. The 1991 season, therefore, was very much in the nature of an evaluation.

The results of the 1991 excavation

The 1991 excavation took place over a six-week period from 17 June to 25 July. A main excavation area of ca.20m by 20m was laid out running back from the crest of the existing earthwork. This was placed so as to try to lie in the apparent break in the 'robber-trench', to locate any post-holes or other structural features in the break and to intercept traces of the road seen on the aerial photographs. In addition a trench ca.20m long north-south by 4m wide east-west was run down the northern side of the earthwork to check the nature of the rampart material and whether there was any trace of the 'robber-trench' extant towards the front of the rampart (cf.fig.2).

In view of the fact that the site is no longer under agricultural threat and in the light of research objective (iv) it was not felt appropriate to strip the topsoil mechanically. Therefore, the site was de-turfed and the underlying topsoil removed by hand, principally using mattock and shovel. Any more time-consuming method would not have been feasible. The artefactual and other material from the topsoil were kept separate by metre square in 20cm vertical spits. Two spits were sufficient to reach the top of the surviving identifiable archaeology. A number of randomly-chosen squares were sieved as a control over the recovery rate of archaeological material. It is intended that the material from each metre square should be quantified by weighing and counting and the results of this presented as a dot-density plot. Some of this work was undertaken during the excavation, but at the time of writing more remains to be done so no definite conclusions are possible here. During the excavation the only patterning observed was that there was a greater density of material over the area to the rear of the rampart, overlying the 'occupation deposits'. It was also noted that the pottery and other material was in general in relatively small, abraded pieces, suggesting that the material in the erstwhile ploughsoil had been there for some time and that the plough had not recently been bringing up material from archaeological deposits.

At the base of the ploughsoil was encountered a series of shallow, parallel slots running north-east - south-west and cutting into the top of the archaeological deposits. Their stratigraphic relationship to F.4 and F.5 showed them to be post-Second-World-War, and information from the regional office of the National Trust suggests that they relate to cultivation practices in the 1950s. Their survival is another argument that ploughing in the 1960s and later did not damage the monument significantly.

Running north-south across the excavations were two closely-spaced linear features, F.4/6 and F.5 (fig.2). F.4/6 was 30cms wide by 50cms deep. F.5 was 25cms wide by 30cms deep: both contained electric cable. Local information indicates that during the Second World War there was a radar station in the field to the south, across the Bell brook (a simple brick structure survives), and that the battery was linked by land-lines to the airfield at Atcham to the north-west. It is evident that F.4/6 and F.5 formed part of these land-lines.

The other features located seem all to have been of Roman date. In the northern part of the main area and in the extension to the north the ploughsoil came off directly onto the body of the Romano-British rampart. This was composed of layers principally of sand and clay, but also with tips of stone and mixed material and a fine, white, silty material provisionally identified as decayed turf. There was no trace of any linear feature which might be construed as the 'robber-trench'. The crest of the rampart ran roughly east-west within the northern limit of the main area (fig.2). On its southern side occupation and use deposits came right up to the crest, obscuring the reverse slope. In the south-western part of the area were two successive surfaces of small, limestone pebbles (1005), possibly part of the road identified on the aerial photographs. North of this and only just appearing within the site was a north-south line of mixed large and small stones and some tile (F.17), which may be part of wall-footings or robber-trench fill. In the south-eastern corner was a less substantial metalled area (1003) to the west of which was a hearth built of re-used roof-tiles (F.1). In the north-eastern part of the site, just to the south of the rampart crest, was an area of mixed stone and tile (1041) containing a complete quernstone. This remains unexcavated. Over the rest of the site a number of pits and pit clusters were identified and some excavated. Most were relatively shallow scoops which yielded no definite evidence of function. The general appearance of the unexcavated deposits over the site was of mixed earths with quantities of stone (some worked), tile, pottery, metalwork and other artifacts and charcoal (bone survival was poor due to soil conditions). These can be broadly categorised as 'occupation deposits'. The possible wall, the metalled surfaces and the hearth suggest the presence of structures, and there are undoubtedly many more pits and pit-complexes than those sampled in 1991. F.5 was in places up to 40cms deep. In its sides there was no trace of the rampart body, instead there was a sequence of surfaces and pits in section and some burnt horizons. Clearly a considerable amount of activity over the back of the rampart is represented by this sequence.

In tandem with the excavations, geophysical surveys were carried out over most of the field in which the excavations took place. These were undertaken by Ms Katherine Roberts, Department of Archaeology, University of Cambridge, using both magnetometer and resistivity techniques. During the excavation a contour survey of the field containing the site was completed by Mr Shaun Richardson.

Discussion of the 1991 Results

It is perhaps appropriate to start this section by comparing the results achieved with the research design as summarised above:

(i) to assess the physical form of the defences and the materials used in their construction.

The excavations only uncovered the crest and front slope of the rampart. Nonetheless, the presence of 'occupation' deposits over the rear slope of the rampart and coming right up to the crest carries with it an unexpected and interesting result. It had generally been assumed that the ramparts as at present visible were much-degraded from their original more massive and defensible form. But the 1991 evidence shows that in fact at the north-eastern angle they can never have been much more substantial than they are now, otherwise the occupation deposits could not have accumulated up to the crest. This carries with it the implication that the ramparts, in this area at least, were not so much a defensive work as a defining and delimiting bank for the city, marking it off from the surrounding cemeteries and countryside. If the purpose of the ramparts here was therefore essentially non-military, it makes the presence of deep deposits over the rear slope less of a problem.

Another possibility is that the rampart was originally fronted by some form of revetment (in the 'robber-trench') and thus stood to a greater height at its front. With the decay or robbing of the revetment the front of the rampart slumped forward into the ditch leaving the present, 'false' profile. This could only be tested by examining a stretch of the 'robber-trench' and its relationship with the rampart material.

(ii) to test for the presence of a 'bastion', gateway or other feature at the north-eastern corner.

Limited progress was made here. The absence of the 'robber-trench' at the north-eastern angle seems to have been confirmed. In the main area the metalled surface 1005 may be part of the road coming from the interior. A gateway or other feature here remains a distinct possibility, though the purpose of a gateway so close to the Chester and London gates is more than a little unclear.

(iii) to recover dating evidence for this part of the defensive circuit.

The datable material recovered in 1991 came from the occupation deposits over the rear of the rampart rather than from rampart body itself. Preliminary examination of the coins, samian and coarse wares suggests that the occupation material was accumulating from the mid second to the mid fourth centuries. How far this provides a 'terminus ante quem' for the rampart it is not possible to say.

(iv) to examine the state of preservation of the monument and the effect of agricultural use on its survival.

If the arguments about the original form of the ramparts presented under (i) be accepted, then it may be that post-Roman agriculture has compromised the deposits less than had been thought. Pending the results of the topsoil artefact survey it is not possible to be definite about the effect of recent cultivation, but, as noted above, the initial impression during excavation was that the effect was limited.

(v) to test the excavated results against the aerial survey and, in particular, the geophysical survey as an aid to assessing their efficacy at Wroxeter.

The broad implications of the aerial survey were confirmed, especially the apparent interruption of the 'robber-trench' at the angle. The more detailed proposals about what was going on instead (bastion, gateway) could not be demonstrated one way or the other in the time available.

The correlation with the geophysical survey was impressive. Both magnetometry and resistivity picked up the rampart, the 'robber-trench' and the break in the latter at the angle. They also indicated the presence of several sub-surface features in the interior of the defences. Detailed correlation of geophysical and excavated data are yet to be undertaken, but the preliminary plots show that both techniques have considerable potential for more extensive, non-destructive survey at Wroxeter.

In general, the 1991 excavations demonstrated that there is a large amount of surviving archaeology in this part of the Romano-British city, more than had been assumed. They also showed that there were questions which could be investigated by limited excavation with consequent controlled compromise of the monument. In particular, topsoil stripping over a larger area over the front of the rampart could help establish (i) the extent of the break in the 'robber-trench' (ii) if the 'robber-trench' terminals were located, whether the break was a formal gateway or merely an interruption (iii) what, if anything, was going on in the break. Also, further stratigraphic excavation of some of the deposits over the rear of the ramparts and near the crest could help (i) characterise the nature of occupation or use in this area (ii) help elucidate the nature and purpose of the break in the 'robber-trench' and further investigate the possible road and wall (iii) yield further stratified datable material, in particular from deposits immediately overlying the ramparts near the crest.

Acknowledgements

Excavation on this site was made possible by the active co-operation of the landowners, the National Trust. We are very grateful to Chris Rolfe (Land Agent) and Jeremy Milln (Archaeological Field Officer) of the Trust's regional office. The farmer of Norton Farm, Mr Walker tolerated the loss of pasture and associated disruption with good grace.

The Inspectorate of Ancient Monuments of the Historic Buildings and Monuments Commission for England, in particular, Dr Anthony Streeten and Ms Gill Chitty, were most helpful both in advising on the obtaining of Scheduled Monument Consent and subsequently in their site visits. The staff of the HBMC (E) regional office were also most helpful in recommissioning the camp-site and facilities at Wroxeter.

The excavation was directed by the writer assisted most ably by Gwilym Hughes of the Birmingham University Field

Archaeology Unit (BUFAU). John MacKelvey (who also drew the figures for this report), Catherine Mould, Shaun Richardson and Nicola Trafford, then students on the Birmingham Diploma in Archaeological Practice acted as efficient and cheerful site supervisors. The excavation was run as a Training Excavation for students of the Department of Ancient History and Archaeology, University of Birmingham (Head of Department: Professor R A Tomlinson), which also provided the funding. The bulk of the administration was undertaken with his customary efficiency and good humour by Simon Buteux, Manager of BUFAU. I am grateful to my Birmingham colleagues Nigel Baker, Lawrence Barfield, Steven Bassett and Susan Limbrey for taking field-trips and giving lectures during the course of the training programme, and to Susan Fischler and Ken Wardle for their visits and support. Thanks are also due to the students for their cheerful participation.

At Wroxeter, Ms Heather Bird, Cameron Moffett and Dr Roger White of the Wroxeter Post-Excavation Programme not only put up with a mass invasion of their rural tranquillity, but were also ready with help and advice on matters practical and archaeological. Ms Moffett and Dr White also helped in the programme of lectures and visits. Last and by no means least, Mrs Anona Jones kept a horde of hungry workers well-fed.

Among visitors to the site, I would particularly like to thank Arnold Baker whose work led to this excavation, and Frank and Nancy Ball, Phil Barker, Don Mackreth, Mike Watson (County Archaeologist for Shropshire) and Graham Webster for discussing the site with me from positions of much greater experience of the archaeology of Wroxeter.

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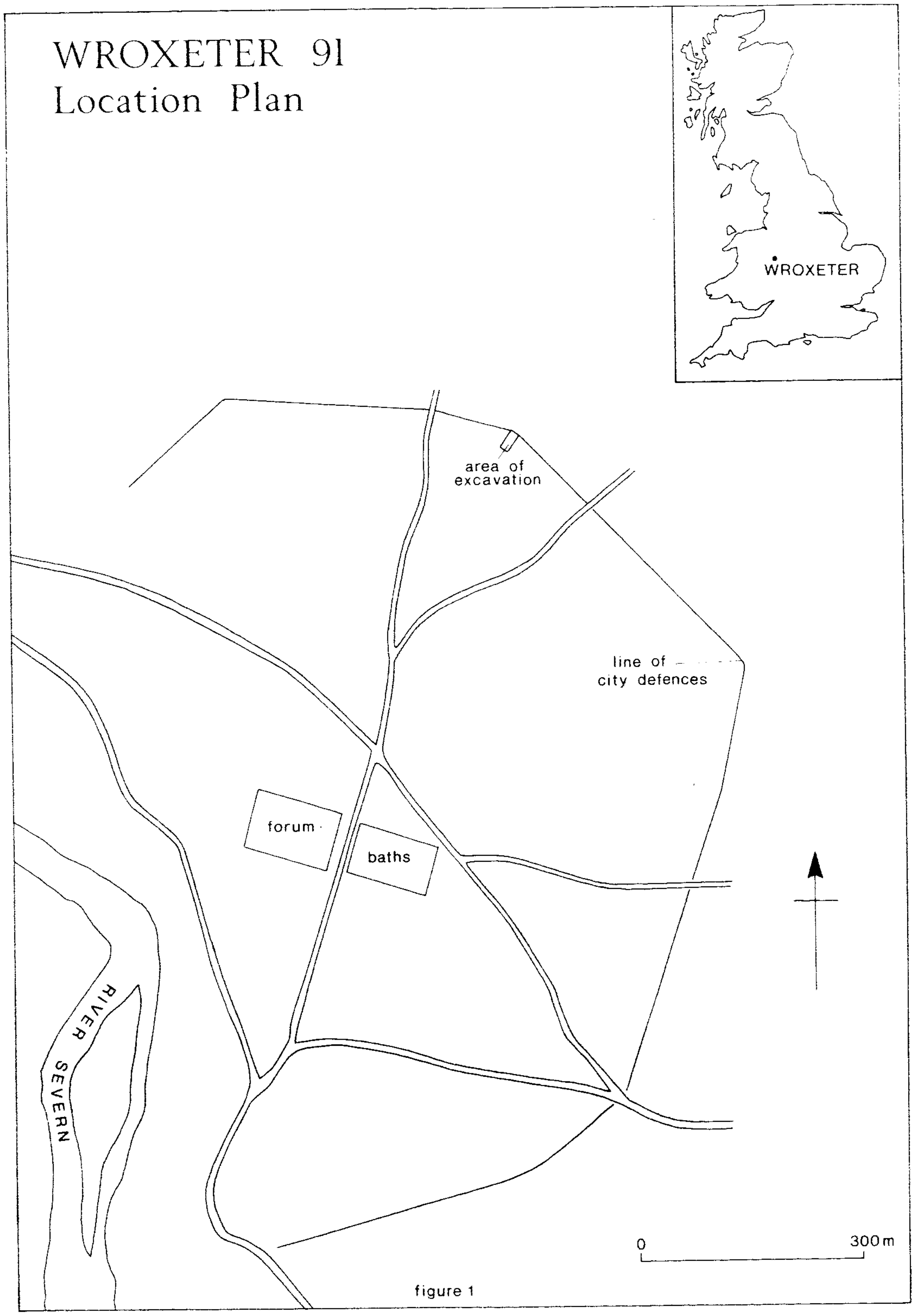
WROXETER 91
Location Plan
WROXETER
area of
excavation
line of
city defences
forum
baths
RIVER
SEVERN
0
300m

figure 1

WROXETER 91
Site Plan

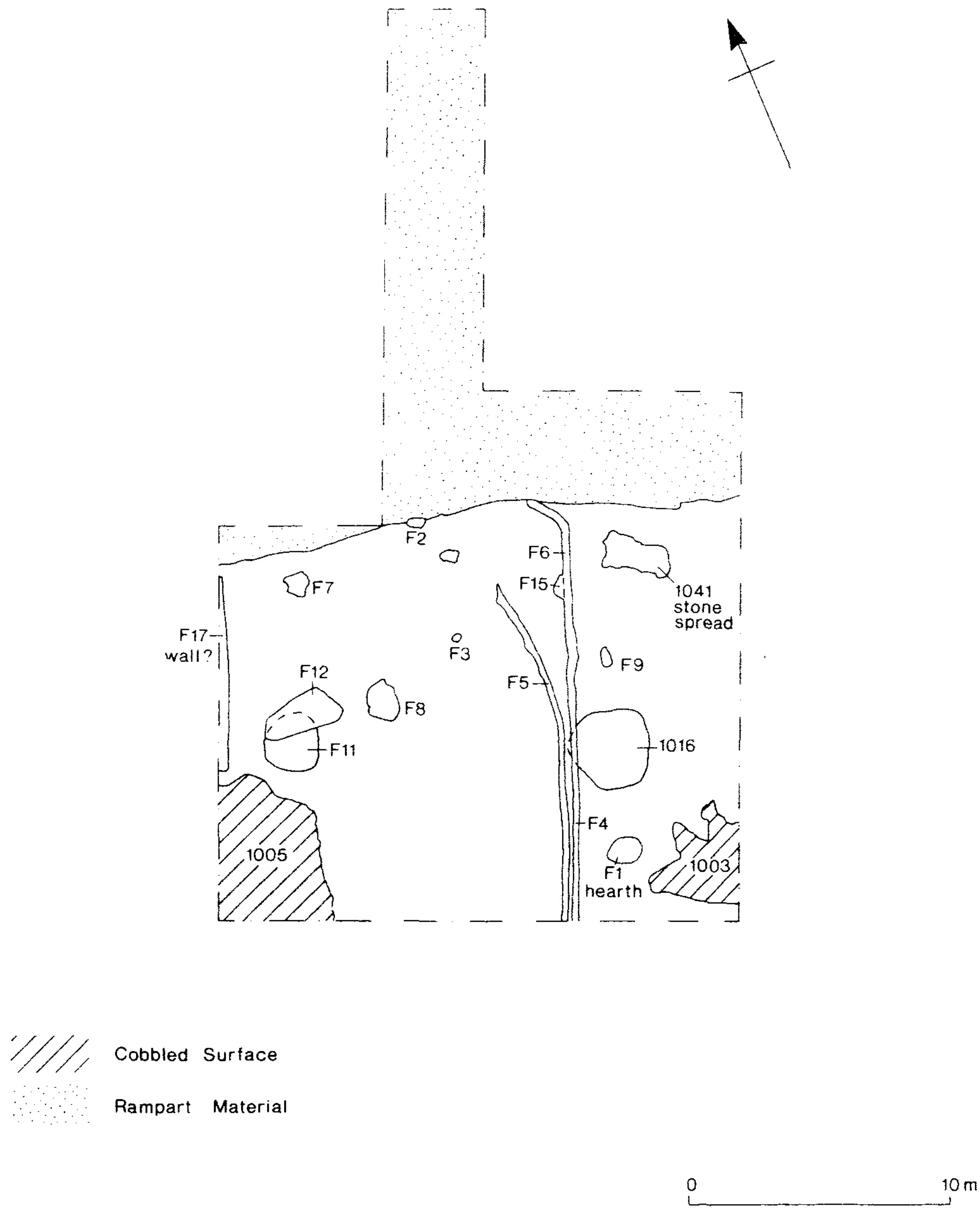

figure 2

APPENDIX 5

CROSS-REFERENCE:

SITE NUMBERS TO FIGURES

FIGURES WITH PREFIX (A), IN VOLUME 3

SITE	FIGURE	SITE	FIGURE	SITE	FIGURE
1	9.19	27	10.38	53	10.37
2	9.20	28	(A)5	54	(A)14
3	9.20	29	9.42	55	10.26(b)
4	9.20	30	(A)6	56	(A)15
5	9.21	31	(A)7	57	9.38
6	9.20	32	9.35	58	(A)16
7	(A)1	33	9.36	59	(A)17
8	(A)2	34	9.34	60	(A)18
9	10.32	35	9.39	61	(A)19
10	10.47	36	(A)13	62	9.41
11	10.22	37	(A)8	63	9.44
12	9.22	38	(A)9	64	9.44
13	9.25	39	(A)10	65	9.44
14	9.25	40	9.39	66	9.44
15	(A)3	41	(A)9	67	(A)20
16	9.24	42	9.33	68	9.45
17	9.25	43	9.37	69	9.45
18	(A)4	44	9.29	70	9.46
19	9.26	45	9.29	71	(A)21
20	9.26	46	9.29	72	9.43
21	9.24	47	9.30	73	(A)22
22	9.27	48	(A)11	74	(A)23
23	9.27	49	9.30	75	9.43
24	9.28	50	9.30	76	(A)24
25	9.28	51	9.30	77	(A)25
26	10.33	52	(A)12	78	10.35

SITE	FIGURE	SITE	FIGURE	SITE	FIGURE
79	(A)26	114	9.55	149	10.4
80	(A)26	115	9.55	150	10.17
81	10.10	116	(A)37	151	10.3
82	10.12	117	(A)38	152	(A)50
83	10.12	118	(A)39	153	9.61
84	10.12	119	(A)40	154	9.61
85	(A)27	120	(A)41	155	9.66
86	10.37	121	10.18	156	10.6
87	(A)28	122	9.57	157	(A)51
88	9.47	123	9.59	158	9.69
89	10.44	124	9.59	159	9.69
90	(A)29	125	(A)42	160	9.69
91	(A)30	126	(A)43	161	9.62
92	(A)30	127	(A)44	162	(A)52
93	9.51	128	13.28	163	9.65
94	9.50	129	(A)45	164	10.40
95	9.49	130	(A)46	165	9.62
96	(A)31	131	9.60	166	(A)53
97	(A)32	132	(A)47	167	10.4
98	(A)33	133	9.64	168	9.70
99	9.48	134	9.64	169	9.70
100	(A)34	135	10.18	170	10.34
101	(A)34	136	13.28	171	(A)54
102	(A)34	137	9.67	172	(A)55
103	(A)34	138	9.67	173	(A)56
104	9.52	139	(A)48	174	(A)57
105	(A)35	140	10.2	175	9.68
106	9.52	141	13.28	176	9.63
107	9.53	142	10.3	177	9.63
108	(A)36	143	9.64	178	10.43(a)
109	9.54	144	10.39(a)	179	(A)58
110	10.36(a)	145	13.28	180	9.71
111	9.58	146	(A)49	181	9.71
112	9.55	147	9.64	182	9.63
113	10.23	148	13.22	183	10.12

SITE	FIGURE	SITE	FIGURE	SITE	FIGURE
184	(A)59	219	(A)73	254	(A)91
185	(A)60	220	10.9	255	(A)92
186	9.72	221	(A)74	256	9.88
187	9.72	222	(A)75	257	(A)93
188	9.72	223	(A)76	258	9.87
189	(A)61	224	(A)77	259	9.87
190	9.73	225	(A)77	260	(A)94
191	9.73	226	(A)78	261	(A)94
192	9.73	227	(A)79	262	(A)95
193	9.73	228	(A)80	263	10.9
194	10.2	229	(A)81	264	9.85
195	9.77	230	(A)83	265	10.7
196	9.78	231	(A)82	266	(A)96
197	9.75	232	9.94	267	9.86
198	9.74	233	(A)84	268	9.86
199	9.74	234	9.95	269	9.84
200	9.76	235	(A)85	270	(A)97
201	9.76	236	(A)85	271	9.82
202	(A)62	237	9.96	272	9.81
203	(A)63	238	9.99(b)	273	9.100
204	9.76	239	9.97	274	(A)98
205	(A)64	240	9.98	275	10.20
206	(A)65	241	(A)86	276	9.90
207	(A)66	242	(A)87	277	(A)99
208	10.2	243	(A)88	278	(A)100
209	(A)67	244	(A)88	279	9.80
210	(A)68	245	(A)90	280	9.80
211	(A)69	246	9.100	281	9.80
212	(A)70	247	9.100	282	(A)101
213	9.93	248	9.99(a)	283	(A)102
214	10.21	249	(A)89	284	(A)103
215	9.101	250	(A)89	285	(A)104
216	9.101	251	9.89	286	(A)105
217	(A)71	252	9.83	287	(A)106
218	(A)72	253	(A)90	288	9.104

SITE	FIGURE	SITE	FIGURE	SITE	FIGURE
289	10.5	324	10.4	359	10.15
290	(A)107	325	10.3		
291	(A)107	326	10.3		
292	9.79	327	9.101		
293	(A)108	328	10.11		
294	(A)109	329	10.18		
295	(A)110	330	10.8		
296	9.11	331	10.8		
297	9.91	332	10.22		
298	9.91	333	(A)117		
299	10.21	334	9.67		
300	(A)111	335	(A)118		
301	10.21	336	(A)119		
302	(A)112	337	9.40		
303	(A)113	338	(A)120		
304	10.9	339	(A)28		
305	9.80	340	13.28		
306	9.92	341	(A)121		
307	10.9	342	(A)11		
308	(A)115	343	9.59		
309	(A)115	344	9.56		
310	(A)114	345	9.23		
311	(A)114	346	(A)122		
312	(A)115	347	(A)123		
313	(A)115	348	10.25		
314	10.17	349	10.26(a)		
315	10.19	350	9.46		
316	10.7	351	9.83		
317	10.7	352	(A)124		
318	10.23	353	(A)125		
319	10.24	354	(A)126		
320	(A)116	355	9.61		
321	10.6	356	9.87		
322	10.10	357	9.80		
323	10.10	358	9.100		

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