

## Geospatial science and the archaeology of the First World War: context for conflict

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### Abstract:

This paper examines the role of geospatial technologies in the development of non-invasive archaeological research methods and relates this development to the expansion of an innovative sub-discipline: 'conflict archaeology'.

Archaeology is predicated on the principle that human behaviour leaves behind physical evidence that is patterned, recoverable and interpretable; while warfare and conflict can appear to be chaotic affairs, they incorporate behaviours that leave behind patterned evidence (Scott 2005). In the last decade, 'conflict archaeology' has become an established sub-field of archaeology, specifically investigating the formation, preservation and conservation of the material record at sites of conflict. These include battlefields and auxiliary sites, such as camps and cemeteries, which are associated with the broader anthropology of conflict (Saunders 2007; Schofield 2005). Many such sites remain sensitive places, in terms of their physical preservation and also with regard to the emotional and political associations bound with past conflict. This is particularly the case with sites of historic conflict, where the past events may still be active in extended social memory. It is often difficult and sometimes forbidden to investigate such sites using traditional archaeological methods of excavation; this poses a considerable challenge to archaeologists.

The development of conflict archaeology has coincided with a rapid increase in the accessibility and affordability of geospatial technologies, including geophysical prospection, precise DGPS (differential Global Positioning System) survey and aerial imaging. This paper will outline the integration of these technologies with archaeological method, highlighting the ways in which targeted application of geospatial technologies is enabling the investigation of sensitive sites of conflict and enhancing research agendas in conflict archaeology. As examples, I draw on the investigation of sites from the First World War, including the mass grave at Pheasant Wood on the Western Front and the extensive battlefields of the Gallipoli Peninsula.

**Key words:** conflict archaeology, geospatial, First World War, Gallipoli, Western Front.

### Introduction

In recent decades, geospatial technologies have proven to be one of the most diverse areas of global research and design, undergoing rapid development and expansion in a broad range of fields. We have all experienced the increasing impact of spatial tools and concepts in our everyday lives, prompted by the broadening accessibility of personal GPS, of geotagging and of the routine use of online mapping applications. In addition to the enthusiasm for geospatial techniques in society at large, the rapid development of geospatial science has come at a time when the humanities and social sciences are especially open to the practical application and theoretical consideration of spatial concepts. In the last two decades, the themes of space, place, mapping and geographical imaginations have become commonplace in a variety of analytical fields, in part because globalisation has accentuated the importance of location (Warf and Arias 2008). The 'spatial turn' in the humanities has provided an important substrate on which to build an enduring partnership between the geospatial sciences and fields such as history and archaeology, and a framework within which to apply newly developing spatial technologies to diverse research agendas (Bodenhamer et al. 2010; Cosgrove 1999; Harvey 1990; Lefebvre 1991; Soja 1989).

Archaeology is a discipline which sits comfortably within both humanities and sciences and was quick to recognise the potential of geospatial techniques and technologies. Archaeology has a longstanding interest in spatial analyses, be it in the development of accurate site plans, or the analysis of artefact distributions, or the investigation of the the human use of space and movement within the landscape; geospatial concepts and techniques are not new to archaeology. There has however been a noticeable increase in the innovative application of spatial analyses in recent years, an increase which is associated with improved accessibility and affordability of key geospatial technologies, including GIS, geophysical prospection, precise DGPS and aerial imaging. Geospatial technologies have been particularly productive in the development of non-invasive archaeological research methods, which have proven useful for initial site assessments and in conjunction with excavation. Such techniques are especially valuable to the investigation of 'sensitive sites', for which the combination of delicate physical, cultural or political qualities of the site precludes more traditional, and destructive, excavation techniques. One such category of sensitive sites are those associated with historical conflicts, the consequences of which are often still very much alive in extended public memory.

The following paper will firstly outline the development of 'conflict archaeology', a sub-discipline specifically addressing the formation, preservation and conservation of the material record at sites of conflict, and will then examine the contribution of spatial technologies to the evolution of this field. In the past decade conflict archaeology has developed considerably, becoming more reflexive, more systematic and more cross-disciplinary in its scope; we are now in a position to investigate sites of industrialised conflict, such as the Western Front and Gallipoli Peninsula, from an archaeological perspective. By demonstrating the practical application of geospatial research to archaeological questions, I highlight the role of geospatial technologies in interdisciplinary studies, in the expansion of 'conflict archaeology' and in the emerging field of digital humanities. My intention is to demonstrate that the integration of modern spatial sciences with historical sources and archaeological methods provides a productive new means of engagement with the material culture of conflict and commemoration.

### ***Conflict archaeology***

Conflict archaeology had its beginnings as an academic pursuit some 25 years ago in studies concentrating on military strategy and frontline tactics at sites of ancient and historical battles (Scott et al. 1989). This field has its roots in historical archaeology and military history and was initially proposed as a means of 'filling in the blanks left by history' (Scott and McFeaters 2011, p. 105). As the field has developed into a fully-fledged sub-discipline, researchers have begun to embrace issues of cultural patterning and behaviours associated with the broader anthropology of conflict. The types of research questions asked have noticeably changed, with studies increasingly addressing auxiliary sites, camps, cemeteries and memorials, and broadening archaeological research agendas to address the material culture of conflict beyond the front line (Pollard and Banks 2008; Saunders 2002; Schofield 2005; Schofield et al. 2006). Archaeological interest in the broader definition of sites of conflict, and in the spatial relationships between various sites, follows corresponding theoretical developments in 'landscape archaeology', an area concerned with describing, interpreting and understanding the development of cultural features identified on the surface and immediate sub-surface (Ashmore 2004; Ashmore and Knapp 1999; Bender 2002; Kvamme 2003; Mcglade 1999; Wilkinson 2003). In conjunction with landscape archaeology, conflict archaeology is an exciting area of research which is now reaching the maturity to be meaningfully applied to complex sites of industrialised warfare.

The events taking place during battles are brief in duration, by archaeological standards, but are typically intense in nature; whilst these events are inherently destructive, they also produce material evidence of distinctive, patterned behaviours which develop in the cultural and social context of the combatants. At its most fundamental, an archaeology and anthropology of conflict is based on the fact that people fight in ways which reflect their training and such fighting leaves behind physical remains that can be interpreted (Scott and Mcfeaters 2011; Van Creveld 1989). An archaeology of conflict offers a unique perspective by investigating the physical remains of everyday life on and around battlefields and sites of conflict. With regard to historic conflicts, archaeological research provides an independent line of evidence which can be used in conjunction with the documentary record of maps, plans, personal records and military reports to build a more complete story of past events. The First World War recently passed out of living memory and has been examined by historians for many years; it is archaeology which is now positioned to produce new information on the material culture of the first global, industrialised conflict.

As we approach the centenary of the First World War, academic and public interest in the legacy of this conflict and the remains of its battlefields is reaching new heights. The increase in public interest in the history and commemoration of recent conflicts is clearly evident in the rising numbers of visitors to First and Second World War battlefields and memorials, and in the public appetite for news, exhibitions and publications on the World Wars (Hall et al. 2010; Slade 2003). Academic interest in recent conflicts has always been relatively high, although archaeology has not been a prominent participant until relatively recently. In the last decade archaeologists have critically engaged with the material culture of industrialised warfare, producing innovative studies of First and Second World War sites (Bleed and Scott 2011; Desfossés and Jacques 2002; Pollard and Banks 2008; Purbrick et al. 2007; Saunders 2002; Saunders 2007; Schofield 2005; Scott and Mcfeaters 2011; Stichelbaut et al. 2009). New specialised qualifications have emerged, with the University of Glasgow establishing the Centre for Battlefield Archaeology in 2006 and the University of Birmingham offering a Postgraduate Diploma and MA in Conflict Archaeology since 2008. The growing academic interest in the material culture of conflict and commemoration is connected to changing ideas and attitudes toward our interpretation of objects, landscapes and memory; the development of a specialised branch of archaeology addressing the material remains of conflict is a product of this conceptual renegotiation. Exciting dialogues have developed at the juncture of history, archaeology and anthropology, addressing the relationships between people, objects and landscape, the role of battlefields as national and trans-national cultural heritage sites, and the development of an archaeological methodology specifically tailored to investigating sites of industrialised conflict.

### ***Spatial Technology***

The choice of analytical methodologies available to archaeologists has diversified in recent decades, at the same time as research agendas in conflict archaeology have embraced broader definitions of sites of conflict and increasingly multidisciplinary perspectives. As a discipline, archaeology is most closely associated with excavation. Excavation is by its very nature a destructive process and it is not always possible to undertake excavation of sites of conflict, particularly those which still represent a public memorial to a traumatic period in the recent past. In order to investigate these sites, of which First and Second World War battlefields and memorials are prime examples, archaeologists have needed to develop non-invasive and minimally destructive

methods of recording and analysing material remains. The recovery and documentation of the physical evidence of conflict at sensitive sites has been supported by the development and availability of specialised spatial technologies.

Context is the cornerstone of archaeological research and professional archaeologists have long been concerned with defining precise spatial information on the location of artefacts and features. Methodological innovations, such as Flinders Petrie's concern for stratigraphic excavation or the grid-based excavations pioneered by Sir Mortimer Wheeler and Kathleen Kenyon, have improved our ability to record the locations of archaeological remains with a degree of precision that permits meaningful interpretation (Kenyon 1953; Kvamme 1999; McCoy and Ladefoged 2009; Wheeler 1943). Likewise, the early aerial photography employed by Antoine Poidebarde in Syria and O. G. S. Crawford in Britain provided some of the earliest archaeological applications of remote sensing for archaeological site location and identification (Crawford 1923; Crawford and Keiller 1928). More modern spatial technologies, particularly GIS, GPS and remote sensing, build on these existing methods to enhance the accuracy with which we can gather, analyse and represent archaeological data. In this framework, 'remote sensing' can be defined as any process by which information is gathered about an area, phenomenon or object without direct contact with it; these remote methodologies include aerial photography, satellite imagery and geophysical survey. Precise GPS provides a means to pinpoint the location of features and Geographic Information Systems in turn enable the management, analysis and display of large quantities of spatial data. Archaeological applications for remotely sensed data have greatly developed in the last decade, with geophysical prospection and satellite imagery analyses both familiar components of archaeological fieldwork (Doneus and Briese 2011; Lock 2000; Thompson et al. 2011). Whilst these methods of analysis are not particularly new to archaeology in general, their application to historic battlefields and auxiliary sites has been influential in the evolution of this area of research. Importantly, non-invasive methodologies employing modern spatial technologies have increased both the quality and range of archaeological data that can be gathered from sensitive sites of conflict *without excavation*.

### ***Conflict archaeology and the Great War***

Nearly 100 years ago, the First World War was declared in Europe. Conflict on such a scale had never been conceived of before; the massive mobilisation and destruction brought about by this global, industrialised conflict earned it the title The Great War. As we approach the centenaries of the major battles of 1914–18, a selection of key archaeological studies are emerging. International research in Great War archaeology is dominated by studies of the Western Front, in which innovative research is bringing to light the details of the battlefield landscape. The other theatres of the First World War also have valuable contributions to offer. The Gallipoli Peninsula has received little archaeological attention, despite its significance in prehistoric and historic periods (Mackie 2010; Özbek 2012; Sagona et al 2010) and the unique position it holds in the national histories of Turkey, Australia and New Zealand. Both the Western Front and the Gallipoli battlefields were defined by trench warfare, which dramatically altered the existing landscape through the development of trench and tunnel networks. Whereas the Western Front saw ground gained and lost along a shifting front line between the Allied and German armies, the Gallipoli campaign consisted of a prolonged and largely static conflict, punctuated by several major offensives, between the Allies and the Ottoman Turks from April to December of 1915.

Conflict archaeology along the Western Front takes in diverse topics, addressing issues of military history, memory and commemoration, formation and preservation. Prime examples of work in conflict archaeology which are directly supported by geospatial sciences include Stichelbaut's current research on the Belgian Western Front and Pollard's recent study of a mass grave near the village of Fromelles. Research by Stichelbaut, Bourgeois, Saunders and Chielens (2009) highlights the value of First World War military aerial reconnaissance photography in the development of early remote sensing technologies and as a valuable resource for modern archaeology. Stichelbaut's research project involves the digitisation and orthorectification of over 1100 aerial photographs taken in 1914–18 and their incorporation into a GIS (Stichelbaut 2006). From the aerial photographs the features of the pre-war and wartime landscape of the Belgian Western front have been mapped and analysed. Using modern geospatial technologies of GIS and GPS, together with landscape archaeological analyses, this project has developed a detailed overview of the material remains of the First World War within their landscape context.

The physical landscape of the Western Front was decimated during the prolonged battles of the First World War but has since been reclaimed for settlement and agriculture. The battlefields of the Western Front are under continual threat from modern land use and increasing tourism; the use of geospatial science in the form of GPS and GIS has enabled the development of an invaluable resource on the location and preservation of First World War and pre-war archaeological features. Not only has the use of geospatial science supported the non-invasive identification of archaeological sites which were destroyed during the war or in its aftermath, it has enabled study of this region at an extent which would be prohibitive for traditional excavation. By applying spatial technologies to historic documents and the modern landscape, non-invasive investigation at a large scale is made possible on the Western Front.

Geospatial sciences can also be seen to tangibly benefit the research agendas of conflict archaeology at a localised scale, in the investigation of discrete sites of conflict. In May 2007, the investigation of a mass grave at the Pheasant Wood (Bois Faisan) in northern France was undertaken. This grave was created sometime shortly after July 16, 1916, following a diversionary attack launched by British and Australian troops against the heavily fortified German front lines near the village of Fromelles. The attack, an attempt to divert resources from the Battle of the Somme, was unsuccessful and the German soldiers captured the battlefield. Many of the Allied dead were transported behind German lines and buried in mass graves; some bodies were recovered after the war ended, but many were simply listed as missing on the memorial at VC Corner Cemetery. When historian



Lambis Englezos identified a location he believed to be the site of a mass grave (Englezos 2008), geospatial science helped to confirm his identification. Detailed analysis of aerial photographs provided an initial site identification followed by a geophysical survey of the site, which included magnetometry, ground penetrating radar (GPR), resistivity and metal scatter pattern analysis (Pollard 2008; Steel 2008). In this rare case, excavation was permitted, but only after these geospatial technologies had provided supporting evidence for the identification of the mass grave at the site. Without modern spatial technologies providing further details on the nature of the site and its extent, it is unlikely that the discovery would have been confirmed and even less likely that excavation of this war grave would have taken place.

These and other substantial studies of First and Second World War battlefields in continental Europe are stimulating new debates and forging inter-disciplinary explorations into sites of conflict and commemoration. The use of geospatial science in the service of archaeological research is also contributing to a current investigation of the Gallipoli battlefields. The Gallipoli Peninsula Historical National Park contains some of the world's least disturbed First World War sites, yet we know very little about the archaeological record of the former battlefields (Bademli and Burak Sari 2002; Cameron and Donlon 2005; Sagona et al. 2011). In October 2010, the Joint Historical and Archaeological Survey of the Gallipoli battlefields (JHAS) commenced an ongoing archaeological survey of the area, centred on the Ariburnu/ANZAC battlefields (Sagona et al. 2011) (**Figure 1**). The JHAS is an interdisciplinary collaboration between Turkish, Australian and New Zealand historians and archaeologists, and is the first project to receive a permit to conduct archaeological research on the Gallipoli battlefields.

Now in its third season, these efforts to study the heritage landscape of Gallipoli draw on existing historical cartography and spatial data from the Peninsula integrated with modern geospatial science. The JHAS employs high precision DGPS to record the artefacts and earthworks significant to the Turkish, Australian and New Zealand soldiers of the 1915 conflict which are still visible in the landscape. To place this landscape of conflict in its broader cultural context, the survey also records the locations of pre-1915 archaeological material and the positions of the roads, cemeteries and other structures comprising the modern commemorative landscape. Within a GIS framework, the results of the current survey are integrated with historical maps and aerial photographs, modern satellite imagery and topographic data. Importantly, this project employs modern geospatial technologies but builds on archival data and archaeological fieldwork at Gallipoli.

Despite an abundance of historical literature providing accounts of the Gallipoli campaign, the remnant battlefields themselves present us with a complex archaeological landscape. The military landscape which developed during the entrenched warfare of 1915 exists within a region inhabited since ancient times, a landscape which has subsequently been modified into the commemorative and agrarian landscape which continues to develop today. Given the degree of destruction and construction which has taken place across the landscape of the Gallipoli battlefield in the last century, historical photographs and cartographic records are invaluable for the information they provide on the formation of the pre-war, wartime and post-war landscape.

The case study presented here shows part of the results of the ongoing JHAS project, highlighting the plateau of Johnston's Jolly/Kırmızı Sirt, which was an intensely contested section of the 'Second Ridge' throughout the Gallipoli campaign. Complex systems of combat and communication trenches developed on the Ottoman (east) and ANZAC (west) sides of this plateau, at some points with only 55–60 meters of no-man's land separating the opposing front lines. The historical archaeological features from the 1915 campaign are distributed throughout a landscape which is now heavily vegetated (the establishment of the Gallipoli Peninsula Historical National Park prohibited the clearance of woodland). Comparisons made with historical photographs and aerial photographs show that the landscape is much more heavily vegetated today than during the conflict or during the initial establishment of the cemeteries and memorials by the Commonwealth War Graves Commission (CWGC) during the 1920s. In this rugged terrain, DGPS has proven to be a very effective method of recording features with high accuracy (>30cm average horizontal accuracy). The manoeuvrability of a roving GPS receiver means that the rough ground poses very few impediments to accessing and recording features, whilst the use of an external antenna ensures that obstruction of the satellite signal by surrounding scrub vegetation is minimised.

The integration of georeferenced historical maps and trench plans, orthorectified aerial photography, modern satellite-sourced spatial data (Shuttle Radar Topography Mission and GeoEye: Farr et al 2007; www.geoeye.com) and archaeological survey is providing a new perspective on this landscape of conflict. Nearly 100 years after construction, it is still possible to identify detailed features of the battleground in the landscape. At Johnston's Jolly, combat trenches are clearly evident, running roughly north-south and associated with communication trenches which run roughly east-west and connect with the front line (**Figure 2**). The Allied side of Johnston's Jolly (the west) is characterised by a deep front line, located immediately west of the Second Ridge road and clearly visible despite being heavily pitted beneath a modern stand of fir trees. A support trench (the older front line) runs parallel to the front line, approximately 100 meters west of the modern road, and the remains of a network of communication trenches are evident running across the plateau. The survey also addresses areas behind the front lines and located a series of dugouts on the south-western ridge of the Johnston's Jolly plateau (**Figures 2 and 4**). A supply area or rubbish dump in which metal tins, opalised glass bottles and ceramic fragments were found was identified immediately north of Artillery Road. On the Ottoman side of the plateau (east of the modern Second Ridge Road), a scatter of bricks was located on the south-eastern edge of the plateau, where it drops into Owen's Gully with a view south to Lone Pine. These bricks bear the imprint 'ΜΑΔΥΤΟΣ' (Madytos), the former name of the modern town of Eceabat, and may have served as a supporting structure for a trench wall. More bricks were located further behind the front line, in a protected location on the southern edge of the plateau. These were in association with a flat cooking stone, which suggests this was a resting place or possibly a kitchen.

From a methodological standpoint, it is important to note that the JHAS field survey only records features which are still

visible within the modern landscape; the purpose of the survey is to record what remains. Comparisons with what was once there, as depicted in historical maps, plans and photographs, occur within a GIS framework following field survey. In the GIS developed for the JHAS the results of new fieldwork are layered with modern and historical documents. In the Johnston's Jolly region, comparisons with a post-war Ottoman map (part of a significant series resulting from the Turkish Mapping Directorate 1916 survey of the battlefield, produced under Brigadier General Mehmet Şevki Paşa) indicate relatively good preservation of the trench lines, especially on the plateau (**Figures 3 and 4**). During the conflict the main trenches would have been around two meters deep and one meter wide; since their abandonment in December 1915, deep deposits of silt have accumulated in the trenches meaning that they are now visible as 50–80cm depressions and are overgrown with shrubs and small *Arbutus* trees, often referred to as rhododendrons by the ANZACs. Nevertheless, after nearly 100 years, these substantial earthworks can still be traced within the landscape. The features located behind the front line, such as the dugouts along the south-western edge of the plateau, also show good correlation with the 1916 survey which depicts a schematic row of dugouts branching from the trench to the south of the plateau.

Layering the archaeological survey results onto rectified aerial photographs of Gallipoli provides additional detail on the 1915 landscape. Using digitally restored copies of early military aerial reconnaissance photographs in the Australian War Memorial collections, it is possible to discern several smaller trenches on the Johnston's Jolly plateau which are not recorded on the Şevki Paşa map and are also no longer visible in the modern landscape. The photograph shown in **Figure 5** and used in **Figure 6** shows the battlefield in October of 1915, meaning that the smaller trenches must have been modified or filled in the later stages of the war. It is also possible that the Şevki Paşa map series, which covers the entire Peninsula from north of Suvla Bay to Cape Helles, recorded only the major features of the battlefield landscape. This map series is rightly praised for its detail and consistency (B.G.C. 1920), but given the complexity of the post-war landscape it is reasonable to conclude that the recording of wartime earthworks was slightly schematised. Whilst the aerial image shows certain trench lines which are not recorded in the Paşa map and are also no longer visible in the modern landscape, comparisons between these two documents also highlight features documented during the Paşa map survey which are too small to be discerned in the aerial image, such as the small cemeteries (Brown's Dip cemetery) located east of Lone Pine and south of Johnston's Jolly. These cemeteries are not evident in the commemorative landscape, their occupants having been moved to the CWGC cemeteries in the 1920s. Using a similar methodology to compare the current and future survey results with trench maps and photographs created at different stages during the war will allow us to investigate the temporal development of the battlefield landscape, tracing the expansion of the Allied and Ottoman systems of war.

The ANZAC/Arburnu area of the Gallipoli battlefields is officially recognised as an open cemetery and is a place of considerable sensitivity to modern Turkey, Australia and New Zealand. Excavation is not permitted in this area, but with the support of geospatial science we are able to undertake entirely non-invasive research. We can record the wartime and pre-war archaeological record within the battlefield area, examining the form of earthworks and the patterns of artefact distribution, investigating the various rates of preservation and studying the relationships between the pre-war, wartime and modern commemorative features in a GIS framework. The trench systems recorded in the survey provide a new form of material evidence for use alongside historical accounts. Likewise, the artefacts which were located away from modern access points provide valuable insight into the daily activities taking place during the entrenched battle and contribute to developing a broader appreciation of the anthropology of war. By understanding the configuration of the archaeological landscape through survey, and integrating archaeological method with historical documents and geospatial science, we can begin to understand the formation, preservation and conservation of First World War features in the modern Gallipoli Peace Park.

## Conclusions

At present, contributions to conflict archaeology are clearly supported by geospatial techniques and technologies such as DGPS, GIS, geophysical prospection and aerial imaging. But the data provided by these methods do not speak for themselves; to interpret and account for the data, archaeologists use diverse concepts and theories drawn from history, anthropology and the social sciences (Evans and Daly 2002; Goodchild and Janelle 2004; Knowles 2008; Llobera 1996). The increasing interest in spatial and digital analyses in the humanities, in conjunction with the increasing accessibility and affordability of geospatial technologies, has seen the integration of geospatial science with diverse analytical fields. Archaeology has been quick to apply key geospatial technologies and these techniques have been influential in the development of non-invasive and minimally destructive field methods. These methodologies are in turn enabling investigation of sites where archaeological excavation methods are either inappropriate or forbidden.

The integration of geospatial sciences with archaeological research has effectively supported the development of 'conflict archaeology', by enhancing both the quality and the range of information which can be gathered about artefacts, sites and regions without excavation. This is especially relevant to the study of sites of conflict from the recent past, notably the First World War. After the passing of almost 100 years, the remnant landscapes of the First World War remain sensitive locations in political and public spheres. As the centenary of the Great War approaches, the value of interdisciplinary studies integrating geospatial science, archaeology and historical analyses is particularly apparent. The detailed study of a large sector of the Western Front using aerial photography and GIS, the identification and eventual excavation of the war grave at Pheasant Wood, and the ongoing archaeological investigation of the Gallipoli battlefields are each supported by geospatial technologies.

While the First World War was extraordinarily destructive, to people and landscape, it also fostered incredibly productive exploratory research in spatial sciences, most notably aerial photography, photogrammetry, cartography and surveying. The array of maps and plans within the war records are testament to the creative energy of pioneering surveyors, photographers and cartographers. Nearly a century since their manufacture, accessing these historic resources and combining them with modern spatial technologies and archaeological method is supporting a new wave of research and engagement with the material culture of conflict and commemoration. As the archaeology of conflict continues to develop, geospatial technologies provide valuable support for scientific contributions to the analysis and conservation of sites of historical conflict.

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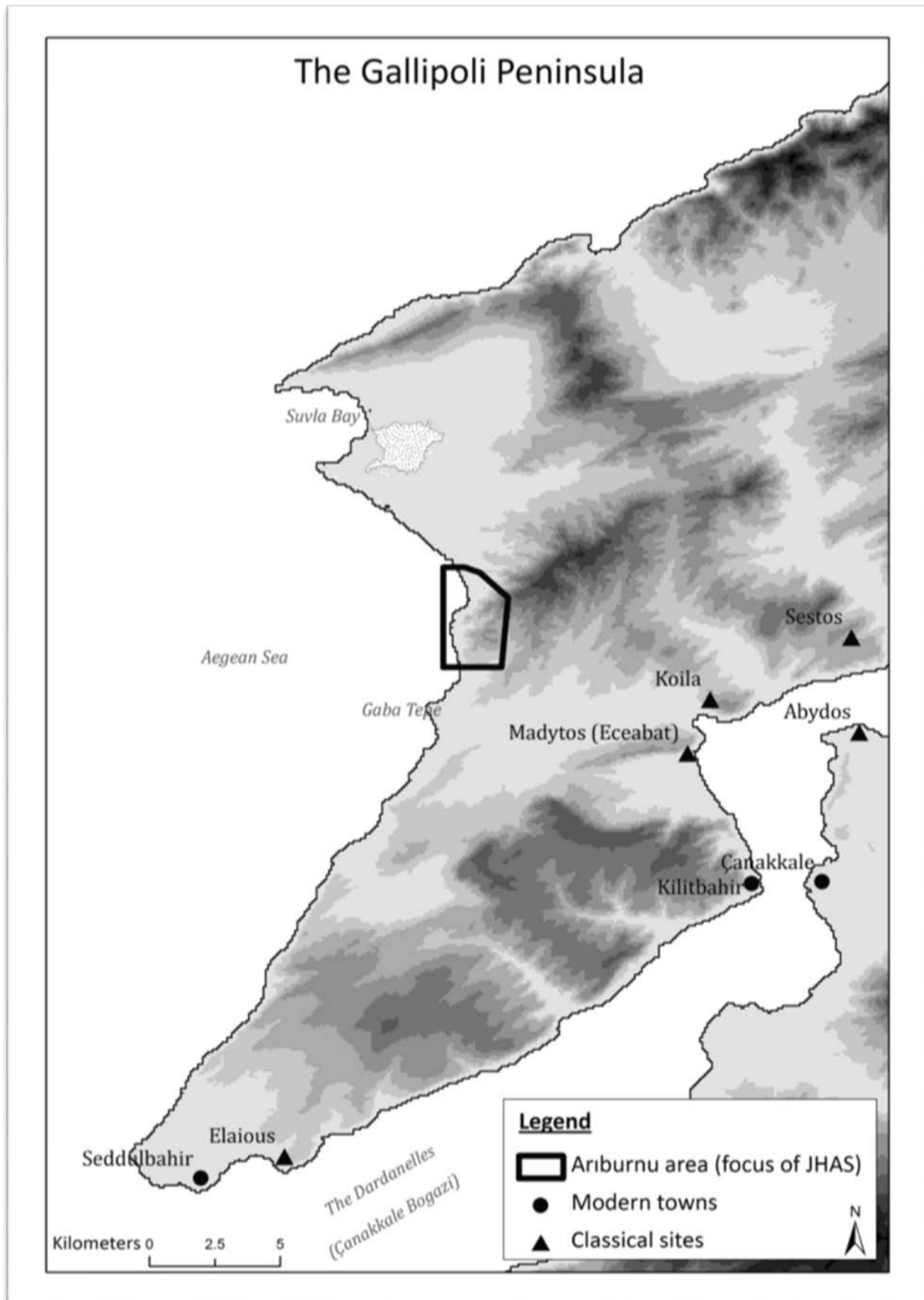


Figure 1: The Gallipoli Peninsula and the JHAS research area.



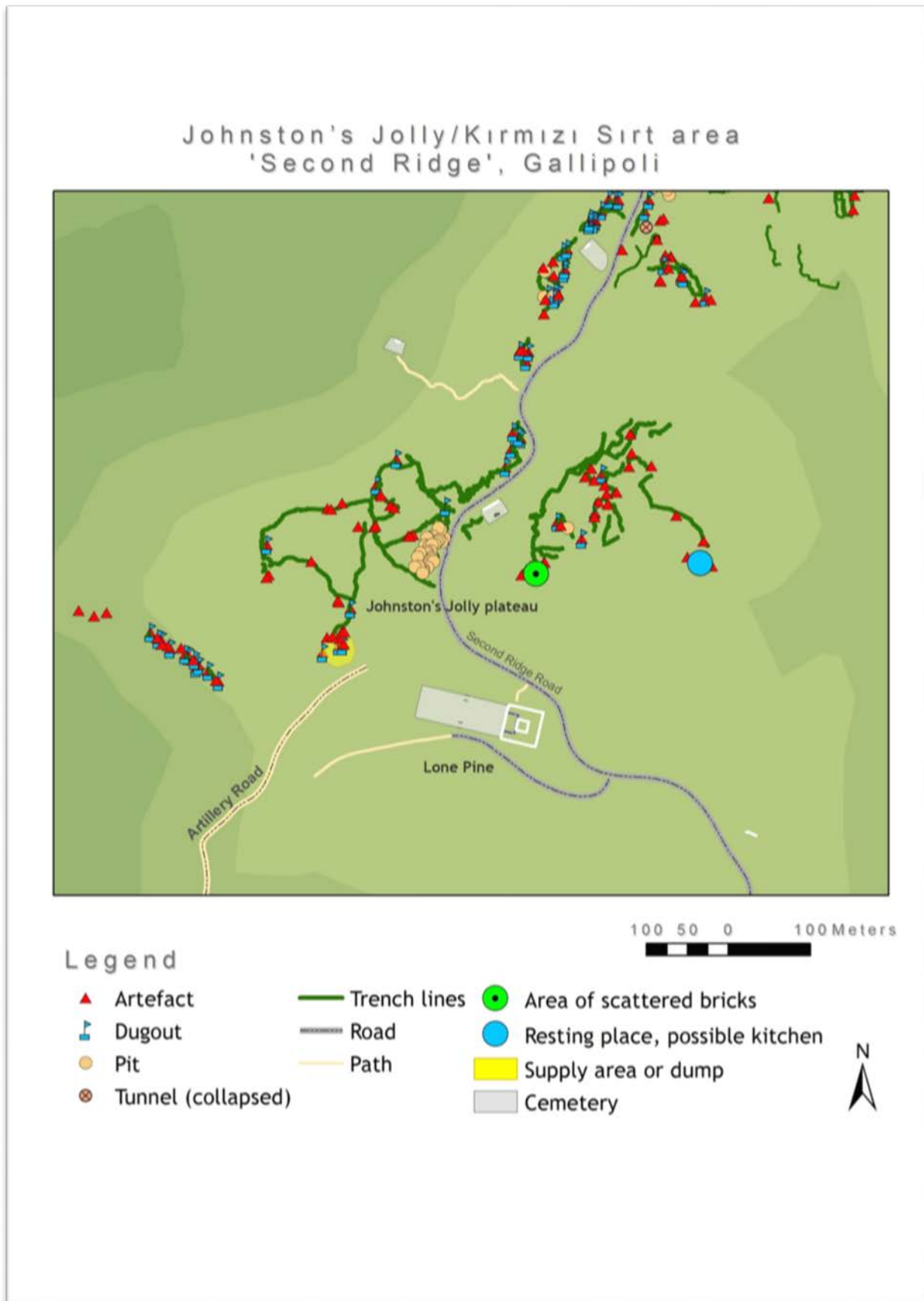


Figure 2: Remnant trench networks visible in the Johnston's Jolly area.





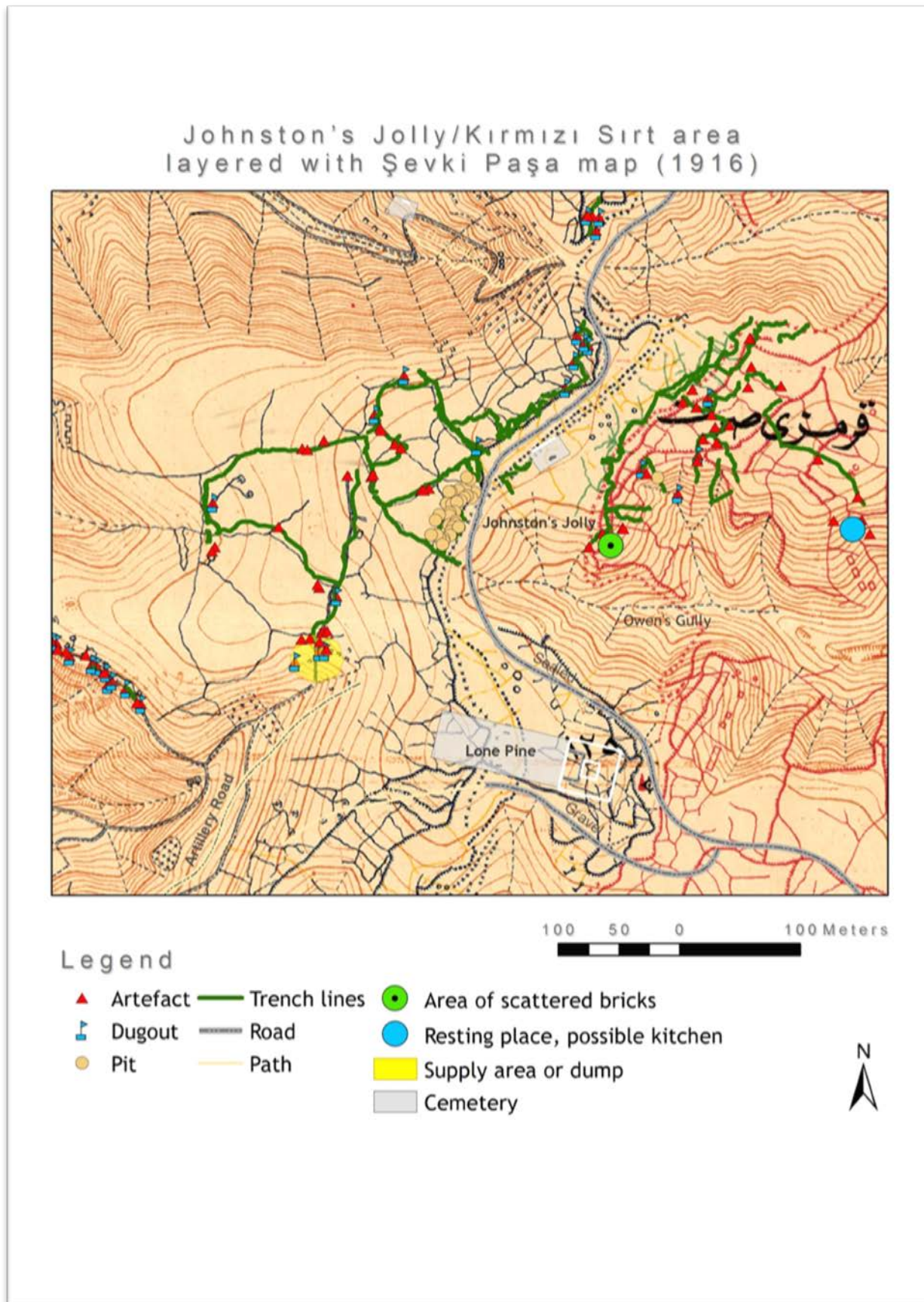


Figure 4: the survey findings in relation to the record of the Paşa map.



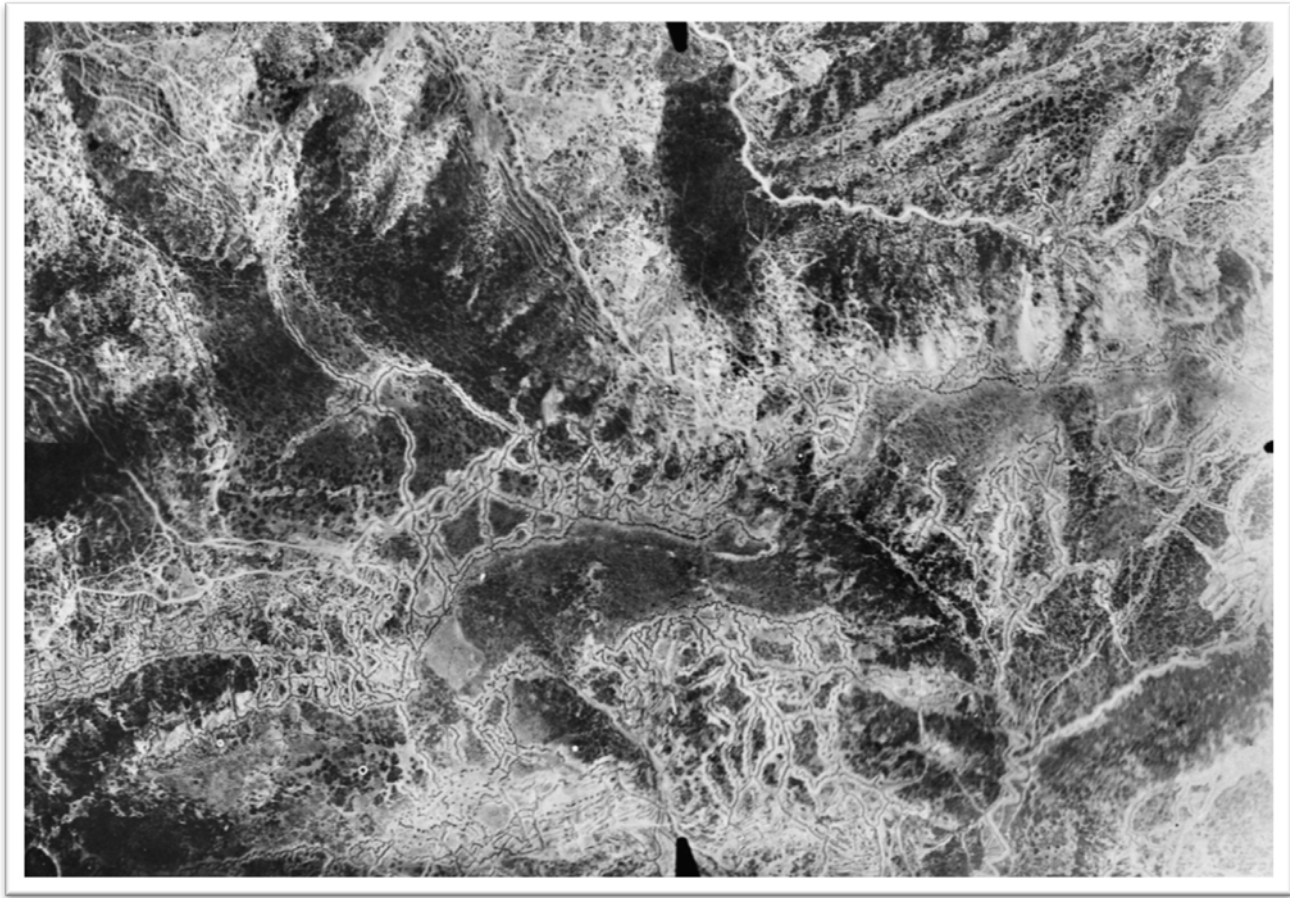
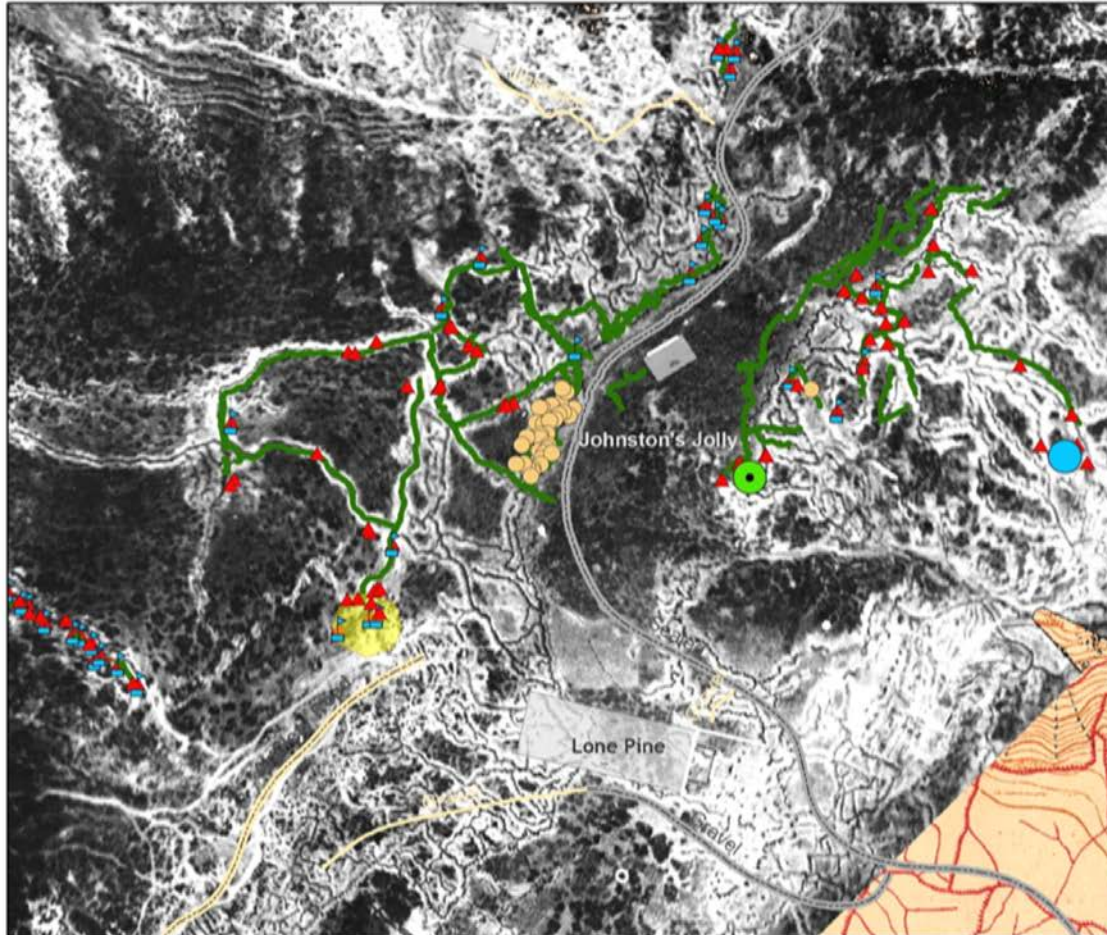


Figure 5: Aerial photograph of the Second Ridge, October 2, 1915. (Australian War Memorial records: RC04311)

## Johnston's Jolly/Kirmizi Sirt area layered with aerial reconnaissance photo (1915)



Aerial photograph: AWM collections RC04311 100 50 0 100 Meters

### Legend

- |            |                |                                   |
|------------|----------------|-----------------------------------|
| ▲ Artefact | — Trench lines | ● Area of scattered bricks        |
| ⚡ Dugout   | — Road         | ● Resting place, possible kitchen |
| ○ Pit      | — Path         | ■ Supply area or dump             |
|            |                | ■ Cemetery                        |



Figure 6: survey findings in relation to the aerial photograph shown in Figure 5.



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