НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ • ІНСТИТУТ АРХЕОЛОГІЇ НАН УКРАЇНИ

АРХЕОЛОГІЯ

НАУКОВИЙ ЖУРНАЛ – ЗАСНОВАНИЙ У 1947 р.
ВИДАЄТЬСЯ ЩОКВАРТАЛЬНО

КИЇВ • 3•2023

NATIONAL ACADEMY OF SCIENCES OF UKRAINE • INSTITUTE OF ARCHAEOLOGY NAS OF UKRAINE

ARHEOLOGIA

SCIENTIFIC JOURNAL — FOUNDED IN 1947
FREQUENCY: QUARTERLY

KYIV • 3•2023

ЗМІСТ — CONTENTS

Статті

УДК: [902:528.93](477.46)
https://doi.org/10.15407/arheologia2023.03.005

© R. PALMER, M. FOWLER, O. V. KARIAKA, V. WARD* 2023

AN ARCHAEOLOGICAL LANDSCAPE SURVEY OF 6600 KM² OF CHERKASY OBLAST, UKRAINE, USING OPEN-SOURCE SATELLITE IMAGES: FIRST REPORT

In the article, methods and use of open-source images to undertake an archaeological landscape survey of part of Ukraine are described. A selection of results — feature types and their placement in the landscape — from the first year of our survey is outlined and discussed. Our results can be assessed and manipulated using an interactive ArcGIS web app.

K e y w o r d s: Cherkasy Oblast, prehistoric era, Aerial Archaeology Research Group (AARG), landscape survey, HEXAGON, Google Earth, mounds, habitation sites, hillforts.

Introduction

This project was a way of showing solidarity with the people of Ukraine after Russia's illegal invasion in February 2022. A project outline was prepared that March and submitted to the committee of the AARG (Aerial Archaeology Research Group — see below) that proposed to examine existing open-source satellite images to identify archaeological features within a defined area. Meanwhile, a search was made of on-line Ukrainian publications to find out if:

a) anybody had already made a landscape survey of an extensive area using aerial or spaceborne data,

b) whether the type of work proposed may be of any use to Ukrainian archaeologists,

c) to seek one or more Ukrainian collaborators.

The purpose of this note is to outline what we have achieved in the first year of what may be a three-year project, to outline some of the types of features that have been recognised on the sources used, and to explain our plans for making the resource available.

Background

The AARG was founded in 1983 by a small number of British archaeologists who were examining aspects of post-reconnaissance uses of aerial photographs. Some illustrated known sites, but the majority had been taken of previously unknown buried archaeological features in arable land which may become visible, and recorded from above, through their effect on crops growing above them or be seen in bare soils. Initially the AARG was a British group that tasked itself to understand the many thousands of aerial photographs of archaeological targets that had been taken by airborne archaeological observers, briefly described, and then filed away with a handful being published as illustrations. At that time, the AARG members were examining methods to gain more information by interpreting and mapping the archaeological content of those photographs and finding ways to classify the mapped information. In the succeeding forty years, the AARG's membership has become worldwide,

* PALMER Rog — Editor, Aerial Archaeology Research Group, ORCID: 0000-0003-0546-9273, *rog.palmer@ntlworld.com*
FOWLER Martin — PhD, Member, Aerial Archaeology Research Group, ORCID: 0000-0003-4211-3671, *danebury216@hotmail.co.uk*
KARIAKA Oleksandr Volodymyrovych — PhD, Research Fellow, the Institute of Archaeology, National Academy of Sciences of Ukraine, Field Committee Department, ORCID: 0000-0003-3066-3641, *akarjaka@ukr.net*
WARD Valerie — Member, Aerial Archaeology Research Group, ORCID: 0000-0002-4936-3932, *Valerie.C.Ward@hotmail.com*

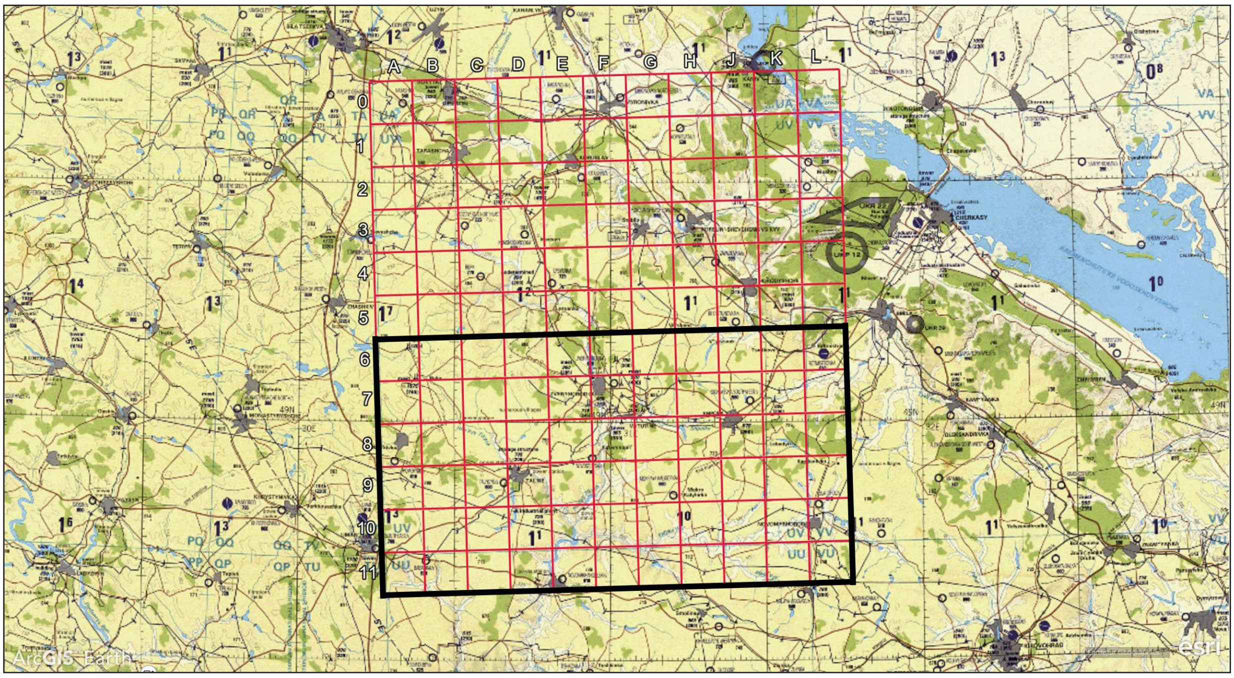

Fig. 1. The original Sentinel 2 tile, L2A_T36UUV, with the area halved for the current project. The grid within the tile is at 10 km intervals and North is to the top. Source: background map TPC series sheet E-3C available online at the Perry-Castañeda Library Map Collection: https://maps.lib.utexas.edu/maps/tpc/

and the breadth of its interests has grown from that beginning.

Aerial images of all types are seen as tools which allow different levels of archaeological investigation to be undertaken. These can range from providing or adding detail to new or known sites, to examining large areas of landscape in detail or, as our survey intends, to provide a basic distribution map of site types. At their most informative, aerial images are translated into maps or plans that show clearly and decisively what a photo interpreter has seen. Surveys at this level result from years of work examining remotely sensed data (aerial and satellite images and those from airborne laser scanning where it is available) to produce maps of archaeological sites and landscapes covering areas of several thousand square kilometres (e.g. Riley 1980; Palmer 1984; Hall, Palmer 1996; Stoertz 1997; Historic England 2023). Results of such surveys are initially multi-period after which the incorporation of existing knowledge and results from fieldwork enable broad division into conventional archaeological periods if recurrent feature types can be matched with those known from excavation. Survey of this type is legitimate archaeological research as photo interpretation can provide knowledge that helps understand relations between topography and archaeological features that inform how past systems of landuse and settlement may have functioned. To the best of our knowledge, extensive surveys of this type in Ukraine began with those by K. V. Shyshkin and published in 1964, 1973 and 1985 (analysed and summarised by O. V. Kariaka 2023 and Ward 2023a). His publications illustrated specific types of feature — tracks, mounds, hillforts and Trypillia sites (megasites) — but it is likely that he saw and mapped many others that were excluded.

This note is not the place to provide a histography of uses of remotely sensed information in Ukraine (Борисов 2020). These uses range in scale and detail from the taking and using of UAV images (Гнера 2015; Ašandulesei 2017) to applications of historical and satellite images (Гнера 2014; Nebbia, Roe 2020) which, in turn, have the potential to provide meticulous local investigations or less detailed studies of greater areas. This range emphasises that not all “aerial work” is the same or comparable other than it shares a common factor through its use of one (or more) of a multitude of above-ground devices to capture data.

Often aerial images will be used to illustrate a site that has been examined by other means (for example, recently at Busurmenske (Прядко 2020, рис. 2—3)) and there has been interest in their uses for monitoring the archaeological heritage both of individual objects and wider areas such as erosion zones of Dnipro River reservoirs (Малолітнева та ін. 2021). Since the war has begun, several organisations have been using satellite images to identify and monitor damage to cultural properties (e.g. Smithsonian Global 2003; Unesco 2023). However, these uses mostly study single sites or locations rather than landscapes which is the focus of our project. Use of remotely sensed images has been made in Trypillia research to look at individual sites and to compare image data to that recovered by geophysics (Rud, Ohlrau, Fedorov 2016). A more extensive survey of an area having a 25 km radius centred on Nebelivka and including part of our survey area was published by M. Nebbia, who used high-resolution satellite images to produce a map (Nebbia, Roe 2020 fig. 3.9) which included a distribution of mounds that is similar to that identified by our project.

Accurately mapping large areas from aerial information requires long-term projects and for our own survey we had a less ambitious aim which was to produce a dot distribution map accompanied by a simple database that includes a note of the type of feature we had recorded. Any survey from aerial information will record sites that were previously known and possibly some that were not, and even with known sites there is the chance of adding supplementary information. The resulting distribution map may add context to excavated features and there and elsewhere might enable a new range of archaeological questions to be asked. It is hoped that our general survey may encourage a more detailed "phase 2" in which smaller locations are studied in greater depth and linked to information already known. This, in turn, can lead to suggestions for further work as has recently been published by A. V. Borysov and colleagues (Борисов та ін. 2022).

With this as a background, how might a simple type of extensive survey help Ukrainian archaeology? Since the 2020 COVID-19 lockdown, the AARG had been running monthly "photo reading" online meetings for its members. "Photo reading" is a term given to an initial level of examination of any type of above ground images of visual and non-visual wavelengths taken from aerial or satellite platforms. We covered the basic theory of how archaeological objects may be visible on aerial images and also spent a lot of time discussing natural and recent features that can could be confused with archaeology in the interpretation.This group gave us a core of experienced archaeologists based across Europe,

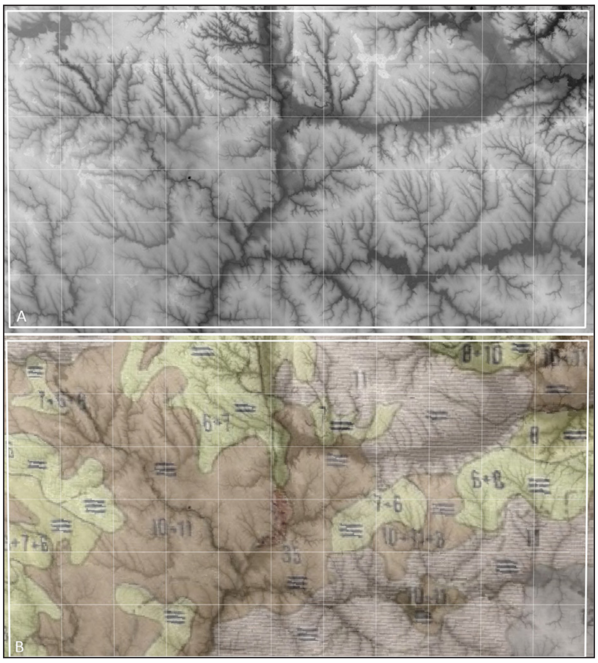

Fig. 2. The survey area showing, A: The SRTM image of the survey area shows topography and watercourses (source: USGS 2023). The N-S course of the Syniukha River divides the area and is fed by tributaries from the East and West. The grid is at 10km intervals and North is to the top. *B*: A soil map is superimposed on the SRTM image and shows fertile black soils (browns) over much of the land with scattered and smaller pockets of Podzols in yellow. Source: ESDAC 2023

who agreed to work voluntarily on the Ukrainian survey project. However, to give the project some credibility we really wanted at least one active participant from Ukraine[1]. Since then, O. V. Kariaka has helped with some of our work and has been an invaluable source of local resources that we would otherwise not have located.

Survey area

The AARG was already undertaking a research project to investigate if, and how, 10—60 m resolution multi-spectral Sentinel 2 satellite images could indicate dates when summer crop growth may show buried archaeological features (Palmer 2021; Broch 2021). Test areas

[1] T. M. Shevchenko from *Arheologia* gave us names of three archaeologists who said that they supported our project, but were not able to work on it. Meanwhile our reading had led us to O. V. Kariaka, from the Institute of Archaeology of the NASU in Kyiv, who had published three papers in which he had used satellite images to examine mounds, tracks and Olbian chora (Kariaka 2008; Каряка 2021; Болтрик, Каряка 2021). An email to him returned an enthusiastic reply followed by a Skype meeting in June 2022.

were primarily in Western and Central Europe but, as a first support for Ukraine, a Sentinel 2 tile (L2A_T36UUV) was added. It included parts of the Cherkasy Oblast where there was a mixture of soil types. Sentinel 2 tiles are large, covering 110 × 110 km, and although this area was proposed for the initial survey area of the project, early indications of the large number of sites being identified and the time-consuming quality-control process for the small working group of participants resulted in the project area being cut back to 110 × 60 km (fig. 1). The large Sentinel 2 tile was sub-divided into 10 × 10 km blocks and those became the working units for our survey project. Coincidentally, this area includes several of the well documented Trypillia megasites.

The project area lies within the Dnipro River Upland and is divided by the Syniukha River as it flows southwards towards the Black Sea. The Shuttle Radar Topography Mission (SRTM — fig. 2: upper) digital elevation model shows an undulating landscape cut by many lesser watercourses that feed into the Syniukha River from the East and West. Some are steeply incised into the landscape, but in places they created broad floodplain valleys. Topographically, there is little major variation with an average height of 250 m that rises in the NW. Environmentally, the area is mainly Forest Steppe with the possibility of Steppe in the SE part although the boundary moves with time. Forest Steppe has been described as a mosaic-like vegetation with woodland on drained soils, elevated areas, and shaded slopes as well as in river valleys, alluvial soils, and on gorge slopes. Between the woodland, the area is dominated by steppe meadow vegetation (Ohlrau 2020, p. 21).

Soils in the area are predominantly fertile black soils with smaller pockets of less fertile podzol variants on which much of the current woodland is located (fig. 2: lower).

Data sources

Our main source material for the survey is the freely available imagery in Google Earth Pro (GE) which, in our project area, dated from about 2007 to 2021, but with different date ranges and dates of cover across the larger area. We supplemented GE images with photographs from the recently declassified US HEXAGON KH-9 satellite programme that had been running between 1971 and 1986 and was itself a successor to the earlier CORONA reconnaissance satellite programme (Fowler 2022a; Hammer, Fitzpatrick, Ur 2022). The Earth Explorer website (USGS 2023) from which the declassified photographs are available identified about 500 forward-looking frames that covered parts of our area. From those we chose a sequence of cloud-free frames taken on 18 May 1982 that covered the whole of our area (Fowler 2022b). These would provide an earlier view of our project area as well as recording many Soviet-era structures that have since been demolished and which this project has included as “archaeological”. HEXAGON frames were scanned by the USGS and provided as a series of overlapping sub images of approximately 35 × 20 km. Parts of 18 of these covered our 110 × 60 km area. Those sub-images were georeferenced in QGIS and were further cropped to provide 10 × 10 km tiles that could be imported in GE. Our data sources were completed by Soviet 1:100000 maps (dating to the mid-1970s) and a topographical survey dated 1872 that was downloaded from Mapire (2023) historical map website. Both map sources were georeferenced and layered in GE.

Using aerial or satellite images

Aerial images taken specifically to record buried or upstanding archaeological features need to be acquired at critical times of year to achieve optimum results and even then there are some surface or crop conditions in which nothing can be seen (e.g., Wilson 2000). For that reason, the more dates of photography that are available for a given location, the more reliable the result of image interpretation should be. The selection of images in GE of our survey area includes some dates on which the archaeological content is spectacular, others in which some things can be seen if you know where to look and yet more where nothing can be seen on that particular image. It is important to be aware that these traces of archaeological information are not necessarily visible all the time. Some sites may show on several dates and thus provide reliable evidence, others may be of lesser certainty, because they have only been recorded on one date. Different parts of our 110 × 60 km area have differing numbers of GE dates — some as few as four, others have had 18 or 19 images on GE that cover parts of one 10 × 10 km square. Examination of images of different dates demonstrates that absence of evidence is not necessarily evidence of absence. What this means for our survey is that we have recorded what has been seen and confirmed through our checking process, but that new images

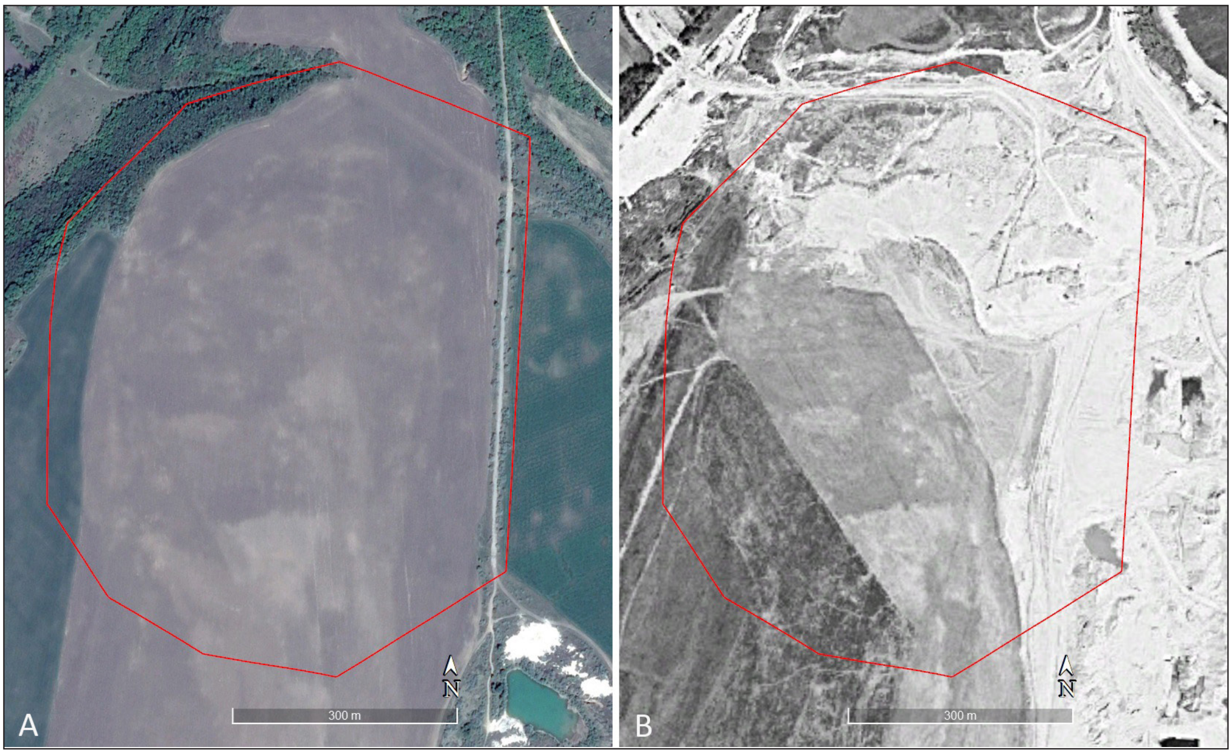

Fig. 3. The value of comparing images taken on different dates was apparent at this site East of Novoselytsia (E08_021) that showed suggestions of being a megasite on Google Earth images of several dates — as above (*A*) on 7 May 2017. E08 was one of the first squares we examined and HEXAGON photographs arrived after we had begun. These made it clear that our "megasite" was a result of backfiiling after quarrying that was active on 18 May 1982 (*B*). HEXAGON image courtesy of the US Geological Survey: entity ID: D3C1217-100073F026

of different dates are likely to change and add to the results presented.

Comparing images of different dates is an essential part of the examination process as it helps discard features that may look genuine on one date, but are obviously not archaeological on others. One example was to identify a site on the East side of Novoselytsia (our reference E08_021) that appeared to show promise as a megasite on GE images of several dates, but has never looked quite right. This was explained when we checked the earlier HEXAGON photograph that showed it as an active quarry in 1982 which had since been backfilled to create the impression of a megasite (fig. 3). In a similar manner, some of our findings on GE have been explained by consultation of the 1872 map that includes boundaries and roads that no longer exist and areas of woodland that have since been felled.

Working in one of the 10 × 10 km square, our process is to systematically scan each image and confirm anything seen on images of the other dates. Examining images in date order also allows us to note changing conditions of some objects (see mounds, below) and how modern land use is affecting their survival.

In GE, a feature will be identified using a uniquely numbered placemark pin with a small set of database fields completed in its description that includes, among other things, a named feature type, its condition, and the image dates on which it was seen (fig. 4). As each 10 × 10 km square is completed it is checked by a second person after which a discussion may be necessary before an agreed set of pins is finalised. These are copied to a third person who processed the pins to convert the data recorded in each pin into a database for subsequent analysis and visualisation. The semi-automated process involved the use of an Excel spreadsheet to extract the formatted data fields present in each GE pin description. These were then combined with the latitude and longitude coordinates of the pin and the pin number into a master spreadsheet database. A technical description of the process can be found in M. J. F. Fowler's work (2022c). The spreadsheet data were then uploaded to ArcGIS Online and used to produce a web application so that the pinned data can be more easily visualised and searched by others. This part of the project is currently in development, but a version can be viewed online

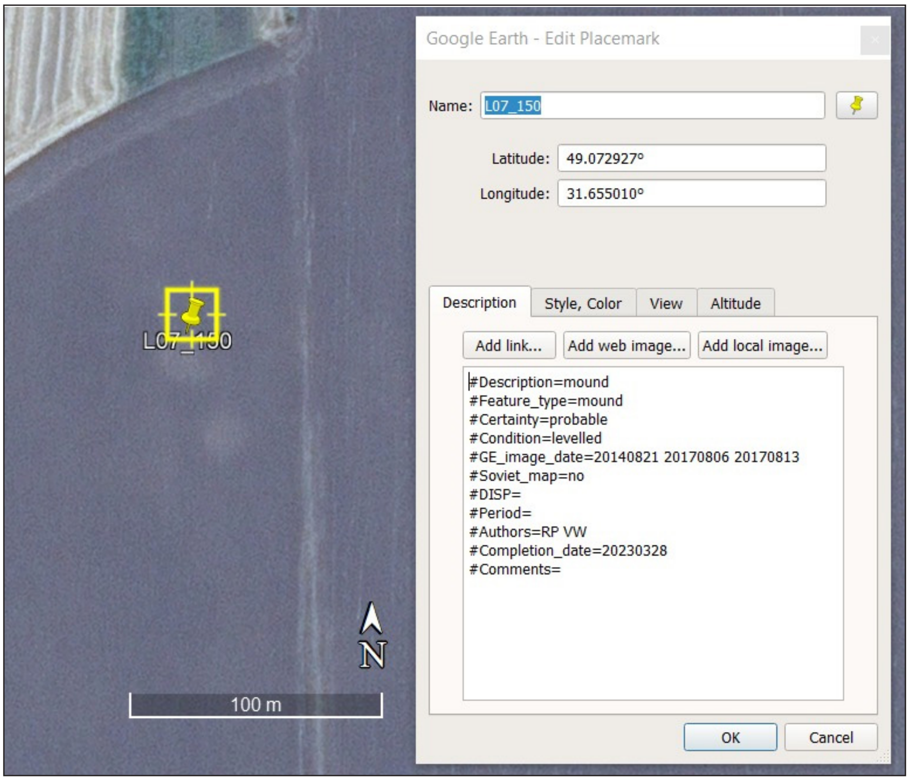

Fig. 4. Pinned site L10_150 is a levelled mound in a cultivated field. Its database fields show that it was visible on three dates in two years which, with its clarity let us give it the highest certainty, probable, from an image source alone. Note that dates are written in the format year-month-day to enable easy sorting. #DISP= refers to Declassified Intelligence Satellite Photographs which at present are only HEXAGON taken on 18 May 1982. There is another mound close to its south side that has been unpinned for this illustration. Source: Google Earth: 6 August 2017

(link at the AARG, 2023) and is shown in some of the following illustrations.

A selection of results

This section makes no claims to new discoveries, although undoubtedly there will be some, but the main purpose of the survey is to draw together information over the 110 × 60 km area and to make suggestions based on distributions rather than individual cases as is more usual following an excavation. These are not necessarily the right suggestions, particularly as most of the authors are new to this part of the world, but are more to show what can be attempted by thinking about an area rather than a site. One of the advantages of the aerial/space view is that it provides the material from which this can be done.

Most of the observed features were compacted soil or the surviving matrix of ploughed mounds rather than ditched features which most of us were familiar with from work further to the West. As would be expected, the mounds showed clearly in bare soil, because of their colour difference, but they were also visible in crops where they caused poorer growth above what is likely to be more compact or poorer soil. This can be clearly seen in fig. 5 where the mounds show as lighter (thinner) crop and are sometimes surrounded by darker rings that are probably denser growth above ditches. The same denser growth can be seen above the numerous soil erosion gullies near the bottom of the picture. These colour changes in the crops also suggest that ditched features would be expected to be visible in certain of Ukraine's crops but, to date, very few have been identified by this survey.

As this note reports on work in progress, no attempt is made to indicate numbers of feature types found although the open access web app (AARG 2023) allows a simple check of types and their distribution against a small range of backgrounds.

Mounds

The most prolific types of sites are those we call 'mounds' (so as not to pre-suppose a function, purpose or date for them) with some 3000 identified in the 50 % of the project area that

Fig. 5. A line of mounds showing as lighter (thinner) crop where growth has been restricted by the poor or compact soil of the mound matrix. Some are surrounded by darker rings that probably indicate ditches marked by lush crop growth. The same denser growth can be seen above the numerous soil erosion gullies near the bottom of the picture. Source: Google Earth: 12 August 2017

has so far been studied. However, we do attempt to distinguish mounds that may have been for burials and/or markers of some kind from those likely to remain from habitation sites, but these are subjective decisions made on the basis of size and clustering. As K. V. Shyshkin identified (Шишкин 1964, с. 200), mounds can occur singly, in groups or in rows, with the latter usually following the high ground or breaks of slope (fig. 6). There have also been repeating patterns of what we call satellite mounds — where a larger mound may have between one and five smaller mounds closely surrounding it (fig. 7). Some, usually plough-levelled, have just two satellites and may be former maidans or saltpeter works that occur as extant and levelled eathworks (fig. 8). The fact that these patterns repeat seems of greater archaeological relevance — perhaps indicating movement of people or ideas — than the identification of individual examples.

We have identified a small number of examples where mounds, including habitation sites, have been levelled by a farmer and the date sequence in GE sometimes records a before, during and after set of images (fig. 9). Examples of this kind may help management and protection of sites. Aerial photographs are used for this purpose, sometimes specifically taken to record damage to protected sites, in the UK.

Habitation sites

Habitation sites that we have identified so far are relatively few in number and tend to comprise clusters or groups of small mounds. These are enclosed in a polygon on our database that is able to show the sum of information that may be visible on different dates in different fields (fig. 10). Many habitation sites include larger mounds among the smaller ones. The larger mounds are thought to be of later dates and in places form one end of a row of mounds that runs along the high ground to or from a confluence of two rivers — a favoured location for habitation sites of all sizes. This raises questions about the chronological sequence of the two kinds of feature: whether, for example, they were contemporary or whether the later mound builders were aware of remains of former occupation and deliberately related their mounds to them.

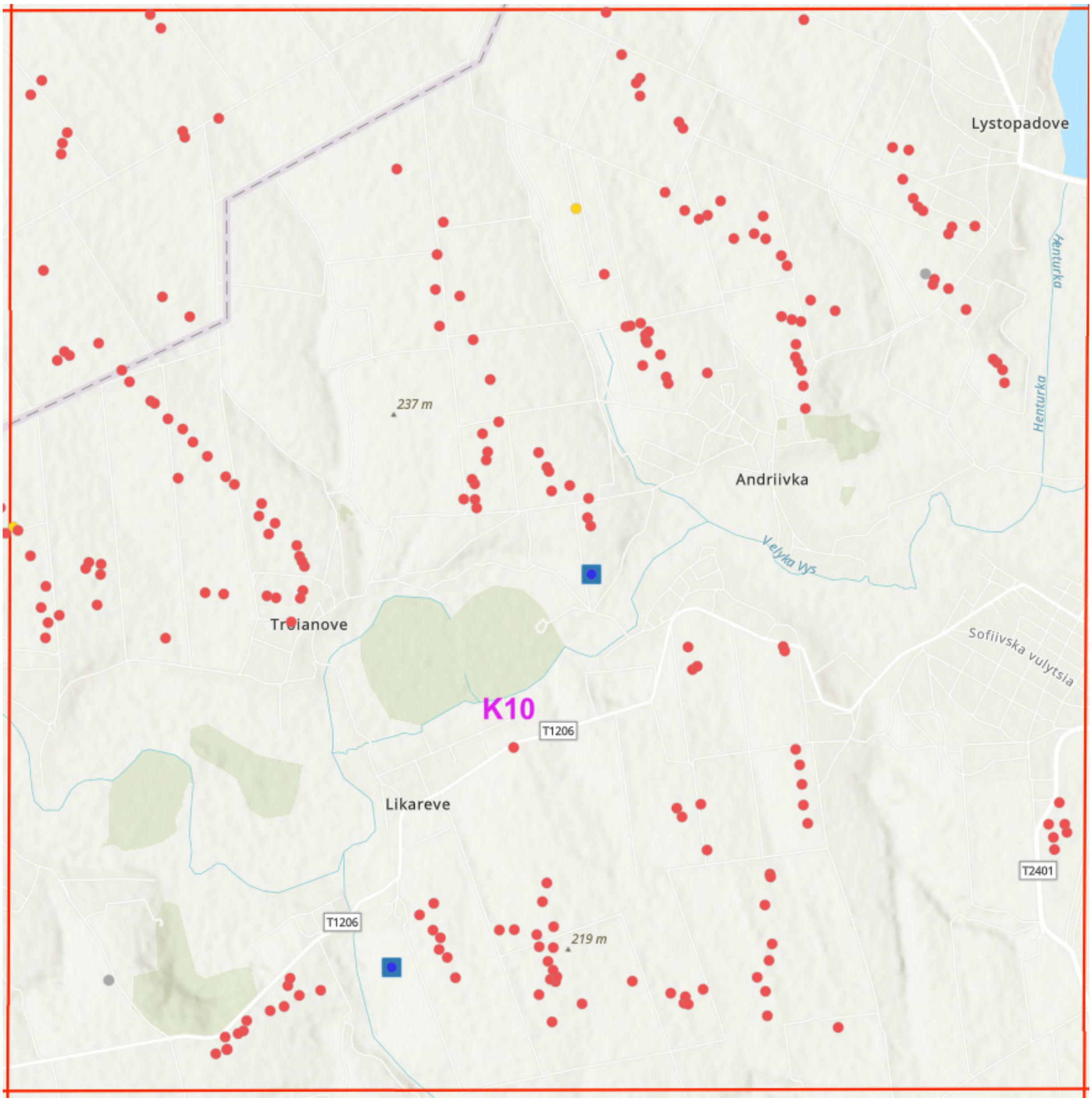

Fig. 6. Square K10 showing rows of mounds (red) on high ground among which are a few habitation sites (yellow) and Trypillia megasites (blue). The square is 10 × 10 km with North to the top. Source: AARG Ukraine WG web app: 31 May 2023; background map: ESRI World Topographic Map https://www.arcgis.com/home/item.html?id=7dc6cea0b1764a1f9af2e679f642f0f5

On rare occasions habitation sites may be enclosed as in the example at Kobrynove in our square D08 (as yet not pinned).

This group also includes the so-called megasites for which one of our group, V. Ward, has collated the several published lists of sites in our area into a single database and located as many as possible on Google Earth to supplement and add information to our identifications. This has also enabled the accurate location of some sites which have been recorded on GE images taken after the publication of the original lists. Some of the lists include very small settlements under the term "megasite" which, following recent publications (e.g. Chapman, Gaydarska, Nebbia 2019; Gaydarska, Chapman 2020), we would rather reserve for sites over 100 ha in extent. At present, we are calling the small sites from the published lists "Trypillia sites" and noting their size in our database where this is provided (Ward 2023b).

HEXAGON photographs have provided some excellent records of certain megasites as

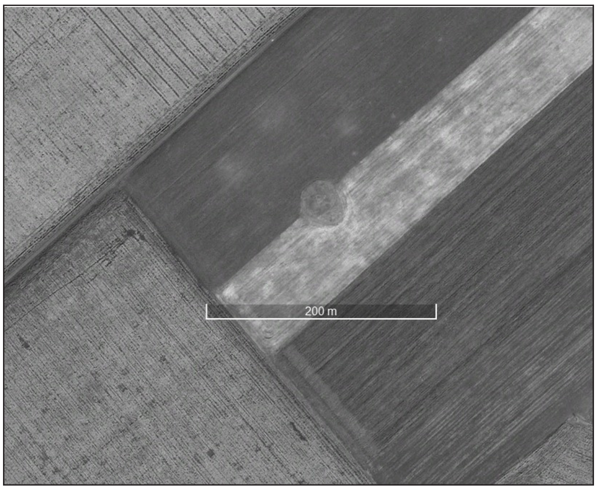

Fig. 7. Site J10_132 is the large extant mound located in two differently managed fields. It has at least three smaller satellite mounds on its North side. Source Google Earth: 8 June 2012

they were taken at a date when Soviet farming practices required large fields. At Maidanetske, for example, much of the site was within two fields in 1982 which, on GE dates (from 2011) have been managed in smaller units that, because of their different cropping regimes, can fragment the overview and may show only one small part of that site (fig. 11). It is worth mentioning here that the drawings made by K. V. Shyshkin (e.g., his interpretation of Maidanetske: Шишкин 1973, рис. 2) showed circuits of lines rather than houses and this may have been due to the small scale (1:35000) and possibly poor resolution of the original aerial photographs that were available to him. Lenses and cameras have improved significantly from the 1960s and can now provide considerably more detail. For example, the HEXAGON image from 1982 clearly shows many individual houses (fig. 12), because of its higher-resolution source.

Hillforts, defensive sites and enclosures

Ukrainian archaeological literature is rich with studies of hillforts (e.g., recently Білинський 2018; Каравайко 2023) and a survey of this kind is unlikely to add new knowledge to individual sites, but it may help provide context for them. An example comes from square E06 that we have glanced at, but not systematically examined. East of Vodianyky is a small known hillfort that can be seen with various clarity on nine GE images between 8 August 2008 and 9 October 2020. It is plough damaged and each year's cultivation is likely to shave further contexts from its upper layers. HEXAGON shows that it was also ploughed in 1982 with its outer bank being degraded and spread. It does not appear on the Soviet 1:100000 map, but that is not unexpected, nor is it marked on the 1872 map although that shows that the area was then wooded with all the problems that brings to identifying sites on the ground. GE also shows a slighter enclosure of similar size some 5—600m to the north-west on a lower hilltop and it is this close proximity that raises questions about their contemporaneity — were they both in use, perhaps for different purposes, at the same time or do they show sequential use? Field survey or excavation may answer that question.

Our survey has also recorded one previously known promontory rampart, L08_051, South of Buda-Makiivka, that has been under cultivation on all dates from 1982 and shows plough damage on those dates, but especially clearly in 2019 when the rampart can be seen to have been dragged and spread by cultivation (fig. 13).

Enclosures of different sizes have been recorded by our survey with one of the smallest south-west of Tashlyk (L09_190). It shows as a ditch, some 80m across, possibly circular, but of unknown shape as part has never been recorded. Within it is a smaller circular feature some 20—25 m in diameter. Elevation profiles taken in Google Earth show it to be situated just off the crest of higher ground on the west facing slope which may offer some shelter from east winds.

Soviet era

The 1982 HEXAGON photographs we are using show a record of economic activity during Soviet times that, in most cases, no longer exists. Predominant among these, and easy to recognise are collective farms whose use (e.g., for dairy, hog or poultry) is indicated on the Soviet maps of similar date. The majority of those farms had been abandoned by the earliest GE image dates (2007—2008), often with buildings collapsed. Land within the former farms was left to become scrub b-covered and remained unused through the dates of GE. Occasionally those farms, or parts of them, continue in some kind of use. All this is noted in comments in our database on the assumption that one day, someone may be interested in structural aspects of this former economic system. Similarly, we record industrial and military sites from the same era, many of which are on the map or documented in now-declassified US intelligence reports (CIA 2023).

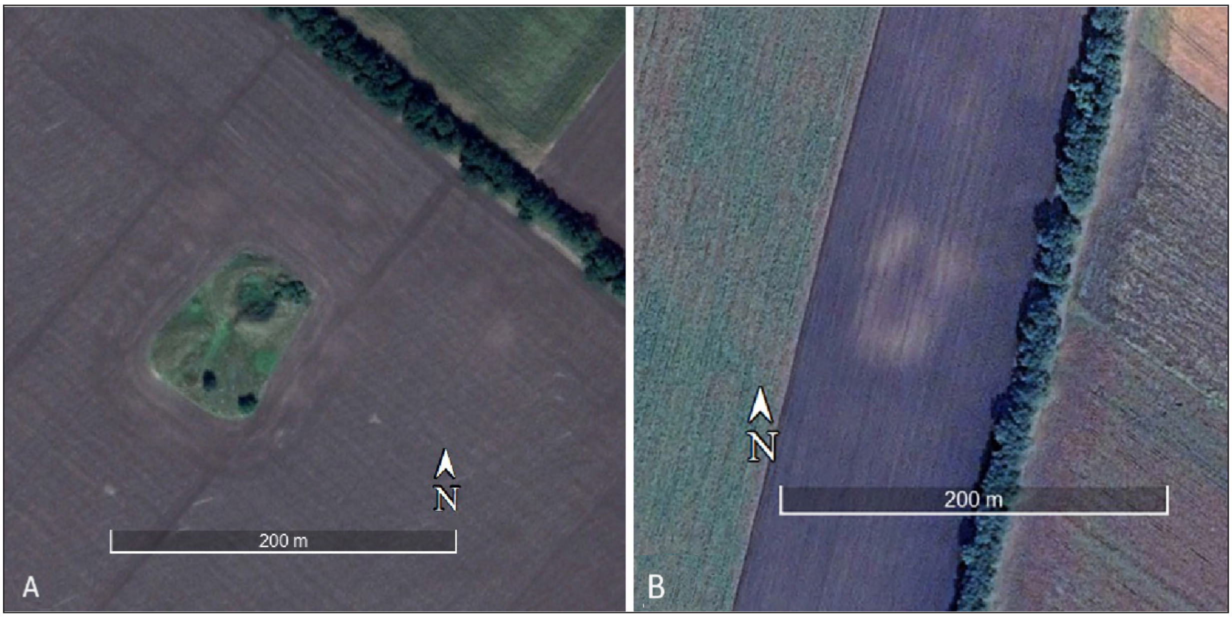

Fig. 8. On the left (*A*) is an extant example of a maidan (saltpeter works: site E10_036) comprising a hollowed mound with tailings to its south-west. Note other small levelled mounds around it visible as lighter discs. *B* shows what may be a levelled example of something similar, but which we are describing as a mound (K06_075 on the South side) with two satellite mounds to its North. Source Google Earth: 21 August 2018 (L) and 8 September 2017 (R)

Fig. 9. Damage to sites is sometimes apparent when viewing a sequence of images. *A* is from an image taken on 6 August 2017 showing two mounds as grey discs in a crop field. Both have been squared off during cultivation or as deliberate levelling. The rectangle close to the field's boundary was a mound in 1982 and has not been sown with crop on this date. Two years later (*B*), on 8 October 2019, the image shows more deliberate signs of mound levelling with parts of each mound being dragged to the south as a result of heavy ploughing when the field was cultivated. Traces of previously-levelled mounds are also visible on this date. Sites L06_056-060. Source: Google Earth

Former quarries are also recorded as many are now backfilled and invisible from above, show areas of disturbed ground where conventional archaeological activity is unlikely now to find anything (see fig. 3).

Our project has also recorded major changes to village structures. Occasionally complete abandonment has been identified with rows of houses seen in 1982 no longer there on GE dates and with strip fields merged into larger land units. One such example West of Korobchyne (J10_142) may have been to move people prior to the expansion of a large mineral extraction development. Occasionally, villages show evidence for 'shrinking', where houses and fields have vanished since 1982, but parts of that village

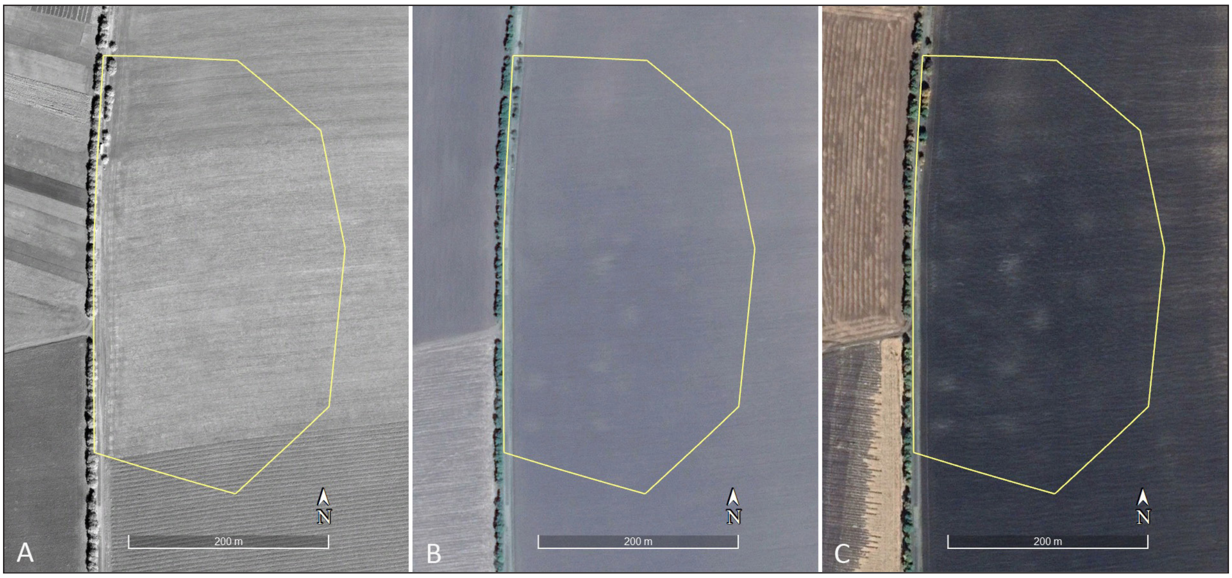

Fig. 10. Habitation site F09_002 as it was recorded on three different dates with each showing differing amounts of information and summised by our polygon. Source: Google Earth, left to right: *A*: 10 September 2012, *B*: 7 May 2017, *C*: 2 October 2019

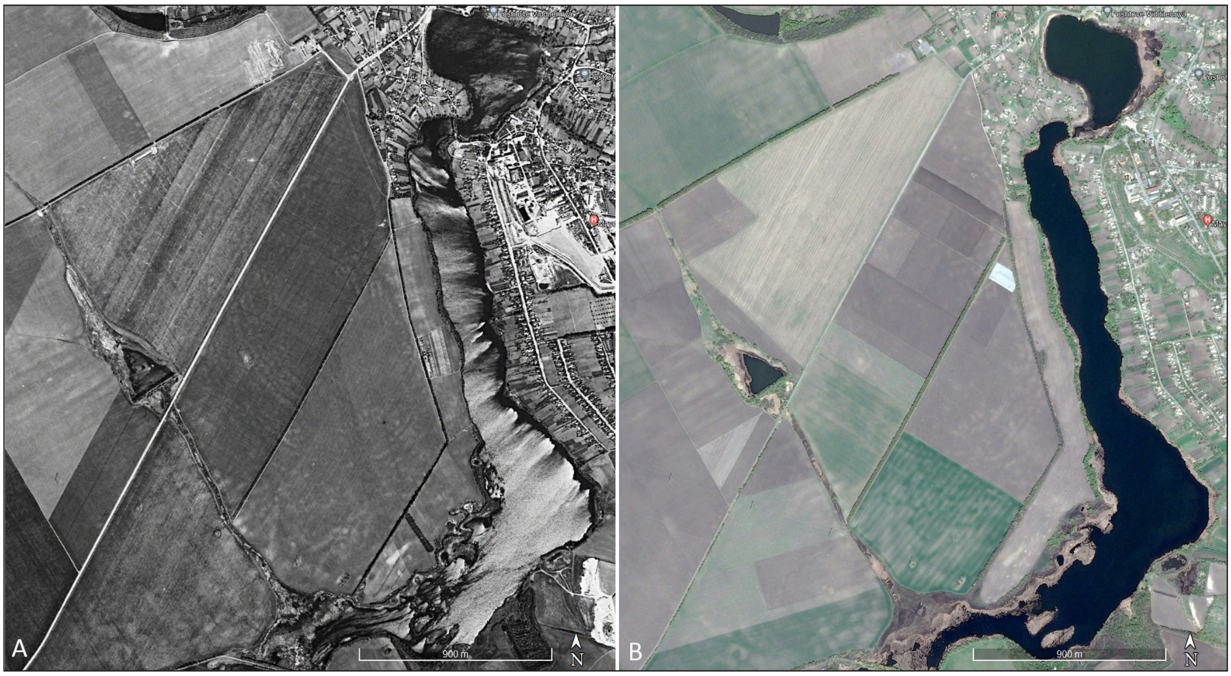

Fig. 11. A: Maidanetske from HEXAGON (18 May 1982 — see Fig. 12 for detail) at a date when most of the site was in two large fields, and from Google Earth (*B*: 19 April 2017) when the patchwork of different fields and crops showed only parts of the site. HEXAGON image courtesy of the US Geological Survey: entity ID: D3C1217-100073F027

remain inhabited. We record these, because they are part of Ukraine's changing landscape rather than in anticipation of any future studies.

Confusion

Finally, we add a note about things that confused those of us examining the images. This is part of learning in any new area and we have more examples from the early days of our survey than from recent months. The most frequent examples were features that appeared as mounds in some years, but on other dates showed as 'hollows' (small pockets of lower ground), sometimes wet and avoided in cultivation, and sometimes showing fringes of dried minerals around their edges. In some places, those hollows

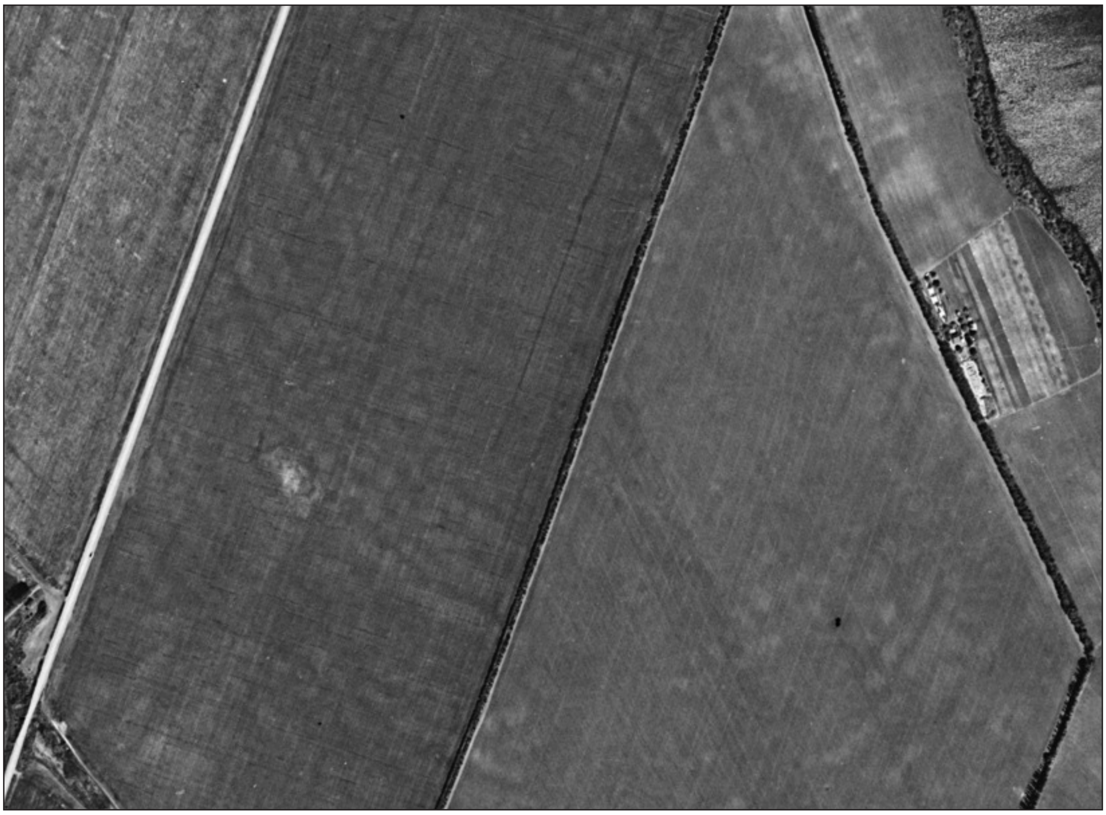

Fig. 12. A crop from the original HEXAGON image scan on which individual houses can clearly be identified at Maidanetske. North is to the top and, by way of a scale, the E-W dimension of this figure is about 1400 m. HEXAGON image courtesy of the US Geological Survey: entity ID: D3C1217-100073F027: 18 May 1982

may be shown to be small ponds in systems of occasional watercourses. Sites of this kind make up the compendium that needs to become part of a photo analyst's mindset as they help the decision-making process and — hopefully — mean that some deceptive or misleading information is omitted from our interpretation of archaeological sites. We do record many of those that are misleading as non-archaeological features, partly to show they have been seen and considered and partly to share our experience withothers.

Database accessibility

Our square-by-square results are added to an interactive ArcGIS web app from which Fig. 6 was taken. This can be used to provide an overview, to highlight specific types of feature, and to show site-specific information from our original GE database. Already, viewing it has raised several questions about settlement distribution, landuse and boundaries that, with applied local knowledge, may encourage and enable new archaeological directions or research. Whilst the web app is still under development, it can be examined and manipulated at the link given in the AARG (2023).

Final thoughts

While this survey project has begun to show support for Ukraine after the invasion of 2022, it is hoped that it will be of some use to Ukrainian archaeologists when we complete the initial area after an estimated further year's work. Landscape studies in the UK have linked evidence from aerial photographs with that known from other sources. For example, a survey can identify specific or repeating forms of feature that may have been given a date range from field walking or excavation and may apply that date to other similar forms to examine how distributions may have changed or landuse has been shared between stock and cultivation (Stoertz 1997, p. 67-73). Aerial survey has been used to add context and shape to field walking survey (Hall and Palmer 1996, fig. 67), and present-day commercial archaeology in advance of development frequently begins with aerial survey and plans specific geophysical grids on that basis. Most such work begins with maps made from aerial information — in

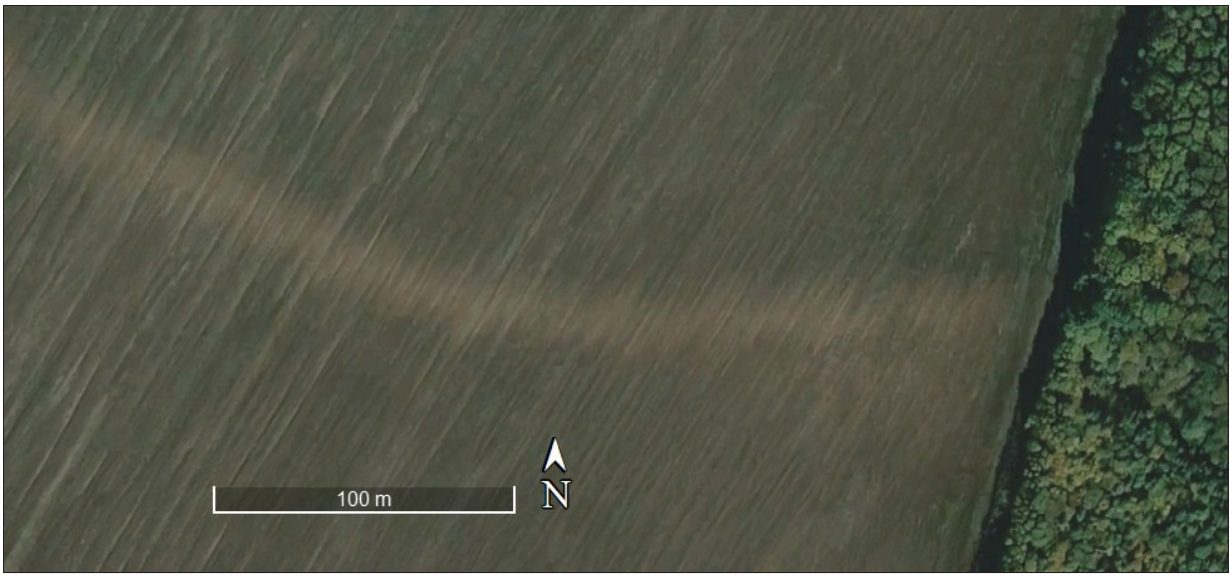

Fig. 13. A close-up of the promontory rampart South of Buda-Makiivka (L08_051) that shows plough damage to the rampart that seems especially severe where the slope steepens on the east side. Source: Google Earth: 8 October 2019

much the same way that K. V. Shyshkin produced — rather than the point and polygon database that results from our survey in Ukraine. However, the simple point distribution database can also be used to pose certain levels of questions about the past as have sometimes been suggested above, and results of our project may encourage work of this kind by those who have access to 'local' data such as site records and information from annual fieldwork reports (АДУ 2023). We see our project as a beginning rather than the end.

Since 1996, the AARG has organised and run many field schools in Europe, most of them in former Soviet bloc countries where aerial survey undertaken by individuals was allowed after the collapse of the Soviet Union. Some schools included flying and aerial photography, but all had a "ground school" element, some entirely so, that taught methods of interpretation, mapping and archaeological uses of aerial evidence. This is the kind of thing that the AARG would be pleased to extend to Ukrainian archaeologists either remotely, as could be done now, or in person when political conditions allow that.

Acknowledgements

The authors thanks Carmen Miu, Simon Seyfried and Sonia Tomaczak for active participation in data collecting for this survey and Darja Grosman for academic input and stimulus in the early days of the project. We also thank the AARG Fund for covering the cost of the scanning of the HEXAGON photographs used for the project which can now be freely downloaded by others. Final and grateful thanks go to the anonymous referee who alerted us to work we previously had not found and the need to more precisely explain the aims and processes of this project.

Болтрик, Ю. В. (ред.). 2023. 2023. *Археологічні дослідження в Україні* [online]. Режим доступу: http://vgosau.kiev.ua/biblioteka/avu.adu

Білинський, О. О. 2018. Городища скіфського часу в Дніпровському лівобережному лісостепу: загальна характеристика, каталог, типологія. *Археологія і давня історія України,* 1(26), с. 213-234.

Болтрик, Ю.В., Каряка, О.В. 2021. Сліди стародавніх шляхів степової Таврії. *Археологія і давня історія України,* 3(40), с. 199-214. https://doi.org/:10.37445/adiu.2021.03.13

Борисов, А. В. 2020. Використання даних аеро та космічної зйомки у археології Середньої Наддніпрянщини. В: Малолітнева, В. К. та ін. (ред.) *Археологічна спадщина — погляд згори: правові та організаційні засади використання даних аерокосмічної зйомки для охорони та дослідження археологічної спадщини*. Матеріали науково-практичної конференції (Київ, 6 листопада 2020 р.). Київ: ДУ «Інститут економіко-правових досліджень імені В. К. Мамутова НАН України», с. 138-145.

Борисов, А. В., Гнера, В. А., Мисак, В. М., Марченко, О. В. 2022. Пам'ятки м. Городища на річці Вільшанка (матеріали до археологічної карти). *Археологія і давня історія України,* 3 (44), с. 252-262. DOI: 10.37445/adiu.2022.03.15

Гнера, В. А. 2014. Аналіз використання дистанційно пілотованих літаючих апаратів у археологічних дослідженнях. *Праці Центру пам'яткознавства*. В: Титова О. М. та ін. (ред.) Центр пам'яткознавства НАН України і УТОПІК, 26, с. 16-25.

Гнера, В. А. 2014. Досвід використання матеріалів аеро- та космічної зйомки в історико-меморіальній роботі. *Ніжинська старовина: збірник регіональної історії та пам'яткознавства*. В: Коваленко О. Б. та ін. (ред.) Центр пам'яткознавства НАН України і УТОПІК , 18(21), с. 10-21.

Каряка, О. В. 2021. Давні шляхи біля Давидового Броду на Інгульці. *Археологія і давня історія України,* 3(40). с. 169-174. https://doi.org/10.37445/adiu.2021.03.10

Малолітнева, В. К., Борисов, А. В., Гурова, А. М., Малишев, О. О. 2021. Основні результати наукового проєкту «Правові та організаційні аспекти використання аерокосмічної зйомки для дослідження й 2021 охорони археологічної спадщини України». *Науковий вісник Ужгородського Національного Університету. Серія Право*, 68, с. 174-179. https://doi.org/10.24144/2307-3322.2021.68.29

Прядко, О. О. 2020. «Бусурменське» городище на р. Іква. *Археологія і давня історія України,* 2(35), с. 137-141.

Шишкін, К. В. 1964. Про використання аерофотозйомки в археології. *Археологія,* 17, с. 199-204.

Шишкін, К. В. 1973. З практики дешифрування аерофотознімків у археологічних цілях. *Археологія,* 10, с. 32-41.

Шишкін, К. В. 1985. Планування трипільських поселень за даними аерофотозйомки. *Археологія,* 52, с. 72-77.

AARG, 2023. AARG Ukraine WG web app [online]. Available at: https://satarchuk.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=e6d6ccf301e7492d8f7cd113c777c264

Ašandulesei, A., 2017. Inside a Cucuteni Settlement: Remote Sensing Techniques for Documenting an Unexplored Eneolithic Site from Northeastern Romania. *Remote Sens,* 9, 41; https://doi.org/10.3390/rs9010041

Broch, M. C., 2021. Working with Normalised Difference Vegetation and Moisture Indexes in AARG's Sentinel 2 Working Group — the Idea, the Method and the Next Step. *AARGnews,* 63, pp. 9-11.

Chapman, J., Gaydarska, B., Nebbia, M., 2019. The Origins of Trypillia Megasites Project: Early Urbanism in Prehistoric Europe?: the Case of the Trypillia Mega-sites. *Frontiers in Digital Humanities*, 6, https://doi.org/10.3389/fdigh.2019.00010

CIA, 2023. Freedom of Information Act Electronic Reading Room [online]. Available at: https://www.cia.gov/readingroom/

ESDAC 2023. Soil Map of Ukraine (1977) [online]. Available at: https://esdac.jrc.ec.europa.eu/content/title-russia-soil-map-ukraine

Gaydarska, B., Chapman, J., 2020. Ancient Ukrainian "Megasites" Might Have Been the World's First Cities [online]. Available at: https://blog.degruyter.com/ancient-ukrainian-megasites-might-have-been-the-worlds-first-cities/

Fowler, M. J. F., 2022a. The Archaeological Potential of KH-9 HEXAGON Satellite Photographs: the Roman Temporary Camps and Siege Works at Machaerus and Masada. *AARGnews*, 64, p. 37-53.

Fowler, M. J. F., 2022b. Through the Keyhole: Exploiting HEXAGON Spy Satellite Photographs in AARG's Ukraine Project. *AARGnews*, 65, pp. 36-45.

Fowler, M. J. F., 2022c. Taming the Unknown: Combining Different Data Sources in AARG's Ukraine Project. *AARGnews*, 65, pp. 29-35.

Hall, D. N., Palmer, R. 1996. *Cambridgeshire Fenland Survey: the Silt Fens.* In: Hall D. N. (ed.) Fenland Landscapes, Cambridgeshire, 3. East Anglian Archaeology, 79. Norwich: Centre for East Anglian Studies.

Hammer, E., FitzPatrick, M., Ur, J., 2022. Succeeding CORONA: Declassified HEXAGON *Intelligence Imagery for Archaeological and Historical Research. Antiquity*, 96 (397), pp. 679-695. https://doi.org/10.15184/aqy.2022.22

Historic England 2023. Aerial Archaeology Mapping Explorer [online]. Available at: https://historicengland.maps.arcgis.com/apps/webappviewer/index.html

Karavaiko, D. V., 2023. Hillforts of the Scythian Period in the Middle Course of the Seim River. *Arheologia,* 1, p. 20-39.

Kariaka, A. V., 2008. The Demarcation System of the Agricultural Environment of Olbia Pontike. In: Guldager Bilde P., Petersen J. H. (eds.), *Meeting of Cultures in the Black Sea Region between Conflict and Coexistence.* Aarhus: Aarhus Universitetsforlag, p. 181-192.

Kariaka, O. 2023. Kostiantyn Shyshkin in Soviet Archaeology, *AARGnews,* 66, pp. 10-18.

Mapire 2023. Historical Map Portal [online]. Available at: https://maps.arcanum.com/en/

Nebbia, M., Roe, J., 2020. *Chapter 3: Landscape Studies.* In: Gaydarska, B. (ed.). Early Urbanism in Europe, The Trypillia Megasites of the Ukrainian Forest-Steppe. Warsaw; Berlin: De Gruyter, pp. 60-110. https://www.degruyter.com/document/doi/10.1515/9783110664959/pdf

Ohlrau, R., 2020. *Maidanetske: Development and Decline of a Trypillia Mega-site in Central Ukraine*. Leiden: Sidestone.

Palmer, R., 1984. Danebury: an Aerial Photographic Interpretation of Its Environs. *RCHM Supplementary Series*, 6.

Palmer, R., 2021. AARG's Sentinel 2 Working Group — Background and First Report. *AARGnews*, 62, pp. 9-10.

Riley, D. N., 1980. *Early Landscape from the Air.* Sheffield: Collis.

Rud, V., Ohlrau, R., Fedorov, S., 2016. Satellite Images and Geomagnetic Plans of Several Cucuteni-Trypillia Sites of the Right Bank of Southern Bug River. In: Mischka, D., et al. (eds.). *Beyond Excavation: Geophysics, Aerial Photography and the Use of Drones in Eastern and South-East European Archaeology: International Colloquium: Programme and Abstracts.* Romania: Piatra-Neamţ, pp. 51-54.

Smithsonian Global 2003. *Remotely Monitoring Ukraine's Cultural Heritage with the Conflict Observatory* [online]. Available at: https://global.si.edu/projects/remotely-monitoring-ukraine's-cultural-heritage-conflict-observatory

Stoertz, C., 1997. *Ancient Landscapes of the Yorkshire Wolds.* Swindon: RCHME.

Unesco 2023. *Damaged Cultural Sites in Ukraine Verified by UNESCO* [online]. Available at: https://www.unesco.org/en/articles/damaged-cultural-sites-ukraine-verified-unesco

USGS, 2023. Earth Explorer [online]. Available at: https://earthexplorer.usgs.gov/

Ward, V., 2023a. Trypillia Sites: a Comparison of Google Earth Satellite Images to Aerial Photograph Analysis by K. V. Shyshkin. *AARGnews,* 66, pp. 19-26.

Ward, V., 2023b. *Trypillia Database for AARG GE Project.* Document circulated to working group on 30 January 2023.

Wilson, D.R., 2000. *Air Photo Interpretation for Archaeologists*. Stroud: Tempus.

Рог Палмер[1], Мартін Фоулер[2], Олександр В. Каряка[3], Валері Вард[4]

[1]*Науковий співробітник, Група аероархеологічних досліджень, ORCID: 0000-0003-0546-9273, rog.palmer@ntlworld.com*

[2]*PhD, науковий співробітник, Група аероархеологічних досліджень, ORCID: 0000-0003-4211-3671, danebury216@hotmail.co.uk*

[3]*Кандидат історичних наук, науковий співробітник, Інститут археології НАН України, відділ Польовий комітет, ORCID: 0000-0003-3066-3641, akarjaka@ukr.net*

[4]*Науковий співробітник, Група аероархеологічних досліджень, ORCID: 0000-0002-4936-3932, Valerie.C.Ward@hotmail.com*

АРХЕОЛОГІЧНА ЛАНДШАФТНА РОЗВІДКА НА 6600 КМ^2 У ЧЕРКАСЬКІЙ ОБЛ. УКРАЇНИ, З ВИКОРИСТАННЯМ СУПУТНИКОВИХ ЗНІМКІВ ВІДКРИТИХ ДЖЕРЕЛ: ПЕРШИЙ ЗВІТ

Проект був розроблений для проведення археологічного ландшафтного дослідження в Україні з використанням зображень з відкритих джерел. Досліджувана територія значної частини Черкаської обл. має різноманітні ґрунти, які можуть виявити зв'язок із заселенням і землекористуванням. Використані джерела зображень — Гексагон (травень 1982 р.) та нерівномірно розподілені знімки Google Earth (2007—2021 р.). Деякі демонстрували чіткі археологічні докази, інші — ні. Загальна площа обстеження становила 6600 км^2, серед яких досліджувались окремі квадрати 10х10 км. Протягом року вдалось обстежити приблизно половину загальної площі та виявити особливості в посівах і голому ґрунті.

Відзначено кілька типів об'єктів, з яких найбільш плідними є кургани, які можуть розташовуватись поодиноко та іноді рядами, що слідують за підвищенням місцевості. Існують також повторювані моделі того, що ми називаємо сателітними курганами, в яких один більший курган має від одного до п'яти менших насипів, що оточують його. Деякі з них можуть бути зруйнованими добувачами селітри. Проект визначає місця проживання як такі, що складаються зі скупчень невеликих насипів, які часто виникають у місці злиття двох річок. Деякі скупчення утворені великими окремими курганами, а деякі розташовані на одному кінці ряду курганів, що залежить від хронології.

Наш проект також об'єднав різні переліки мегасайтів і розмістив якомога більше в нашій базі даних. Територія обстеження охоплює кілька городищ, відомих до цього часу, і невелику кількість огороджених споруд, які могли бути необоронними. Виявлені об'єкти також включають ті, які зараз залишилися з радянської епохи, такі як колгоспи, промислові та військові об'єкти, призначення яких можна визначити в розсекречених звітах розвідки США. Місцями простежено серйозні зміни в структурі села, що призвело до виникнення закинутих територій. Це також було зафіксовано як частину зміни ландшафту України.

Ключові слова: Черкаська обл., доісторична доба, Дослідницька група повітряної археології, ландшафтна розвідка, HEXAGON, Google Earth, кургани, поселення, городища.

References

Boltryk, Yu. V. 2023. *Arkheolohichni doslidzhennia v Ukraini* [online]. Available at: http://vgosau.kiev.ua/biblioteka/avu-adu

Bilynskyi, O. O. 2018. Scythian Time Hillforts in the Dnieper Left-Bank Forest-Steppe: General Characterization, Catalogue, Typology. *Archaeology and Early History of Ukraine*, 1(26), p. 213-234.

Boltryk, Yu. V., Kariaka, O. V. 2021. Traces of the ancient paths in the Steppe Tavria. *Archaeology and Early History of Ukraine*, 3(40), p. 199-214. https://doi.org/10.37445/adiu.2021.03.13

Borysov, A. V. 2020. Vykorystannia danykh aero ta kosmichnoi ziomky u arkheolohii Serednoi Naddniprianshchyny. In: Malolitneva, V. K. et al. (eds.). *Arkheolohichna spadshchyna — pohliad zghory: pravovi ta orhanizatsiini zasady vykorystannia danykh aerokosmichnoi ziomky dlia okhorony ta doslidzhennia arkheolohichnoi spadshchyny.* Materialy naukovo-praktychnoi konferentsii (Kyiv, 6 lystopada 2020 r.). K. DU "Instytut ekonomiko-pravovykh doslidzhen imeni V.K.Mamutova NAN Ukrainy", p. 138-145.

Borysov, A. V., Hnera, V. A., Mysak, V. M., Marchenko, O. V. 2022. Sites of Horodyshcha on the Vilshanka river (materials for the archaeological map). *Archaeology and Early History of Ukraine,* 3 (44), p. 252-262. DOI: 10.37445/adiu.2022.03.15

Hnera, V. A. 2014. Analiz vykorystannia dystantsiino pilotovanykh litaiuchykh aparativ u arkheolohichnykh doslidzhenniakh. *Pratsi Tsentru pamiatkoznavstva*. In: Tytova, O. M. et al. (eds.). Tsentr pamiatkoznavstva NAN Ukrainy i UTOPIK, 26, p. 16-25.

Hnera, V. A. 2014. Dosvid vykorystannia materialiv aero- ta kosmichnoi ziomky v istoryko-memorialnii roboti. *Nizhynska starovyna: zbirnyk rehionalnoi istorii ta pamiatkoznavstva.* In: Kovalenko, O. B. et al. (eds.). Tsentr pamiatkoznavstva NAN Ukrainy i UTOPIK, 18(21), p. 10-21.

Kariaka, O. V. 2021. Ancient roads near Davydiv Brid at Ingulets river. *Archaeology and Early History of Ukraine,* 3(40), p. 169-174. https://doi.org/10.37445/adiu.2021.03.10

Malolitneva, V. K., Borysov, A. V., Hurova, A. M., Malyshev, O. O. 2021. Osnovni rezultaty naukovoho proiektu "Pravovi ta orhanizatsiini aspekty vykorystannia aerokosmichnoi ziomky dlia doslidzhennia y 2021 okhorony arkheolohichnoi spadshchyny Ukrainy." *Naukovyi visnyk Uzhhorodskoho Natsionalnoho Universytetu. Seriia Pravo,* 68, p. 174-179. DOI https://doi.org/10.24144/2307-3322.2021.68.29

Priadko, O. O. 2020. "Busurmenske" hill-fort on the Ikva river. *Archaeology and Early History of Ukraine,* 2(35), p. 137-141.

Shyshkin, K. V. 1964. Pro vykorystannia aerofotoziomky v arkheolohii. *Arheologia*, 17, p. 199-204.

Shyshkin, K. V. 1973. Z praktyky deshyfruvannia aerofotoznimkiv u arkheolohichnykh tsiliakh. *Arheologia*, 10, p. 32-41.

Shyshkin, K. V. 1985. Planuvannia trypilskykh poselen za danymy aerofotoziomky. *Arheologia,* 52, p. 72-77.

AARG, 2023. AARG Ukraine WG web app [online]. Available at: https://satarchuk.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=e6d6ccf301e7492d8f7cd113c777c264

Ašandulesei, A., 2017. Inside a Cucuteni Settlement: Remote Sensing Techniques for Documenting an Unexplored Eneolithic Site from Northeastern Romania. *Remote Sens,* 9, 41. https://doi.org/10.3390/rs9010041

Broch, M. C., 2021. Working with Normalised Difference Vegetation and Moisture Indexes in AARG's Sentinel 2 Working Group — the Idea, the Method and the Next Step. *AARGnews,* 63, p. 9-11.

Chapman, J., Gaydarska, B., Nebbia, M., 2019. The Origins of Trypillia Megasites Project: Early Urbanism in Prehistoric Europe?: the Case of the Trypillia Mega-sites. *Frontiers in Digital Humanities*, 6, https://doi.org/10.3389/fdigh.2019.00010

CIA, 2023. *Freedom of Information Act Electronic Reading Room* [online]. Available at: https://www.cia.gov/readingroom/

ESDAC 2023. Soil Map of Ukraine (1977) [online]. Available at: https://esdac.jrc.ec.europa.eu/content/title-russia-soil-map-ukraine

Gaydarska, B., Chapman, J., 2020. *Ancient Ukrainian "Megasites" Might Have Been the World's First Cities* [online]. Available at: https://blog.degruyter.com/ancient-ukrainian-megasites-might-have-been-the-worlds-first-cities/

Fowler, M. J. F., 2022a. The Archaeological Potential of KH-9 HEXAGON Satellite Photographs: the Roman Temporary Camps and Siege Works at Machaerus and Masada. *AARGnews*, 64, p. 37-53.

Fowler, M. J. F., 2022b. Through the Keyhole: Exploiting HEXAGON Spy Satellite Photographs in AARG's Ukraine Project. *AARGnews*, 65, p. 36-45.

Fowler, M. J. F., 2022c. Taming the Unknown: Combining Different Data Sources in AARG's Ukraine Project. *AARGnews*, 65, p. 29-35.

Hall, D. N., Palmer, R. 1996. *Cambridgeshire Fenland Survey: the Silt Fens.* In: Hall, D. N. (ed.) Fenland Landscapes, Cambridgeshire, Volume 3. East Anglian Archaeology, 79. Norwich: Centre for East Anglian Studies.

Hammer, E., FitzPatrick, M., Ur, J., 2022. Succeeding CORONA: Declassified HEXAGON. *Intelligence Imagery for Archaeological and Historical Research. Antiquity*, 96 (397), pp. 679-695. https://doi.org/10.15184/aqy.2022.22

Historic England 2023. Aerial Archaeology Mapping Explorer [online]. Available at: https://historicengland.maps.arcgis.com/apps/webappviewer/index.html

Karavaiko, D. V., 2023. Hillforts of the Scythian Period in the Middle Course of the Seim River. *Arheologia,* 1, p. 20-39.

Kariaka, A. V., 2008. The Demarcation System of the Agricultural Environment of Olbia Pontike. In: Guldager Bilde P., Petersen J. H. (eds.), *Meeting of Cultures in the Black Sea Region between Conflict and Coexistence.* Aarhus: Aarhus Universitetsforlag, p. 181-192.

Kariaka, O. 2023. Kostiantyn Shyshkin in Soviet Archaeology, *AARGnews,* 66, p. 10-18.

Mapire 2023. Historical Map Portal [online]. Available at: https://maps.arcanum.com/en/

Nebbia, M., Roe, J., 2020. *Chapter 3: Landscape Studies.* In: Gaydarska, B. (ed.). Early Urbanism in Europe, The Trypillia Megasites of the Ukrainian Forest-Steppe. Warsaw; Berlin: De Gruyter, p. 60-110. https://www.degruyter.com/document/doi/10.1515/9783110664959/pdf

Ohlrau, R., 2020. *Maidanetske: Development and Decline of a Trypillia Mega-site in Central Ukraine.* Leiden: Sidestone.

Palmer, R., 1984. Danebury: an Aerial Photographic Interpretation of Its Environs. *RCHM Supplementary Series*, 6.

Palmer, R., 2021. AARG's Sentinel 2 Working Group — Background and First Report. *AARGnews*, 62, p. 9-10.

Riley, D. N., 1980. *Early Landscape from the Air.* Sheffield: Collis.

Rud, V., Ohlrau, R., Fedorov, S., 2016. Satellite Images and Geomagnetic Plans of Several Cucuteni-Trypillia Sites of the Right Bank of Southern Bug River. In: Mischka, D., et al. (eds.). *Beyond Excavation: Geophysics, Aerial Photography and the Use of Drones in Eastern and South-East European Archaeology: International Colloquium: Programme and Abstracts.* Romania: Piatra-Neamţ, p. 51-54.

Smithsonian Global 2003. *Remotely Monitoring Ukraine's Cultural Heritage with the Conflict Observatory* [online]. Available at: https://global.si.edu/projects/remotely-monitoring-ukraine's-cultural-heritage-conflict-observatory

Stoertz, C., 1997. *Ancient Landscapes of the Yorkshire Wolds.* Swindon: RCHME.

Unesco 2023. *Damaged Cultural Sites in Ukraine Verified by UNESCO* [online]. Available at: https://www.unesco.org/en/articles/damaged-cultural-sites-ukraine-verified-unesco

USGS, 2023. Earth Explorer [online]. Available at: https://earthexplorer.usgs.gov/

Ward, V., 2023a. Trypillia Sites: a Comparison of Google Earth Satellite Images to Aerial Photograph Analysis by K. V. Shyshkin. *AARGnews,* 66, p. 19-26.

Ward, V., 2023b. *Trypillia Database for AARG GE Project.* Document circulated to working group on 30 January 2023.

Wilson, D.R., 2000. *Air Photo Interpretation for Archaeologists.* Stroud: Tempus.