An integrated approach to surveying the archaeological landscapes of Yemen

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SUMMARY

This paper presents recent research by the Endangered Archaeology in the Middle East and North Africa (EAMENA) project at the Universities of Oxford and Leicester, and Jérémie Schiettecatte at Centre National de la Recherche Scientifique (CNRS) in Paris. It critically investigates the contribution of documenting sites through recent remote surveys using freely available satellite imagery to improve our understanding of ancient landscapes in Yemen, and the role of field surveys and excavations in this process. The documentation and recording includes an assessment of the threat to sites with a view to improving their protection in the future.

Keywords: Yemen, satellite imagery, remote sensing, fieldwork, landscape

Introduction

This paper explores the potential and limitations of freely available satellite imagery and its use in archaeological research when combined with data gathered during fieldwork in Yemen. The significance of the research is heightened because of the current inaccessibility of Yemen for archaeological fieldwork. While there are limitations in utilizing archaeological data derived solely from satellite imagery, this approach can make a significant contribution to archaeological research in the whole region and specifically Yemen, not least in monitoring land-use change and the impact of these changes on cultural heritage. The research presented in this article shows that both imagery and field-based surveys stand to gain from this comparative approach; while imagery interpretation can be considerably refined and enhanced by reference to field data, the latter may be greatly expanded, particularly in the breadth of its coverage.

Background

The EAMENA project was initiated in January 2015 with the aim of documenting archaeological sites across the Middle East and North Africa, assessing the threats to them so that the state of preservation can be monitored (Bewley et al 2015). The project, which is funded by the Arcadia Fund, uses satellite imagery and aerial photography as its main source of evidence to record archaeological sites and landscapes across more than 20 countries, from Mauritania to Iran and from Syria to Yemen. Information about each site is recorded onto a heritage management platform, which the team has developed by adapting the open-source Arches package.[1]

From mid-March 2015, Yemen has been caught up in a complex civil war, principally between supporters of the current president Abd Rabbuh Mansur Hadi and Houthi groups in an alliance with the former president Ali Abdullah Saleh, although this simplifies a far more

[1] www.archesproject.org (accessed 14 Oct 2016).

[2] The resolution of the inspected imagery ranged between 2.5 m and 0.4 m. However, the image processing workflow used by both Google Earth and Bing Maps has not been released to the public and the exact imagery resolution as well as other metadata remain difficult to specify. For problems related to loss of spatial and

complicated geopolitical situation (Salisbury 2016). Since the beginning of the conflict, the former has been supported by the Saudi Arabian-led coalition, which has targeted Houthi positions with air strikes and ground operations. The threats that this conflict posed to the incredibly rich and largely under-investigated archaeology of Yemen (Antonini de Maigret & Gerlach 2015; Khalidi 2015; Simpson 2016), has led the EAMENA team to focus a significant part of its work programme on this country, not least because the country has been barely accessible to archaeologists since 2011.

Collating archaeological data for the entire country is problematic as published archaeological surveys that contain gazetteers of sites for Yemen are rare. Archaeological fieldwork has been heavily concentrated on major wādī beds (e.g. Bowen & Albright 1958; Breton et al. 1980; Brunner 1983; Toplyn 1984; Brunner 1997; Breton et al. 1998; Breton 2000; De Maigret 2004). More recently there has been research in the highlands (de Maigret 1990; Wilkinson et al. 1997; Barceló et al. 2000; Hitgen 2003; Lewis & Khalidi 2008; Yule 2013) and in the coastal plains (e.g. Keall 1998; Rougeulle 1999; Khalidi 2005). Before the 1990s, the highlands, which make up about one third of the country, had been the subject of epigraphic surveys rather than broader archaeological field studies (Robin 1979, 1982; Grjaznevic 1994, Arbach & Schiettecatte 2012; Prioletta 2013; Rijziger 2016). Survey or excavation in the face of development i.e. the Yemen Liquid and Natural Gas pipeline (YLNG) survey, have produced data limited to narrow linear transects and around areas of modern development. Rescue archaeology, all too rarely carried out in Yemen, is limited by the constraints of the project extent, budgets and timescales (Arbach et al. 2006), a familiar story elsewhere in the world. As a result, the existing published literature does not yet provide a holistic view of Yemen's diverse archaeological landscapes.

Methodology

This paper presents the results of recent surveys conducted with the aid of satellite imagery and combined with the results of recent, and mostly unpublished, fieldwork in Yemen. The imagery used was freely available high-definition colour virtual globe imagery accessed via the Google Earth Pro platform and the Bing Maps website, and systematically assessed visually.[2] This freely available source material has successfully been used for multiple archaeological surveys (such as Kennedy & Bishop 2011; Thomas et al. 2008; cf. Myers 2010).

Previous studies have utilised more complex methods for assessing archaeological sites in the Middle East utilising satellite imagery. For instance, locating tell sites using historical satellite imagery (Beck et al. 2007: 169-171; Casana 2014: 228-230), and visible spectral signatures in false colour images has an established history (see Kennedy 2002), and yielded positive results for tell landscapes in Mesopotamia (Menze & Ur 2012) and Egypt (Parcak 2007). In Yemen, digital elevation models can be particularly effective for identifying areas most likely to be utilised for hydrological purposes (Harrower 2010). Historical aerial photography has also been utilised in previous studies (Brunner 2001). Although RAF-collected aerial imagery dated to the late-1950s and 1960s was available for one of our study areas (al-Bayḍāʾ), its resolution was found to be too low to aid in the archaeological

[2] The resolution of the inspected imagery ranged between 2.5 m and 0.4 m. However, the image processing workflow used by both Google Earth and Bing Maps has not been released to the public and the exact imagery resolution as well as other metadata remain difficult to specify. For problems related to loss of spatial and spectral definition using virtual globe platforms see Beck 2006.

interpretation. Other, higher-quality photography (such as the GE Infra imagery collected in the 1970s, see Charbonnier 2012) was unavailable for our case studies.

This paper tests the application of satellite imagery assessment to the mapping of sites of cultural heritage significance in Yemen. For this article, imagery used consisted exclusively of high-definition virtual globe imagery. Although remote sensing provides a relatively quick tool to map heritage on a large scale, a number of caveats should be borne in mind. In particular, it only rarely allows for fine-grained site categorisation, whether typological or chronological. Moreover, the risk of identifying a large number of 'false positives' (principally geological features, or modern structures which bear resemblance to cultural sites) is significant. Another danger is that of representing a skewed cultural landscape, where certain categories of sites, such as fortified hilltop settlements, end up being overrepresented because of their generally better visibility on satellite imagery.

The remote-sensing survey as conducted by EAMENA investigated four continuous grid squares of 0°15' in length (*c*. 25 km^2 at this latitude). This approach of systematic visual assessment of satellite imagery provides a cost-effective and rapid methodology to interpret and document archaeological sites on a large scale. However it is not a panacea and there are a number of limitations, such as the visibility of certain types of sites (cave tombs, smaller features and buried structures). As is well known in aerial archaeology the time of day and year of the imagery has a crucial influence on what is visible; most satellite imagery is captured in the middle of the day, a time when shadows (which can reveal archaeological sites) are at their minimum, so the worst time of day for archaeologists. Larger, more prominent sites, such as fortified hilltop settlements will be more likely to be seen and recorded and thus introduce a bias into the record. Despite these constraints the approach has proved successful for Yemen and the wider region, allowing for the identification of thousands of potential cultural heritage sites.

To improve site interpretation and develop a more balanced understanding of the cultural landscapes in Yemen, using more than one source of evidence is not only best practice, but has also produced important results for the three case study areas discussed below that have previously been subject to significant ground research. These are: al-Bayḍāʾ (BYD), the eastern Ḥaḍramawt (HDOR) and the route of the Yemen Liquid Natural Gas (YLNG) pipeline (Fig. 1).

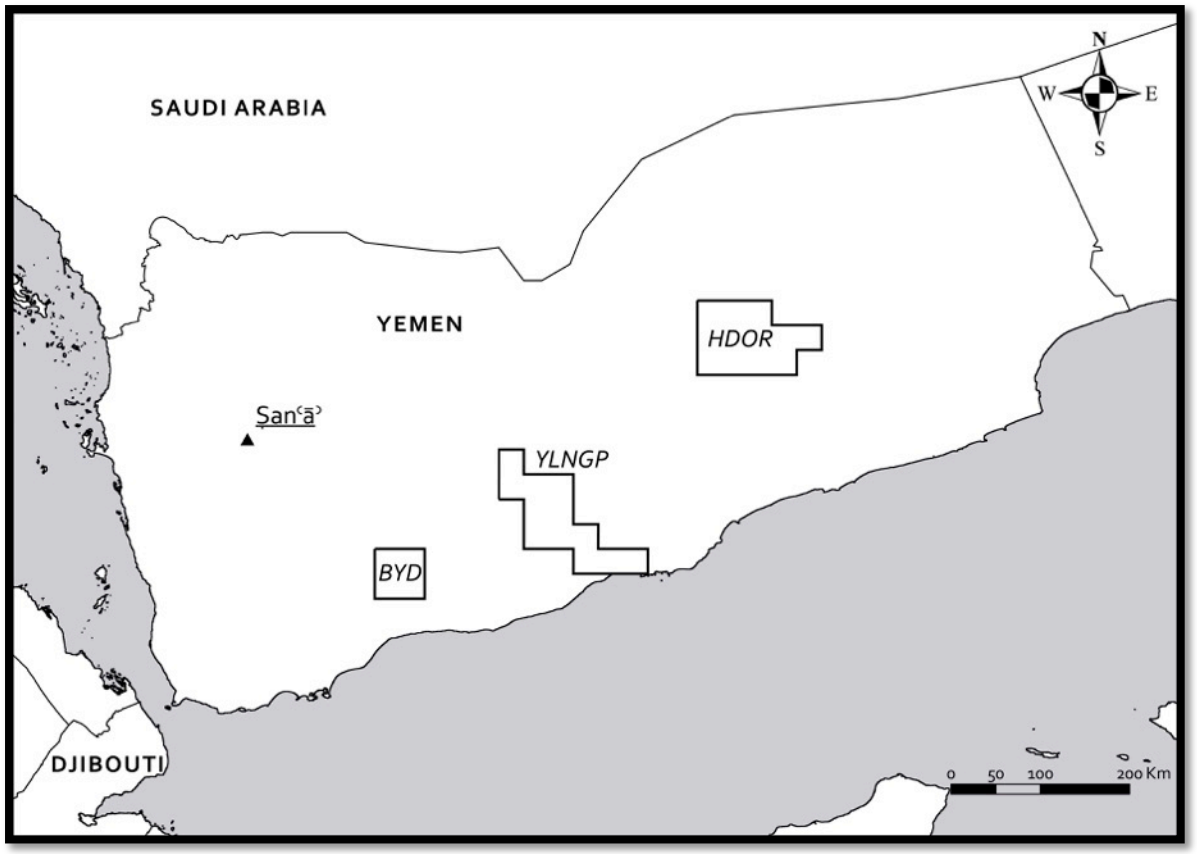

Figure 1. Location of the three case studies. BYD: al-Bayḍāʾ; YLNGP: Yemen Liquid Natural Gas pipeline; HDOR: Eastern Ḥaḍramawt.

The al-Bayḍāʾ results

The al-Bayḍāʾ (BYD) region is located in south-western Yemen, and the case study area is located *c*.175 km south-east of the national capital of Sana'a. The EAMENA survey area investigated was ca. 3,000 sq. kms covering highland plateaux to the north of the Lawdar ridge and lowlands in the neighbouring Abyan region to the south-east of the Lawdar ridge. The EAMENA dataset of over 1,800 sites was created with reference to material collected by the epigraphic and archaeological field surveys carried out by the Mission Qatabān and the French Mission in the Wādī Yafiʿ. The purpose of the surveys was to understand the archaeology and history of the pre-Islamic kingdom of Qatabān through epigraphic studies and the excavation of a prominent site, Ḥaṣī (Charloux et al. 2009; Dridi et al. 2006; Gajda 2016; Schiettecatte 2016). The analysis and interpretation of satellite imagery has increased the geographical area studied as well as the chronological range of occupation of the region, by recording several previously unknown sites that may possibly belong to the Bronze Age.

The field survey in Qatabān concentrated on the hinterland of Qatabān's capital Ḥaṣī and focussed on collecting epigraphic data, so the numbers of sites recorded for this area increased dramatically with the use of satellite imagery (see Fig. 2). The highlands are characterised by a moist and temperate climate and relatively abundant rains during the monsoon season (March to May and July to September), the Abyan lowlands by hotter and drier conditions and flash flooding. The northern uplands feature intensively terraced landscapes and water management infrastructure aimed at collecting rainwater to support agriculture, in the lowlands the fields rely on an irrigation system.

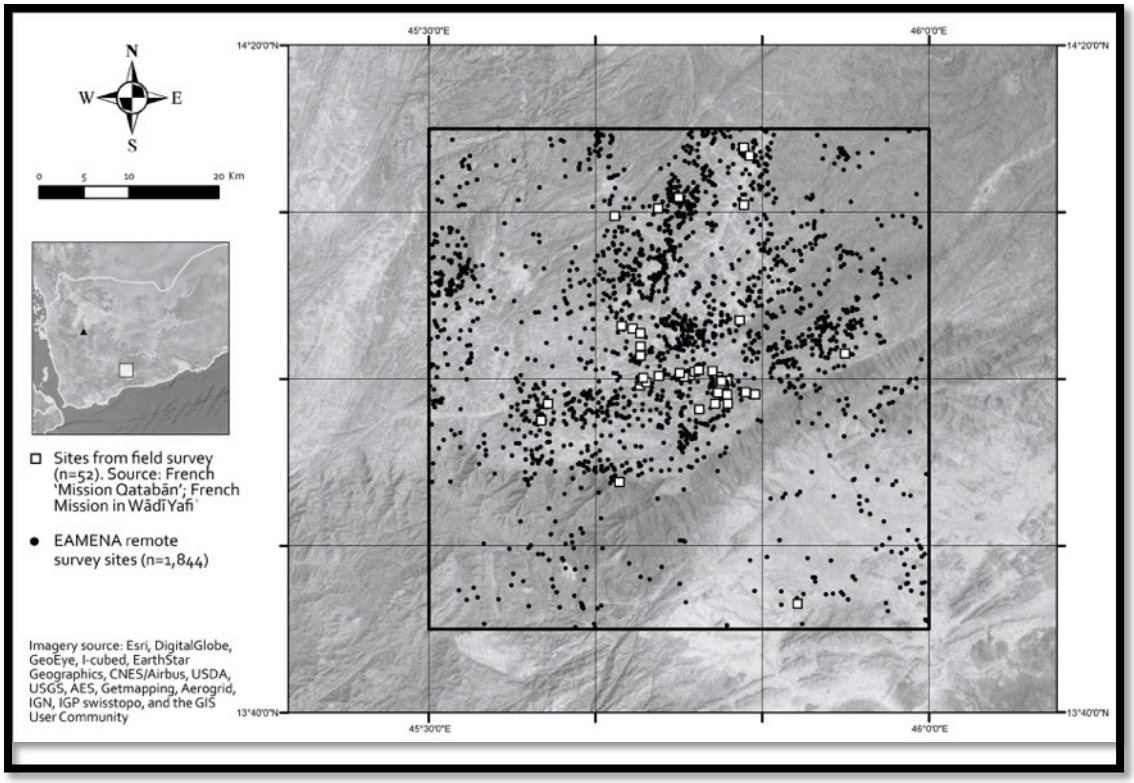

Figure 2. Distribution of field- and EAMENA-recorded sites in the al-Bayḍāʾ survey area.

These two different ecosystems influenced past human settlement patterns. Potential Bronze Age settlements discovered by the EAMENA survey project are concentrated in the uplands (see Fig. 3), consisting of over 100 sites with a striking morphological uniformity. They are characterized by clusters of closely packed circular and subcircular dwellings and enclosures, sometimes surrounded by a boundary wall. The size of these sites varies widely, with the smallest only ca. 210 sq.m and the largest ca. 68,000 sq. m (the mean area is ca. 7,100 sq. m). In the highlands, the highest concentration of settlements of likely Bronze Age date is to be found in an area of barely 30 sq. km (see inset in Fig 3) located ca. 2 km south of the town of al-Faraʿah along the main road connecting the towns of al-Bayḍāʾ and al-Ṣawmaʿah. Based on their morphological similarity, these have been tentatively interpreted as Bronze Age sites through comparison with evidence from excavated sites in other parts of Yemen: the late third millennium site of Wādī Yanaʿīm (de Maigret 1990), particularly in the Khawlān region (see Fig. 4). Further evidence of a likely Bronze Age date for these settlements is provided by a number of burial cairns (seventy-six to date), in the same landscape areas.

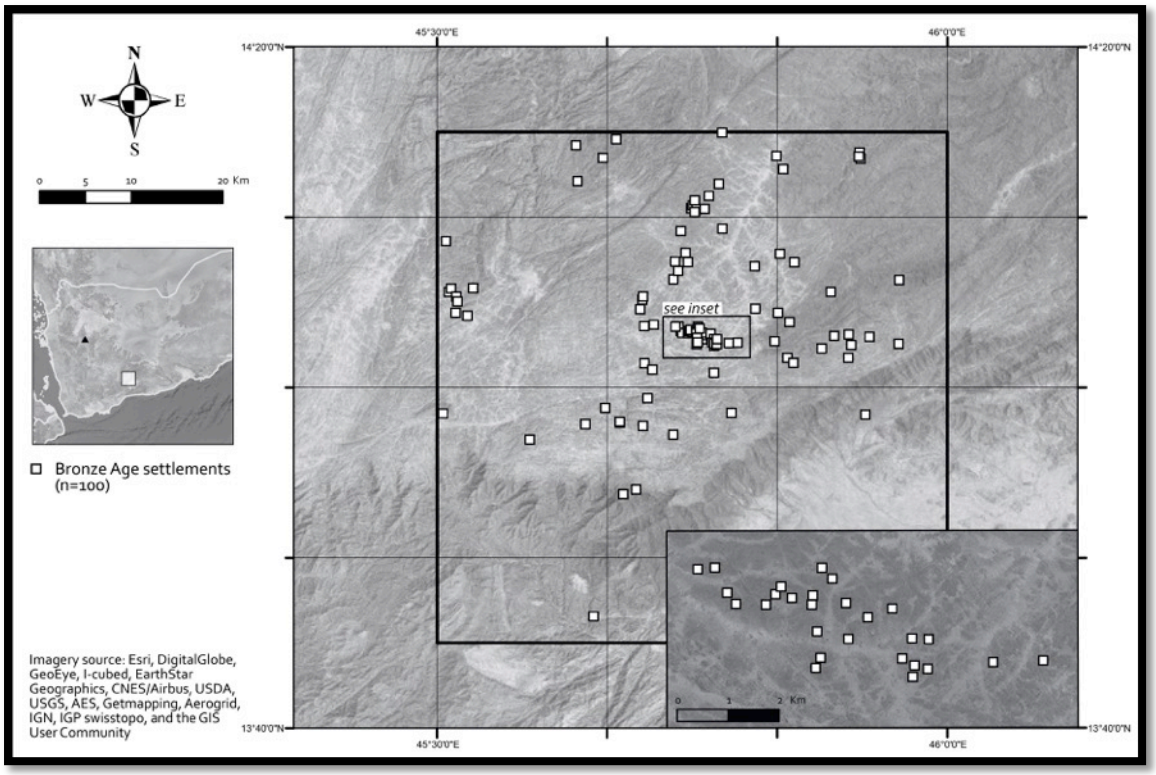

Figure 3. Distribution of 'Bronze Age' sites in the al-Bayḍāʾ survey area.

By contrast, and except for a small cairn field, these categories of settlements and burials are absent from the Abyan lowland. Although the deposition of silt and sand make it harder to identify sites in the Abyan, there is little evidence for any settlement until the pre-Islamic period (early 1st millennium BC onwards). It may be tentatively suggested that this specific pattern be linked to the fact that irrigation – and therefore more complex social structures sponsoring large-scale investment plans – were necessary to support settlement in this region, while dry agriculture is possible in the highlands owing to the more abundant rains.

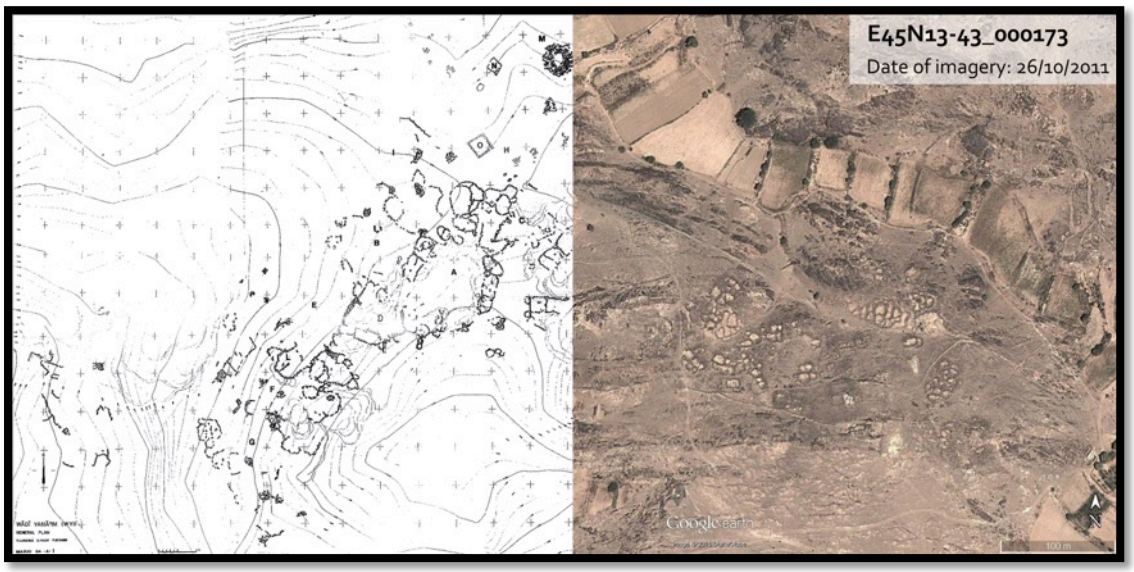

Figure 4. Morphological similarities between an EAMENA-recorded site in al-Bayḍāʾ and the 3rd-millennium site of Wādī Yanaʿīm.

Connected to this type of settlement, the EAMENA survey identified sites described as ‘long walls’: these are winding walls that either flank or, in some cases, overlay clusters of subcircular (Bronze Age) structures. The function of these walls is unknown and will require field investigation to ascertain their origin (and even if they are as a result of human action). There is a possibility they may be retaining walls for ancient roads and tracks, such as in the case of the partially-paved al-Kāfirī road identified during field survey by the French mission in Qatabān (Rigot 2006) (Fig 5).

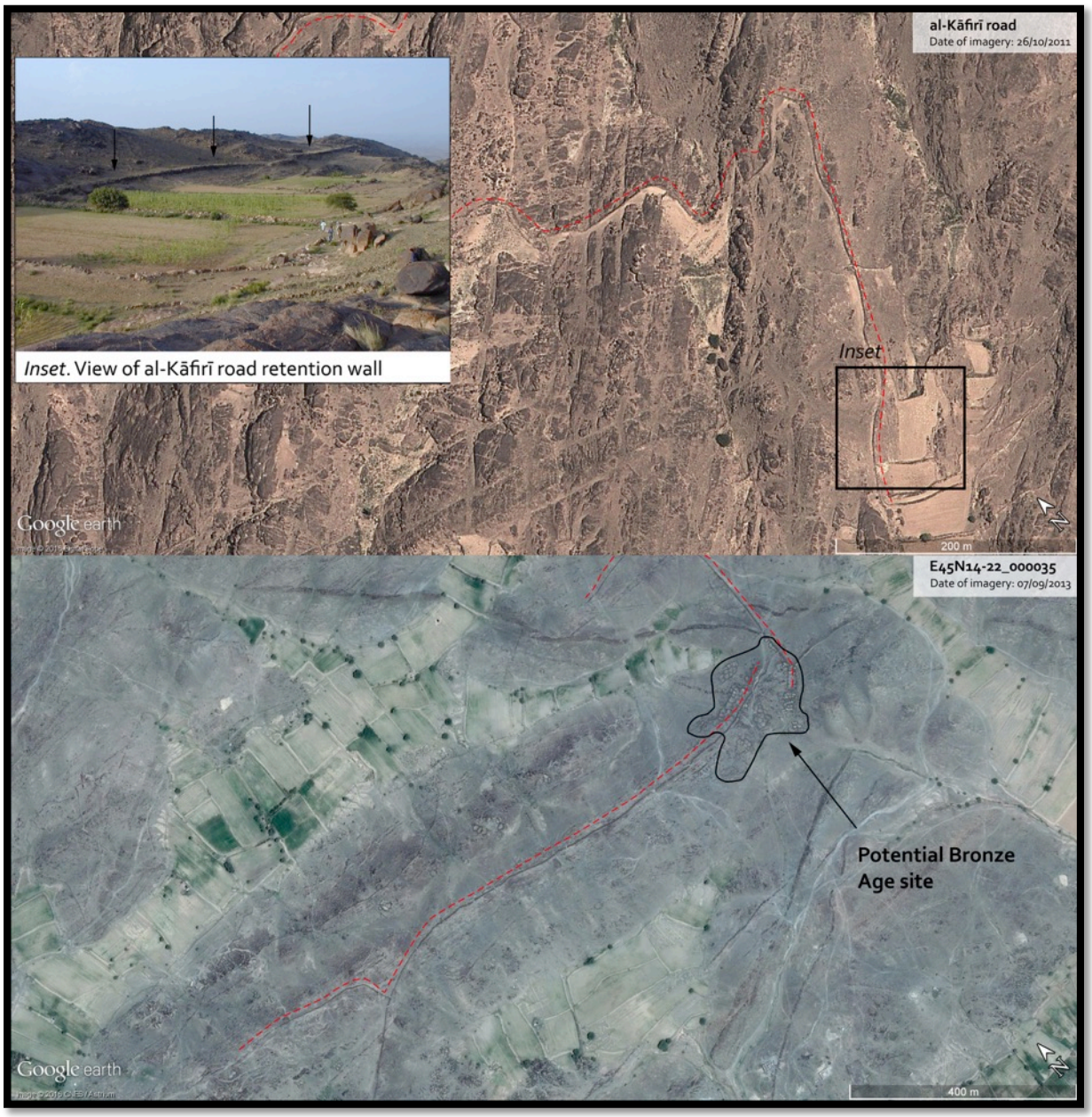

Figure 5. A comparison between the appearance of the al-Kāfirī road (top and top left) and a ‘long wall’ crossing a ‘Bronze Age’ site in the central al-Bayḍāʾ region (bottom).

While the remote survey helped identify sites that are likely to be representative of an important Bronze Age settlement phase in al-Bayḍāʾ, other features and even the large settlements of the pre-Islamic period have in some cases eluded our efforts for identification.

For example, the site of Ḥaṣī, likely the main seat of the *qayls* (prince) of the Maḍḥā tribe and a large urban centre at least from the 2nd cent. BC to the 6th cent. AD (Charloux et al. 2009; Schiettecatte 2016) was only detected on the satellite imagery at our disposal thanks to a large excavation trench (Ḥaṣī's sector C) that had not been backfilled.

The bulk of the sites discovered by the French mission (22 sites out of a total of 52) were related to water management infrastructure (dams, wādī, barrages, wells and cisterns). Dams in the al-Bayḍāʾ region belong to the wider category of Himyarite dams (Wilkinson 2003: 192; Charbonnier 2011), built primarily between the 1st century BC and the 4th century AD. The field survey identified both storage dams, which were built to create upstream basins, and diversion dams (to manage flood water). Both may be considered as fitting with the description of Type 3 dams in the typology elaborated by Charbonnier and Schiettecatte (2013: 76 These are built of double-faced squared masonry, with a filling of field stones, with sluices, which fed a network of irrigation channels, and, in most cases, a scouring gallery to clear silt. Downstream, the faced stone wall is stepped, making the base of the dam much wider than the top. The latter was often laid with slabs and fashioned into a walking surface of a width varying between 3.5 and 7.5 m (see Robin & Dridi 2004 for two, particularly well preserved, examples). Of the ten dams identified by fieldwork, six were dated by inscriptions identified in situ, all but one to the late-third century AD. Silting, both upstream and downstream, makes these dams nearly indistinguishable on satellite imagery from terrace walls. However, comparison with ground data has shown remarkable promise in fine-tuning the remote identification of dams (Fig. 6).

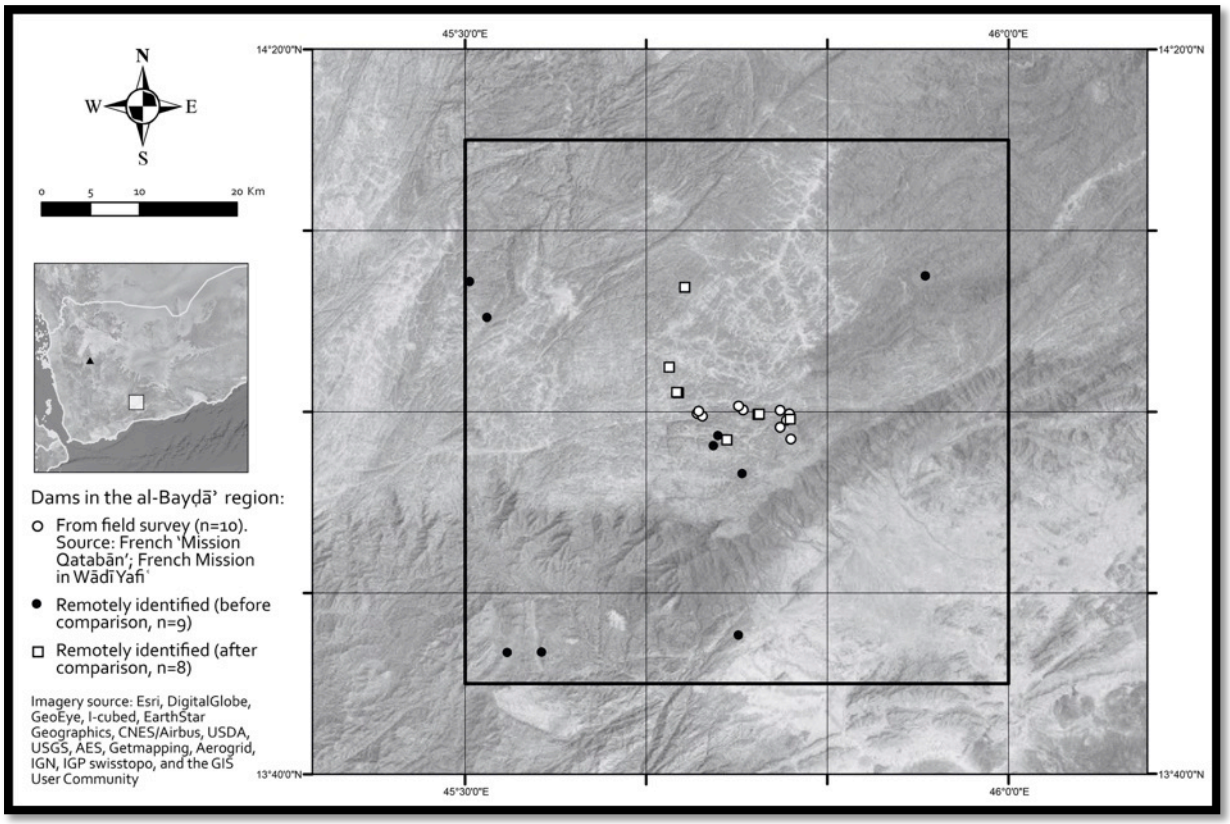

Figure 6. The distribution of dams in al-Bayḍāʾ as recorded via field survey and EAMENA survey (before and after comparison with field data).

In general, dams appear to be consistently wider than terrace walls (the latter vary in width between 1.5 and 3 m). The faced-stone wall and the stepped downstream profile characteristic of Type 3 dams is sometimes discernible on silted up dams viewed on high-resolution satellite imagery. Even more distinctive is the configuration of broken dams (Fig. 7). Flooding and excessive silting may lead to the collapse of the central section of a dam. When this happens, silt banks and the central portion of the dam are quickly washed downstream, but eroded silt banks survive behind the remaining portions of the dam. Comparison between ground photographs of broken dams identified in Qatabān (and, most notably, in the case of the Wādī dhū-ʾl-Qayl 2 dam, see Robin & Dridi 2004: 72-3) and their appearance on satellite imagery made it possible to identify at least one further site of this kind in the survey area. Silted up field walls of with a width of greater than 4 m and having a double facing, have been tentatively identified as dams (eight in total).



Figure 7. Recognising broken dams. A comparison between the ground-checked site of Wādī dhū-ʾl-Qayl 2 (top) and a newly-discovered dam site (bottom right). Ground photos of Wādī dhū-ʾl-Qayl 2 (top left) and Wādī al-Faraʾ 4 (bottom left) show upstream silting.

The Ḥaḍramawt Results

The expansive area of the 'Ḥaḍramawt' (HDOR) study (*c*.8,900 sq. kms) was determined by the extent of the survey conducted by the French Archaeological Mission in the Jawf-Ḥaḍramawt and the extent of the predetermined EAMENA grid squares (twelve full squares were inspected in this remote survey). The southern section of the study area consists of upland plateaux and deep cut wādīs, dominated by the Wādī Masīla, while the northern area is a higher plateau cut by networks of wādī basins. Fieldwork in this region was driven by an

interest to study the evolution of settlement patterns through time, from prehistory to the present day.

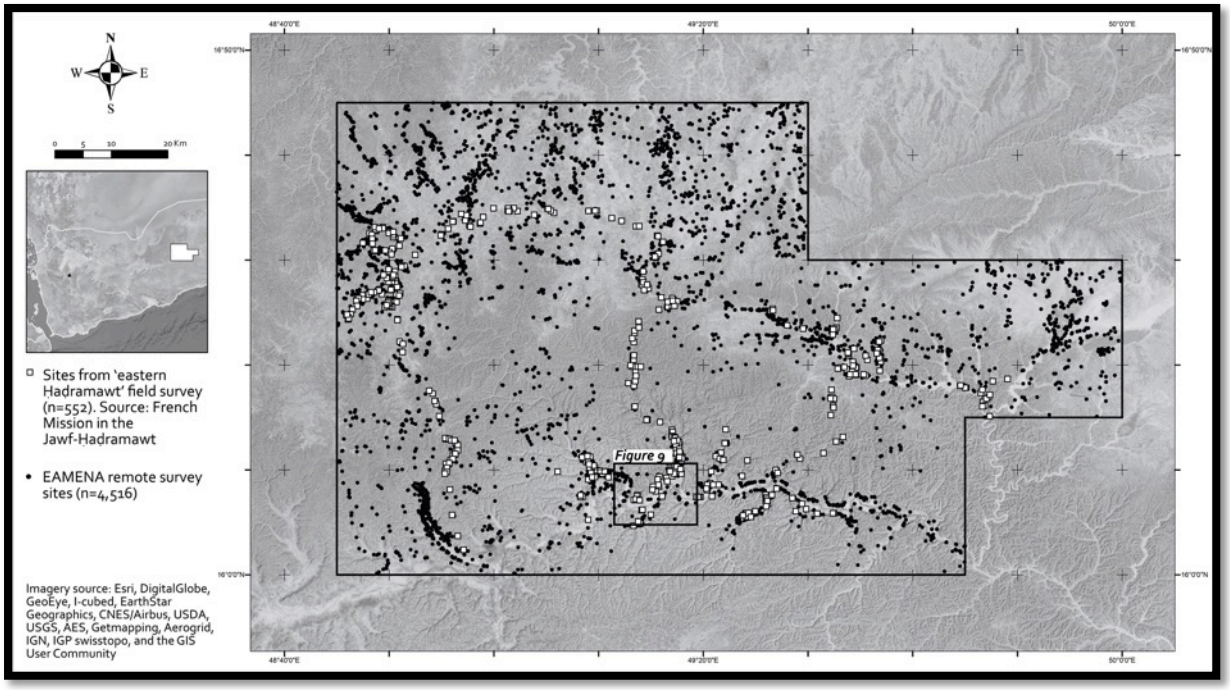

Figure 8. Distribution of field- and EAMENA-recorded sites in the Ḥaḍramawt survey area.

The distribution and the types of sites discovered and recorded were in two broad geographical regions - the plateau in the north and the Wādī Masīla in the south (Figure 8). In the north, structures of irregular cells, trilith arrangements (in wādīs), and cairn and pendants (on ridges) were prolific, concentrated primarily in the major wādī systems, which were the focus of the ground survey efforts. The large concentration of irregular cell structures may represent Bronze Age habitation as indicated by similar sites investigated in field excavation (Steimer-Herbet et al. 2006). In the south, the distribution of sites is entirely concentrated in the deeply incised Wādī Masīla system, either in the wādī bed or lower slopes, with the upper plateau comparatively void. Visible sites were predominantly rectilinear structures and settlements, cairn and pendants (on slopes), and mounds (in wādī beds). Unique to this area, and not represented in known ground surveys, are distinctive long walls running down the rocky scree on both sides of the valley (112 have been recorded), which we have termed 'slope walls'. Five examples of hilltop settlements, not previously known and without known comparanda, were also identified. As Figure 9 shows, the number of known sites (4,516 in total) has increased considerably as a result of the EAMENA survey.

Site Type	Total (n=4,516)	Interpretation (Probable)	Interpretation (Possible)	Eastern Ḥaḍramawt field survey (n=552*)
Cairn/Stone pile (single/multiple)	1,656	994	662	253
Pendant/tailed cairns (single/multiple)	189	153	36	16
Enclosure/s	806	732	74	-
Structure/s (all)	1,261	697	564	43
Structure/s (indeterminate)	776	228	548	-
Structure (Fort)	7	7	-	1
Structure (Mosque)	7	7	-	-
Structure/s (irregular cells)	332	332	-	34
Structure/s (rectangular)	129	125	4	-
Structure (shrine/temple)	10	8	2	8
Hydraulic Structures (incl. Field systems)	80	58	22	58
Cemetery	44	25	19	6
Historical settlement	15	15	-	-
Settlements	67	30	37	102
Temporary Camp	8	7	1	-
Trackway	3	2	1	1
Trilith arrangement/s	111	77	34	27
Wall/s	154	120	34	2
Isolated inscription(s)	-	-	-	5
Rock art site	-	-	-	7
Settlements (cave)	-	-	-	17
Lithic industry	-	-	-	15
Colour/Texture difference (indeterminate)	4	3	1	-
Non-site (Linear arrangements (modern))	11	-	-	-
Non-site (geological)	106	-	-	-
* The number of sites has been re-calculated according to the methodology of the remote survey conducted by EAMENA to provide a more accurate comparison.				

Figure 9. Initial number of probable and possible sites returned from remote survey for the Ḥaḍramawt, with sites re-categorised according to the EAMENA methodology.

Site type	Remote Survey (n=121)	Number also identified by Makaynūn survey	Topography	Probable false positives	Makaynūn area field survey (n=293)
Cairn/Stone Pile	37	-	Plateau (3), Slope (33), Wādī (1)	-	29
Cemetery	2	-	Wādī (2)	-	1
Enclosure/s	5	-	Slope (5)	-	-
Isolated inscriptions	-	-	-	-	2
Structure/s	37	11 (1 Fort, 5 Temples, 3 Hydraulic Structures, 2 Settlement)	Peak (2), Plateau (2), Slope (25), Wādī (8)	9 (geological?)	251 (1 Fort; 9 temples; 212 hydraulic structures; 22 settlements, 6 indeterminate)
Pendant/Tailed Cairn	2	-	Slope	-	6
Colour/Texture Difference	11	-	Plateau (1), Wādī (10)	5 (geological?)	-
Mounds/Tells	2	1 (Settlement)	Wādī (2)	1 (geological?)	1 (Settlement)
Wall/s	23	2 (Hydraulic Structure)	Slope (20), Wādī (3)	-	1
Linear Arrangements	2	-	Plateau (2)	2 (modern disturbance)	3 (trackways)

Figure 10. Initial number of Makaynūn area remote survey recorded sites in the context of their topography and the Makaynūn area field survey.

Within this survey area there was one area, Makaynūn (Fig.10 and 11), which demonstrated the benefit of combining information from both sources, because of the more intensive survey by the French Archaeological Mission in the Jawf-Ḥaḍramawt by M. Mouton and O. Barge (Mouton, Benoist & Schiettecatte 2011). While the field survey identified 293 sites, the EAMENA survey identified 121 in the Mayaynūn survey area, predominantly on the wādī slopes (Fig.11). Only 14 of the EAMENA sites corresponded with those discovered in the ground survey.

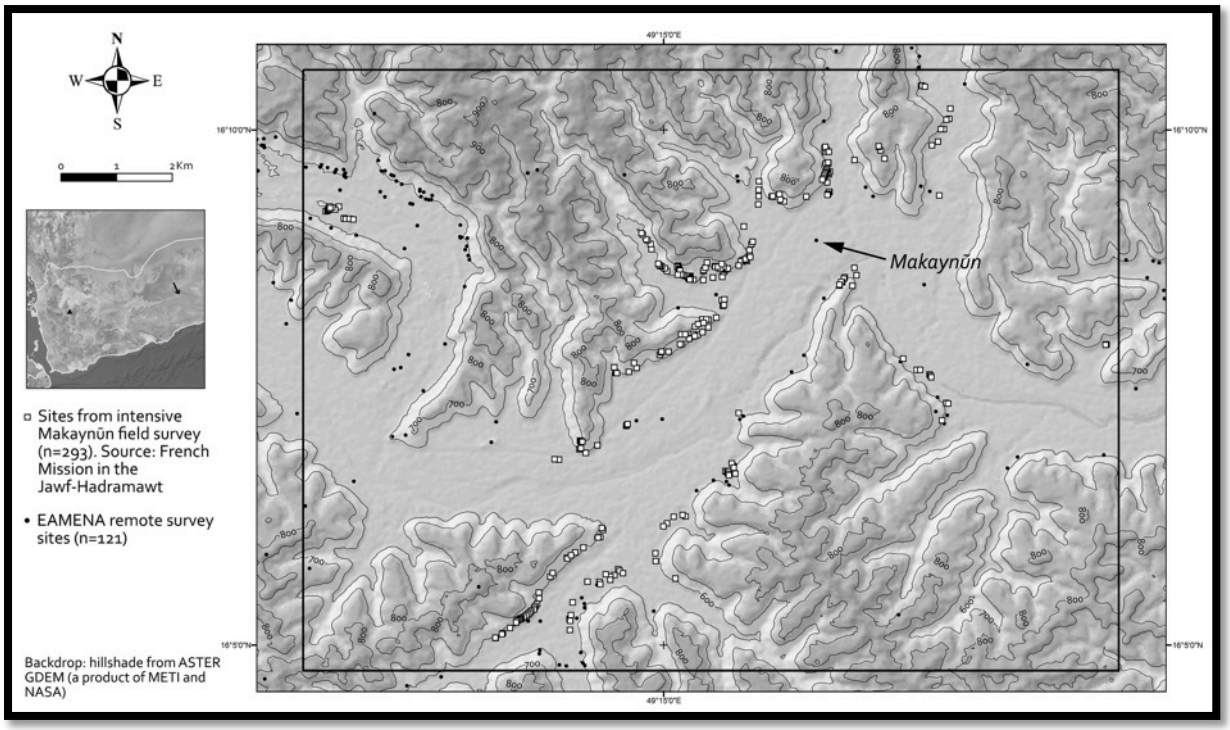

Figure 11. Distribution of field- and EAMENA-recorded sites in the Makaynūn survey area.

While the EAMENA survey was able to locate sites in the majority on the exposed rocky slopes of the wādī systems, the Makaynūn Survey's sites are concentrated in the wādī floor or lower slopes). This includes a number of hydraulic structures (channels, walls etc.) that were not always recognised as archaeological in the EAMENA interpretation of the imagery. The bleached silted wide wādī beds provide limited contrast and shadow of colour in the available satellite imagery, hindering the identification and interpretation of sites. Site identification was also similarly difficult for the broad shifting sand landscapes of desert plain in our YLNG analysis. Moreover, these locations in the Ḥaḍramawt wādī beds have been in continual use for settlement and agriculture making the differentiation of 'ancient', 'historic' and 'modern' hydrological and agricultural systems difficult to discern (note also Brunner 2001: 812). This is not a problem unique to the remote approach however: the continual refurbishment of the irrigation systems prevented the identification of phases by the ground investigation (Mouton et al. 2011: 160).

Without the support of the Makaynūn Survey data to assist with the EAMENA assessment of the satellite imagery, many potential site identifications would have been missed. Reassessment of the entire initial Ḥaḍramawt remote survey data with the benefit of the information from the ground survey will produce a more accurate dataset for the region. This was clearly evident with dam structures in the al-Bayḍāʾ region, whose identification strategy has been discussed above, and for sites apparent as colour/texture difference or mounding in the Ḥaḍramawt.

The Yemen Liquid natural Gas Pipeline (YNLG)

The YLNG pipeline runs across the Maʾrib and Shabwa regions from the oil fields of the former, running south-eastwards to the port of Balḥāf on the coast of the Gulf of Aden (Fig. 1). Running a distance of *c*.300 km the route crosses deserts sands and rocky uplands, with the majority of identifiable archaeological sites restricted to the uplands. Corresponding field

data were collected in a rescue programme funded by the contractor and carried out by a French-German team in 2005-2006 (Crassard & Hitgen 2007; Hitgen et al. 2008a; 2008b; Crassard et al. 2010). The systematic pipeline survey examined a narrow transect (determined by the pipeline) whereas the remote sensing approach was able to cover a wider region of ca. 8,900 sq km In total the two surveys recorded over 2,200 sites ranging from Bronze Age and later funerary monumentsthrough to standing settlements of probable medieval date that are still inhabited today. Importantly, the EAMENA survey did not identify all the built structures that had been recorded by the YLNG fieldwork, even in areas where satellite imagery was available that pre-dated the pipeline construction. This in part was due to the desert sand terrain that obscured sites in the remote imagery. The EAMENA analysis did enable an analysis of the impact of subsequent infrastructure construction along the pipeline route that was not preceded by rescue fieldwork, and in some instances had a negative impact on archaeological features. On a research level, it also allowed a rapid contextualisation of the YLNG survey results within the site distributions across the wider landscape.

Conclusions

Using more than one source of evidence to improve the quality of archaeological interpretations, and a better understanding of past human activity, is recognised as best practice in archaeological survey. In the sections above, we have shown how the analysis of satellite imagery and the comparison of such analyses with field data may be used to shed light on new and hitherto unidentified archaeological landscapes in the three case studies under investigation. The extent of Bronze Age settlement in the al-Bayḍāʾ region that we have suggested in this paper had never been previously recognised in the field. Equally, the data gathered by the French mission in Qataban allowed for the identification of a larger number of dams in that region, some of which located further away from the centre of power of the *qayls* of the Maḍḥā tribe. In the Hadramawt, we were able to highlight the density of occupation of the northern plateaux, and to identify new site types, including the 'slope walls' and hillock settlements.

The EAMENA methodology, when compounded with the analysis of field survey data, has proved to be a highly successful technique for the rapid identification of archaeological sites and in creating a consistent archaeological record: the surveys have not only increased the number of documented sites (*c*.8500 in all) but also increased the confidence in the data produced. This paper presented some of the preliminary results of a collaborative approach which, even with its limitations, should be seen as a valid foundation for future archaeological research and cultural heritage protection in a country where war has made the former all but impossible, and the latter a particularly urgent task.

Acknowledgements

Archaeological researches in the al-Bayḍā and Yafiʿ regions (French Mission in Qatabān, dir. Ch. Robin; French Mission in the Wādī Yafiʿ, dir. I. Gajda) and in the Eastern Ḥaḍramawt (dir. M. Mouton) were made possible thanks to the financial and technical support of the Centre National de la Recherche Scientifique (Paris, Lyon), the French Ministry of Foreign Affairs and the General Organization of Antiquities and Museums (Sanaʿa). The survey along the YLNG pipeline (dir. R. Crassard & H. Hitgen) benefitted from the financial support of the Yemen LNG Company Ltd and the technical support of the Centre français d'archéologie et de sciences sociales (Sanaʿa) and of the Deutsches Archäologisches Institut - Orient Abteilung (Sanaʿa Branch).

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