Journal of Archaeological Science 50 (2014) 383–393

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Geoarchaeology of defensive moats: its importance for site localization, evolution and formation process reconstruction of archaeological sites in NE Spain

J.L. Peña-Monné [a, *], V. Rubio-Fernández [b], J.R. González-Pérez [c], J.M. Rodanés [d], J.V. Picazo [d], J. Medina [c], M.P. Vázquez [c], M.M. Sampietro-Vattuone [e], F. Pérez-Lambán [d]

[a] Departamento de Geografía y Ordenación del Territorio, Universidad de Zaragoza, 50009 Zaragoza, Spain
[b] Dpto. de Geografía, Universidad Autónoma de Madrid, 28049 Madrid, Spain
[c] Servei d'Arqueología, Institut d'Estudis Ilerdencs, Pl. Catedral, s/n, 25002 Lleida, Spain
[d] Dpto. de Ciencias de la Antigüedad, Universidad de Zaragoza, 50009 Zaragoza, Spain
[e] Laboratorio de Geoarqueología, Universidad Nacional de Tucumán-CONICET, España 2903, 4000 Tucumán, Argentina

ARTICLE INFO

Article history:
Received 15 February 2014
Received in revised form
20 July 2014
Accepted 30 July 2014
Available online 8 August 2014

Keywords:
Geoarchaeology
Defensive moat
Iron Age
Iberian period

ABSTRACT

A geoarchaeological methodology for studying defensive moats is proposed that localises and reconstructs the evolution and formation processes of archaeological sites in NE Spain. This paper analyses three cases. Firstly, a moat at Puig Pelegrí, an Iberian site (Second Iron Age) where little infill is preserved in the moat, and therefore, the materials removed and deposited when the moat was excavated are analysed. Secondly, the stratigraphy of the infill of a moat at Cabezo de la Cruz (a well preserved site from the First Iron Age) is examined. Thirdly, a moat at Carrassumada (a highly eroded site from the Iberian period in the Second Iron Age) is analysed. The results presented in this paper highlight the importance of sedimentary contexts for understanding human occupation in semi-arid regions.

1. Introduction

The moats studied in this paper are artificial ditches excavated to enhance the natural isolation of an inhabited area. They are generally part of a complex defensive system including walls, and sometimes stone slabs planted in an upright position in the ground (*chevaux de frise*). In the western Mediterranean the most ancient sites known to have moats are Neolithic and Chalcolithic sites in southern France (Carozza and Burens, 1995; Brossier and Marlière, 2000; Beylier, 2011; Vaquer, 2001, 2011). However, these defensive systems reveal continuity in the Bronze and Iron Ages (Gailledrat et al., 2006–2007).

Interest in the study of defensive moats in the Iberian Peninsula has increased recently. As a result, several academic meetings have been held, including those edited by Alonso et al. (2003) and Junyent et al. (2011).

From the 8th century BC the defensive systems of settlements in the Iberian Peninsula comprised of moats, sometimes complemented with *chevaux de frise*, (Esparza, 2003; Romero, 2003; Redentor, 2003; Junyent and Moya, 2011). Excavations carried out in the eastern and central sectors of the Ebro Depression and in the Iberian Ranges show that most Second Iron Age settlements used this defensive structure (Rubio et al., 2006). It was formerly believed that moats were little used during this period (Moret, 1996). The typology of moats is varied and adapted to the circumstances of each site (González-Pérez and Peña-Monné, 1991; González-Pérez et al., 1996, 2005; Junyent, 2009; Rubio et al., 2006; Asensio et al., 2011). Only one of the known moats (in Els Vilars d'Arbeca) could have been flooded (Junyent and Moya, 2011).

One of the main difficulties in the study of archaeological sites in NE Spain is the high level of erosion. This is especially true in

* Corresponding author. Departamento de Geografía y Ordenación del Territorio. Universidad de Zaragoza. Grupo de Investigación Paleoambientes del Cuaternario. C/ Pedro Cerbuna, 12. 50009 Zaragoza (Spain). Tel.: +34 976761000; fax: +34 976761506.
E-mail addresses: jlpena@unizar.es (J.L. Peña-Monné), virginia.rubio@uam.es (V. Rubio-Fernández), jrgonzalez@diputaciolleida.es (J.R. González-Pérez), jmrodanes@unizar.es (J.M. Rodanés), jpicazo@unizar.es (J.V. Picazo), jmedina@diputaciolleida.es (J. Medina), mpvazquez@diputaciolleida.es (M.P. Vázquez), sampietro@tucbbs.com.ar (M.M. Sampietro-Vattuone), fperezlamban@gmail.com (F. Pérez-Lambán).

http://dx.doi.org/10.1016/j.jas.2014.07.026
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Fig. 1. Situation map showing the position of the studied archaeological sites within the Ebro Depression: Puig Pelegrí (Lleida); Cabezo de la Cruz (Zaragoza); and Carrassumada (Lleida).

the Ebro Depression due to its semiarid climate and intense human intervention in the region during the Upper Holocene (Peña-Monné et al., 2001, 2004; Constante et al., 2010, 2011; Pérez-Lambán et al., 2014). These alterations of sites mainly affected constructions, which have sometimes almost disappeared, but also moats as they were partially or totally filled with sediments. Despite this high level of transformation and destruction, it is possible to identify moats in aerial photographs. Filled moats have several distinctive morphological and micro-environmental aspects that reveal their presence (Peña-Monné et al., 1986; Vaquer, 2000). This is due to the relatively high humidity in the sediments of the moat, which allows the growth of specific vegetation that differs from surrounding drier areas. Levels of destruction of the sites can be so severe that moats remain as the only visible evidence of the ancient occupation. In this situation, the infill of the moat becomes a valuable record from which information of the past land uses can be obtained. Therefore, it is very important to carry out excavations of these sedimentary records (González-Pérez and Peña-Monné, 1991; Moret, 1996; Beylier, 2011). The use of appropriate geoarchaeological techniques and methods ensures that the most is made of the data contained in the moats and this facilitates a reconstruction of the site and a reconstruction of the site history.

2. Objectives and methodology

This study proposes a geoarchaeological methodology for studying defensive moats to obtain information concerning the cultural evolution of archaeological sites from NE Spain.

The analysis of these structures begins with their detection in aerial photographs and geo-referencing. Their location and shape is then transferred to a detailed geomorphological map (1:5000). This map represents the features generated during the Holocene in order to contextualise the moats with the geomorphological information of the recent evolution of the relief.

The presence of the moat and potential chronology are then confirmed through a field-walking survey. Sometimes a moat cannot be detected through aerial photo-interpretation because it has been completely destroyed by erosion and coverings. Furthermore, some structures with similar morphologies may correspond to uses unrelated with defence and only fieldwork can enable a positive identification.

Finally, the study of moats must be completed with the excavation of a test-pit that enables an examination of the stratigraphy of the infill and an evaluation of the significance of its data. In some cases, the existence of natural later incisions or anthropogenic excavations in the infill of the moat creates observation points where the stratigraphy can be examined. However, it is preferable to make an archaeological excavation.

This study relies on the materials extracted during the previous excavation of a moat (Puig Pelegrí, Lleida) (Peña-Monné and Vázquez, 2000) and on the archaeological excavations of the infill of the moats of two sites: Carrassumada (Lleida) (Medina and González-Pérez, 2005) and Cabezo de la Cruz (Zaragoza) (Picazo and Rodanés, 2009). The location of these sites within the Ebro Depression is shown in Fig. 1. Their detailed stratigraphic profiles and evolutionary diagrams constitute the most important documents for the reconstruction of the consecutive occupation stages and their subsequent erosion reveals environmental changes.

3. Results

3.1. Elements of the moats of geomophological interest

Three distinguishing elements of the moats have been established (Fig. 2A):

3.1.1. The moat escarpments

If the moat was dug in hard rock the resulting escarpments are the most visible elements of the structure. This is the case of Los

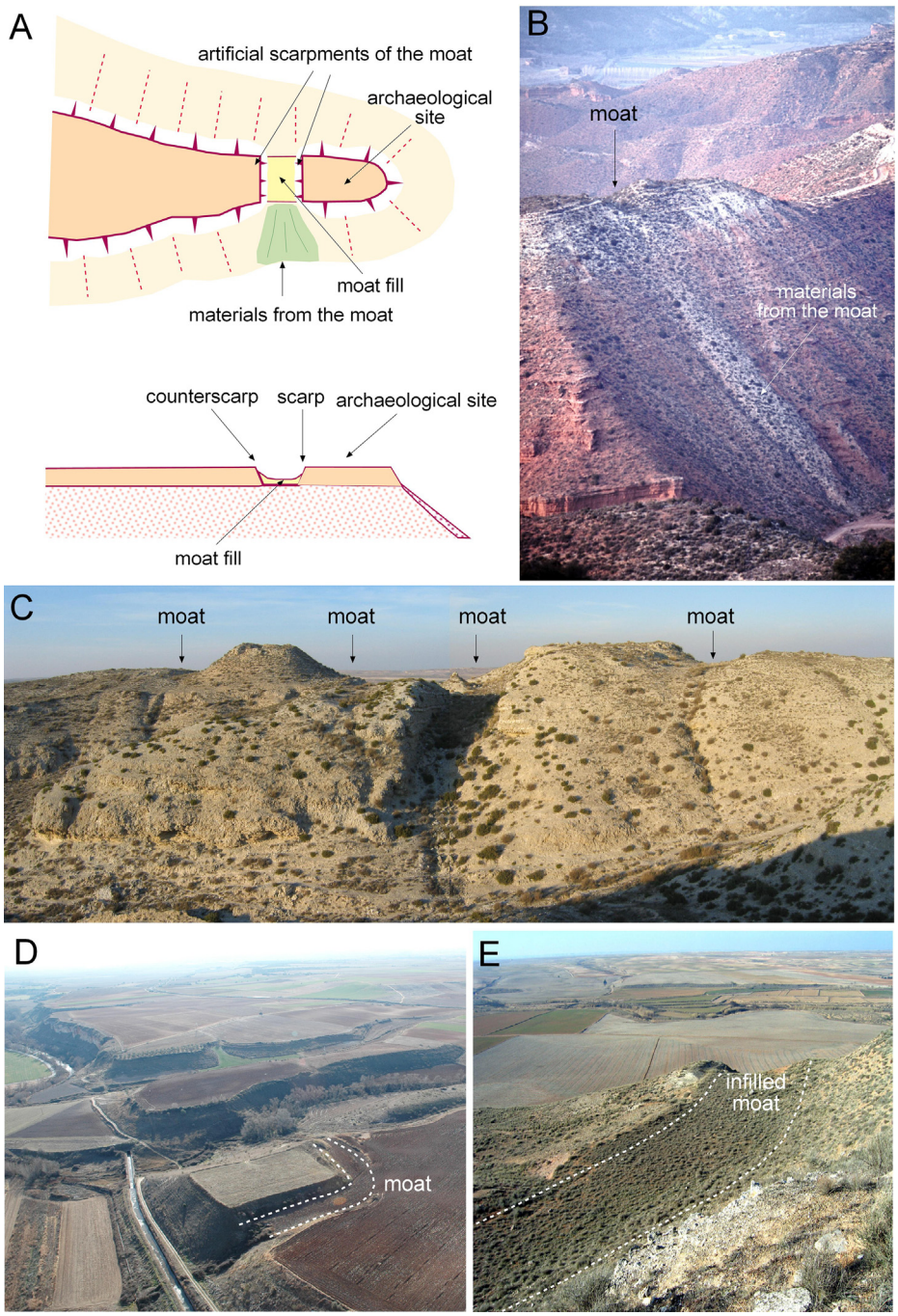

Fig. 2. A – Schematic drawing showing an archaeological site with a defensive moat that isolates a rocky spur. Main moat components have been highlighted. B – Material extracted from the moat and dumped on the slope in the El Campo Iberian settlement (Teruel). C – Iberian moats of Los Castellazos (Zaragoza). D – Course of the Roman moat of Humanes (Guadalajara). E – Filled moat from the Iberian city of Cabezo de Alcalá (Teruel).

Castellazos de Mediana de Aragón (Zaragoza) (Fig. 2C). However, the abandonment of the settlement and cleaning and maintenance tasks can lead to progressive erosion. When the escarpments are cut in soft materials (Tertiary clays, Quaternary gravels) they may need retaining elements (such as walls and palisades). This has occurred in the moats of Puig Pelegrí, Cabezo de Alcalá (Azaila, Teruel) and Humanes (Guadalajara) (Fig. 2D and E). In many of these moats there are internal escarpments (*scarp*) and an external escarpments (*counterscarp*) that can be enhanced with artificial walls as in the case of Cabezo de la Cruz (Figs. 4 and 5).

3.1.2. The materials removed from the moat

In the moats dug into hard rock the extracted blocks were used as building material for the walls, houses, and pavements; and the excavation of the moat operated as a quarry (Rubio et al., 2006; Tréziny, 2011). In these quarry-moats every morphological trace of the extracted material has disappeared. *Chevaux de frise* constructed with the materials dug from the moat are frequently found in the settlements of the central region of Spain (Esparza, 2003; Romero, 2003). However, if the moat was cut into softer materials most of the detritus was dumped on the slopes beyond the

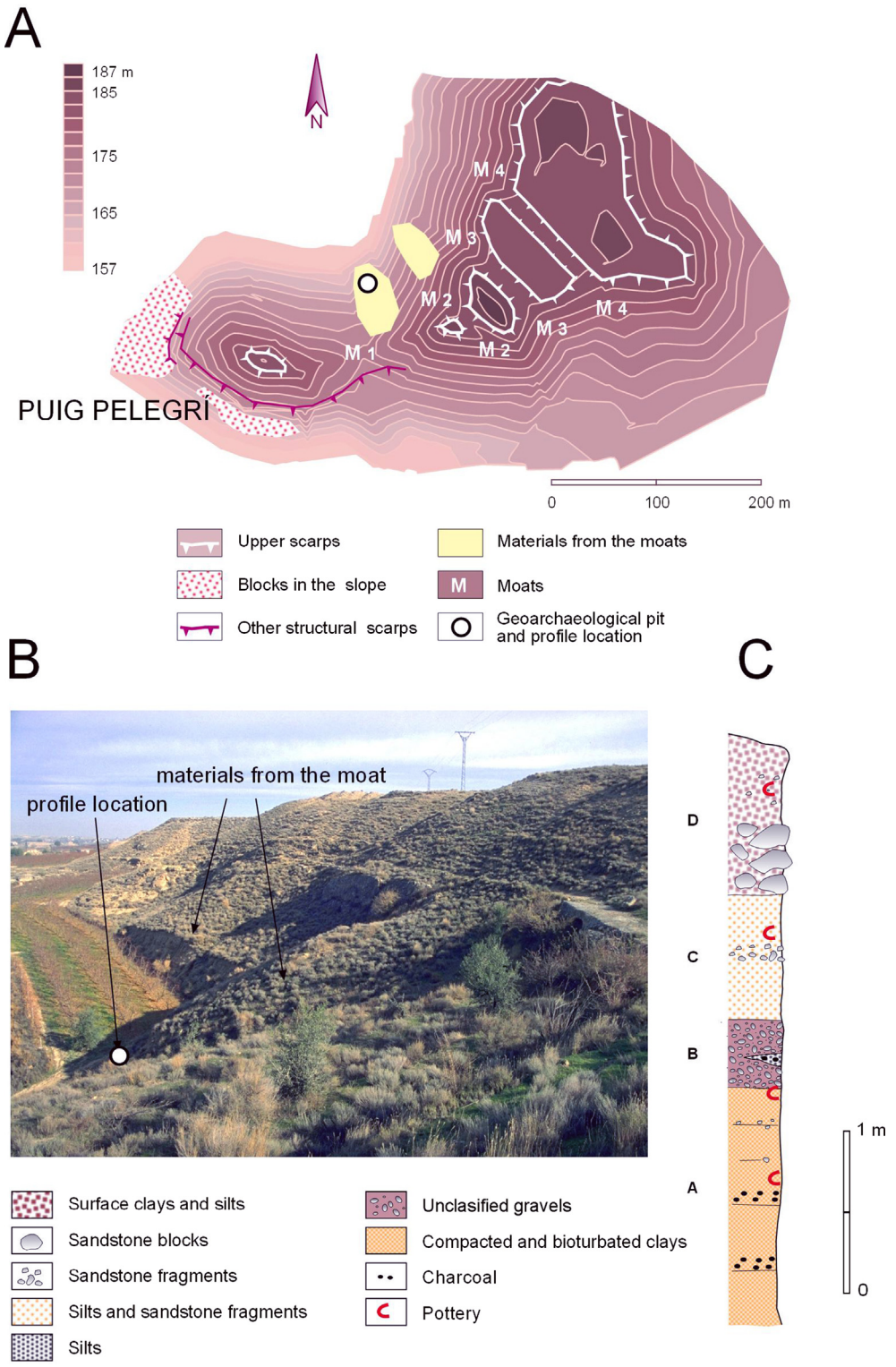

Fig. 3. A – Topographic map of the Puig Pelegrí archaeological site with indication of the position of the moats and the material extracted for the excavation. B – General view of the materials extracted from the moats and accumulated in the northern slope with evident convex morphology. C – Stratigraphic profile of one convex accumulation. Iberian potsherds indicate the chronology of the moat.

extremes of the entrenchment. These dumps can be seen in Puig Pelegrí (Fig. 3B) and El Campo de Libros (Teruel) (Fig. 2B). Subsequent evolution of these sediments includes their transport down the slope due to diverse processes (water sheet and rills, creeping, solifluction, etc.) that blur the original shape of the artificial accumulation.

3.1.3. *The moat infill*

After excavation, the trench bottoms collect sediments. Without frequent cleaning of the moat, the accumulation will reduce its functionality until it is completely filled. The deposits of the infill come from the natural erosion of the escarpments of the moat, and from nearby buildings, especially during abandonment periods. The entre

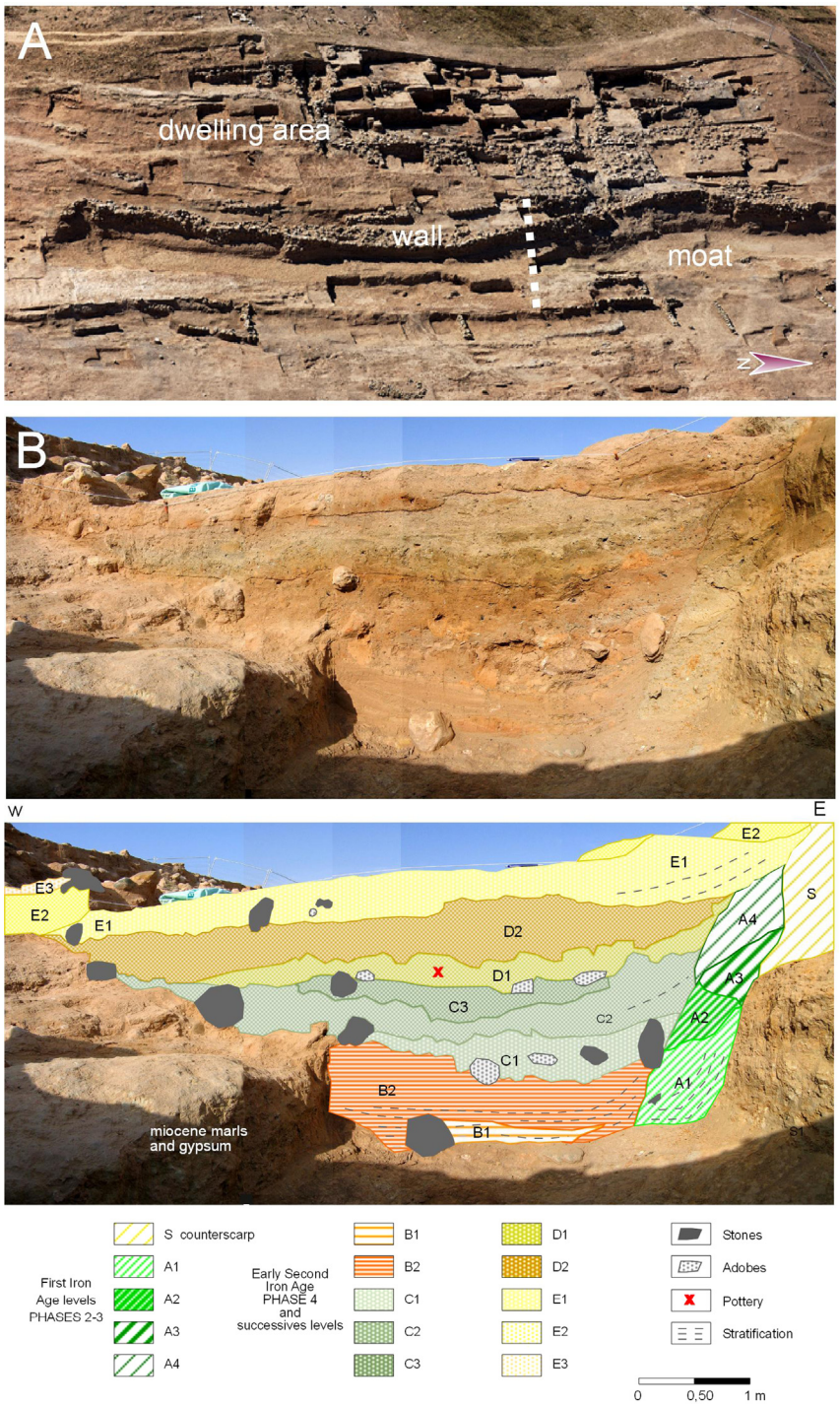

Fig. 4. A – Plan view and detail of the moat of Cabezo de la Cruz after its archaeological excavation in 2005. B – Profile of the infill of the moat with distinct stratigraphic units.

nchment can also contain anthropogenic accumulations (dumps) and even new occupation levels inside the moat, as will be seen in Carrassumada. The last and extreme possibility is the intentional dumping of material into the moat in order to make it useless as a defensive element. Some moats have been re-excavated to recover their defensive functionality; an example being the moat in Cabezo de la Cruz (Peña-Monné et al., 2009). The sedimentary record deposited in a moat can span over a long period, with deposits from the occupation stage of the settlement and the filling that follows abandonment.

These components of the moats show great variability depending on the topography, geologic consistency of the rock substratum, and the dimensions and importance of the settlement. In general terms, four types of moats have been established (Rubio et al., 2006) according to their arrangement and morphology. Three are found in high isolated settlements (*moats cutting a rocky spur*, *moats in the upper perimeter of a hill*, and *moats in the basal perimeter of a hill*). The fourth type corresponds to *moats on the perimeter of a site on flat land*.

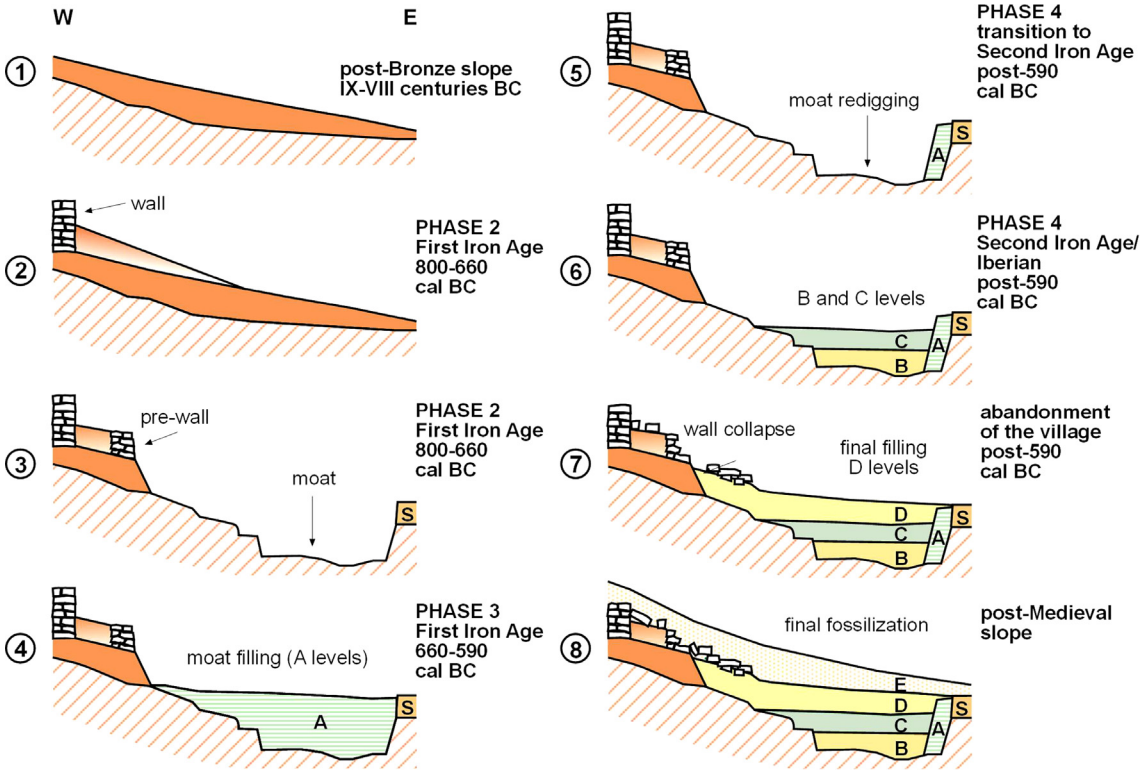

Fig. 5. Distinct evolutionary stages of the moat of Cabezo de la Cruz reconstructed from archaeological and chronological data acquired from the study of sedimentary infill.

3.2. Archaeological interventions

Archaeological interventions in our three sites offered the following results:

3.2.1. The moat at Puig Pelegrí (Lleida)

This site is on the edge of the fluvial terrace of the River Segre in the eastern sector of the Ebro Depression (31T 297114, 4606945 and 183.5 m.a.s.l.) (Fig. 1). It consists of a conic hill separated from a mesa of Quaternary gravels by a low pass. There are no perceptible remaining dwelling structures in the upper part of the site, although disperse pottery and other archaeological remains are frequent on the slopes. These materials indicate the existence of human occupation at the site from the Bronze Age to the Second Iron Age (Peña-Monné and Vázquez, 2000). The interpretation of aerial photographs and the execution of field surveys have led to the identification of a set of '*moats cutting a rocky spur*' consisting of three rectilinear and parallel moats on platform of gravels (M2, M3, and M4) (Fig. 3A). Another moat (M1) was dug to separate the main hill from the platform. Nowadays, this final moat has no internal infill. Adjacent materials from the excavation of the entrenchment lying in the northern slope made its identification possible. Its section is V shaped although it has a wide bottom opened into Oligocene sandstones. The large dimensions of this moat (more than 100 m wide in the upper part and some 50 m deep) indicate that it was made by deepening a natural landform. Moreover, the traces of extraction of rock blocks show that it was a quarry-moat exploited to obtain building material for the settlement. The other moats are narrower (3–4 m) and shallower (1–2 m). However, it is difficult to calculate their dimensions because the erosion of the escarpments cut into non-consolidated gravels whose detritus filled the moats.

The most relevant aspect of the case of Puig Pelegrí comes from the identification of the materials extracted in the excavation of the moats. An initial observation of the north facing slopes revealed the existence of convex landforms in contrast with the usual concave morphologies of the slopes, which are dominant in the semi-arid morphoclimatic environments of this region (Fig. 3B). Once these accumulations had been delimited and drawn on the map (Fig. 3A) it was evident that they coincided with the northern ends of the moats. A stratigraphic profile was made (Fig. 3C) under the assumption that these materials had come from the excavation of the M1 moat. The type of sediment and its structure showed that the origins of these accumulations were gravitational processes coming from a higher position. The low frequency of gravel within these sediments gave support to the interpretation of an extraction area restricted to Tertiary materials. The sharp angular blocks of sandstone rock without natural alteration indicate a rapid extraction and transport of the materials. Moreover, the profile from bottom to top showed Iberian potsherds (indicating the building period of the moat). There might have existed other defensive structures in former occupations (Bronze and First Iron Ages) but nothing remains. It has been demonstrated that the currently visible structure of moats is inherited from the Iberian settlement (Second Iron Age) and the surface findings suggest an intense occupation.

3.2.2. The moat at Cabezo de la Cruz (Zaragoza)

Cabezo de la Cruz is on the left bank of the Huerva valley, to the south of the city of Zaragoza (30T 661186, 4595551, 428 m.a.s.l) (Fig. 1). The site occupies the top and slopes of an isolated hill modelled in red and grey shales and gypsum formations from the Miocene sedimentation in the central sector of the Ebro Depression. At its summit are the remains of a Pleistocene fluvial terrace of the River Huerva. The natural isolation of the hill topography is reinforced to the north and south by two gullies that flank the site. However, access to the hill is still open to the east towards the river, and so in this area a moat was dug to make the site more defendable.

This site was discovered many years ago (Burillo and Fanlo, 1979) and was affected by the recent construction of the Mudéjar

motorway (A-23). The road construction obliged an extensive archaeological excavation of a large part of the site in 2004 (*approx.* 30000160 sqm) affecting mainly the mid and lower part of the eastern hillslope.

Excavation results showed a settlement with a complex urbanism and a wide stratigraphic sequence: the first phase (*Phase 1*) of the settlement is Late Bronze Age and extremely eroded. This phase is not represented in the stratigraphy of the moat because it was prior to its construction. There are three consecutive phases from the First Iron Age and the very beginning of the Second Iron Age (*Phase 2*, 800–660 cal BC; *Phase 3*, 660–590 cal BC; *Phase 4*, 590 – second half of 6th century cal BC) with periods of building, living, and destruction (Picazo and Rodanés, 2009).

The defensive system of the settlement in the eastern area consisted of a set of towers and walls (Fig. 4A) and a moat of the type '*moats in the basal perimeter of a hill*' (Rubio et al., 2006). The moat had a slightly sinuous course and flat bottom, and was 62 m long and approximately 4 m wide (5 m maximum width). The escarpments are currently 0.6 m, but the reconstruction of the scarp and counterscarp indicates an earlier height of up to 2.7 m in some stretches. In the central part of the moat an intermediate step and cistern were discovered. The scarp was a wall of sandstone and mortar, but the counterscarp was carved in the clay and sandstone of the rocky substratum, and then raised with a mortar wall that appeared very eroded during the excavations (Fig. 4B, profile, item S). In addition, some postholes were found, so it is possible that this moat was completed with a palisade.

This moat was unnoticed in aerial photographs, but appeared during the excavations made before the construction of the motorway. Although, there is no information regarding the highly eroded Late Bronze site; the existence of a wall has preserved *in situ* a great deal of the structures and artefacts from the First Iron Age. This is why the study of the stratigraphy of the infill of the moat can be used as an example of the excellent correlation between accumulation in the moat and stages of settlement. The moat received water, sediments, and dirt from the streets of the settlement because one of the gates of the wall opened towards the moat near the place where the stratigraphic profile was drawn (Fig. 4B).

Before the excavation of the entrenchment there was a slope accumulation (Fig. 5 Stage 1). This deposit belongs to a general slope formation phase very frequently found in the region (Gutiérrez-Elorza and Peña-Monné, 1998; Peña-Monné and González-Pérez, 1992; Peña-Monné et al., 1996, 2002, 2011; Pérez-Lambán et al., 2014), which has its morphogenetic origins in climate change (higher humidity and lower temperatures in the transition between the Subboreal to the Subatlantic). The slope deposit supports the basal part of the wall (Fig. 5, Stage 2). Before the excavation of the moat, the wall was reinforced with a pre-wall on its outer side. This pre-wall served as the scarp of the moat on its western side (Fig. 5, Stage 3). The profile of the moat was drawn in the deepest stretch, where the accumulation of sediments reaches some 2 m. The bottom of the moat is flat. The rocky substratum supports level B1, which can be placed chronologically in the 6th century cal BC. However, the moat was dug much earlier – namely, at the beginning of Phase 2 occupation (First Iron Age, 800–660 cal BC) since placed against the counterscarp are four levels (A1 to A4) that belong to a former sedimentary set (Fig. 4B). These residual materials evidence the filling of the moat during the occupation phases of the First Iron Age (Fig. 5, Stage 4). Only the last level of this former infill (A4) contains some potsherds of Iberian pottery, chronologically placed at the very beginning of the transition to the Second Iron Age. The moat was dug again in the 6th century cal BC with a narrower shape, leaving some remains of the former infill (the above mentioned levels A; Fig. 5 Stage 5). During the Second Iron Age, B levels were deposited that consisted of mainly limes and decantation clays, waterlogs, drying cracks, etc. (Fig. 5, Stage 6). Other building materials began to appear in the accumulations of the C levels and so revealing that the settlement was abandoned. D levels contained stones and blocks of the wall and pre-wall, and more abundant Iberian potsherds (Fig. 5, Stage 7). Finally, the entire site, including the wall and the moat, was covered by sediments coming from the upper sector of the slope. All defensive structures disappeared under a regularised slope (Fig. 5, Stage 8). At a regional scale, this new slope accumulation is related with the post-Medieval phase which has been recently placed, in terms of chronology and paleoenvironment, in the Little Ice Age, and which has its most intense geomorphological dynamism between the 17th and the 18th centuries AD (Peña-Monné et al., 2011; Pérez-Lambán et al., 2014).

3.2.3. The moat at Carrassumada (Lleida)

This site is at the edge of a high fluvial terrace of the River Set, a tributary of the Segre River, in the eastern sector of the Ebro Depression (31T 0294853, 4599657 and 212 m.a.s.l.) (Fig. 1). In an initial approach to this site, field-walking prospection revealed the existence of a Second Iron Age settlement, but neither dwellings nor defensive structures were documented. In addition, the presence of a hermitage and an attached house (Mare de Deu de Carrassumada) in the centre of the site made the acquisition of further data difficult. Analysis of aerial photographs enabled the identification of a possible moat at the eastern border of the site (Peña-Monné, 1988; González-Pérez and Peña-Monné, 1991). Identification was uncertain because of the complete infill of the entrenchment and anthropogenic alterations of the area (construction of a modern road). Between 1998 and 2000 further surveys were conducted. Remains of several Iberian houses were documented and the southern part of the moat was excavated. The entire stratigraphy of the sedimentary infill of the moat was documented and drawn (Medina and González-Pérez, 2005). In this case, the settlement was highly eroded and affected by later occupations, so the moat is the main source of information about the evolution of the site.

The moat isolates a spur formed in the Quaternary terrace containing mainly Oligocene calcareous gravels coming down from the mountains in the upper part of the River Set at Les Garrigues. This accumulation is very resistant and behaves similarly to a very hard conglomerate due to the development of a very thick and tough petrocalcic soil. In the cut produced by the modern road, 2.5 m of this Quaternary terrace was visible before the archaeological excavation began. This deposit of gravel in the area of the site is about 6 m thick and lies on top of levels of Oligocene sandstones and shales.

The moat belongs to the type known as '*moat cutting a rocky spur*' (Rubio et al., 2006). It defends the eastern border of the site; the other margins are naturally defended by steep escarpments above the surrounding flat lands. The archaeological intervention (Fig. 6A) uncovered a stretch of the moat 14.8 m long. The moat is believed to be 30 m long. Its section has U shape, with a flat bottom, and an upper width of 13 m and basal width of 9 m. The depth reaches 9 m. These dimensions correspond to a large moat and therefore it can be assumed that it defended an important Iberian settlement with a wall to enhance the scarp of the moat. It may have served as quarry-moat when its excavation reached the hard sandstone levels in its basal part. However, the building materials of the presumed wall and other structures were probably reused for the building of the hermitage and attached house. Therefore very few Iberian structural vestiges remain *in situ*.

The documented stratigraphy has several levels (Fig. 6B). A level lies on the Oligocene marly levels. This level contained potsherd from the Middle Iberian Period, possibly from the 5th century BC

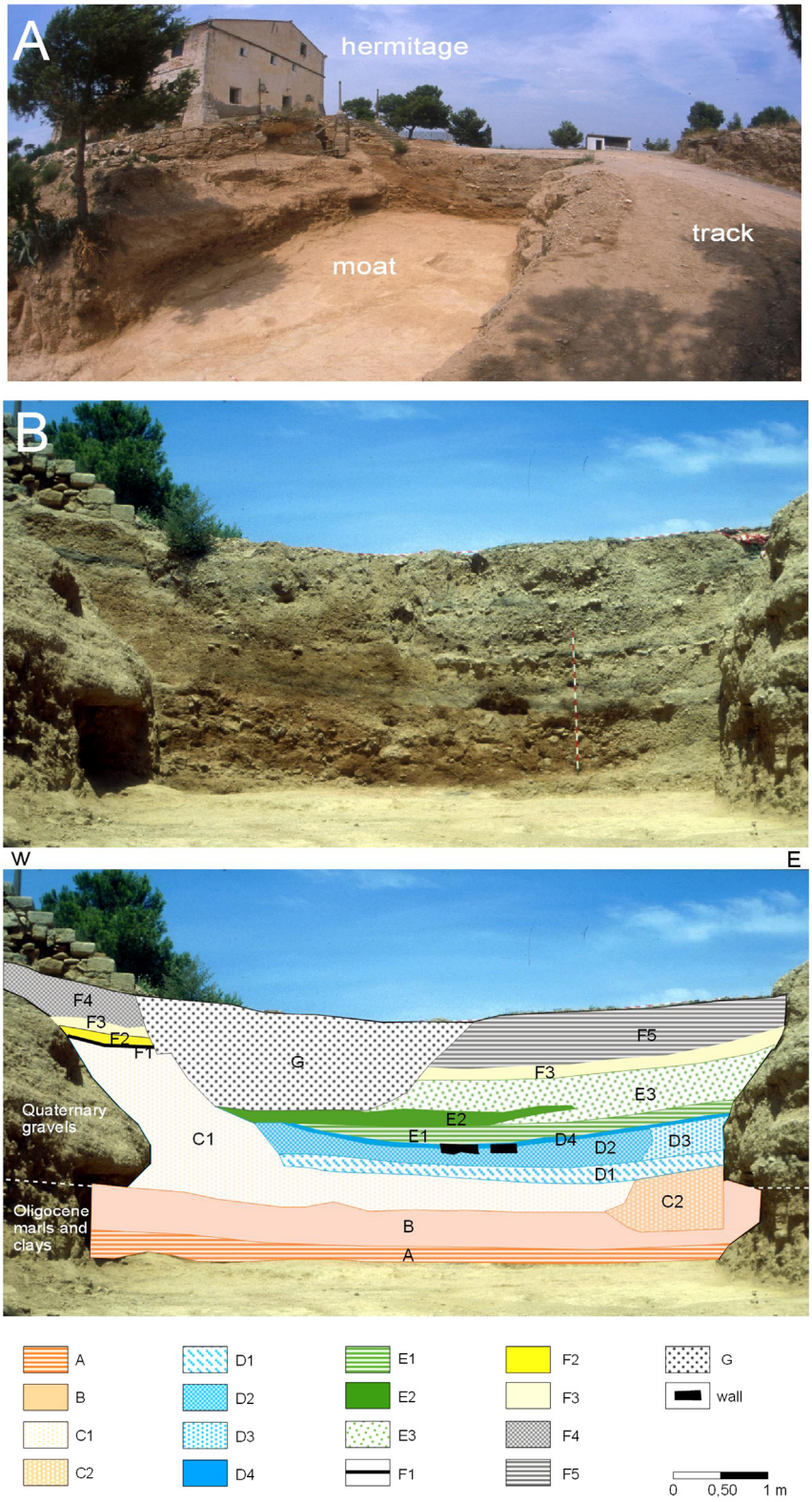

Fig. 6. A – General view of the moat of Carrassumada after its archaeological excavation in 2002. The 13th century AD hermitage and the current road are shown. B – Profile of the infill of the moat with distinct stratigraphic units.

(Fig. 7, Stage 3). The moat was in use at that time, as well as during the deposition of unit B that contained black gloss pottery from the late 3rd century BC or early 2nd century BC (Fig 7, Stage 4). C and D levels (second half of the 2nd century BC) showed evidence of a rapid accumulation whose sediments reduced the depth of the moat. At the beginning of the 1st century BC during the Roman period, there was a temporary occupation of the moat that left remains of walls and ash layers (level D4) (Fig. 7, Stage 6). E levels

probably marked the end of the occupation of the site during the 1st century BC (Fig. 7, Stage 7). In the sedimentation it is possible to identify filling materials (Fig. 6B, level E3) coming from the erosion of the margins of the moat, which was at that time just a shallow depression. F levels are related to the time during which the hermitage and attached hermit's house were built and used – namely, the 13th century and onwards (Fig. 7, Stage 8). During this period the moat was almost completely filled with sediments and survived as just as a smooth hollow. Finally, the moat suffered further transformations during the Spanish Civil War (1936–1939 AD) (Fig. 7, Stage 9) as a result of the construction of trenches and a tunnel. These military features were covered by a levelling of the area, the building of a stairway, and the widening of the road (Figs. 6B and 7, Stage 10). Thus the excavation of the moat at Carrassumada provides a better documentation of the time during which the site was occupied, as well as a deeper knowledge of the shape and dimensions of this Iberian poliorcetic structure.

4. Discussion and conclusions

The existence of moats in the NE of Spain and their importance as defensive features have been highlighted in recent years. Their use comprises a wide chronology, probably beginning in the Chalcolithic or Bronze Age and continuing in later periods, with the best and more abundant examples in use during the First and Second Iron Ages.

These moats belong to a varied typology that results from the adaptation of the structure to the topography of the place to be defended. The conservation of the moats against the erosion that follows abandonment is easier than the preservation of other structures. However, identification can be problematic and in semi-arid environments it is necessary to take into account geomorphological criteria in order to distinguish the traces left by the components of the moat: escarpments, extracted material, and internal infill. If the effects of erosion are severe, the extracted materials and infill becomes the decisive geoarchaeological record. But the material extracted is not always present in the site in the form of accumulation because it was frequently used as building material. In this case, the moat can be considered as a quarry-moat during its excavation. Therefore sedimentary infills almost always become the last remaining evidence of occupation.

The proposed methodology is very accurate in identifying and making a complete approach to the study of moats while considering much more than their presence, shape, and type. At Puig Pelegrí, the first of the presented cases, there is no evidence of human occupation preserved on the surface of the landform, but it is possible to identify a complex defensive system of four moats. However, none has enough infill to provide information comparable to that obtained in the moats of Cabezo de la Cruz and Carrassumada. At Puig Pelegrí it was possible to establish the date of the beginning of the excavation of the main moat through the stratigraphy and chronology of the material extracted during construction. Moreover, the presence of the moat made it possible to infer the location and chronology of what was probably a large – although now vanished – archaeological site. With the archaeological materials recovered from the old deposits left after the

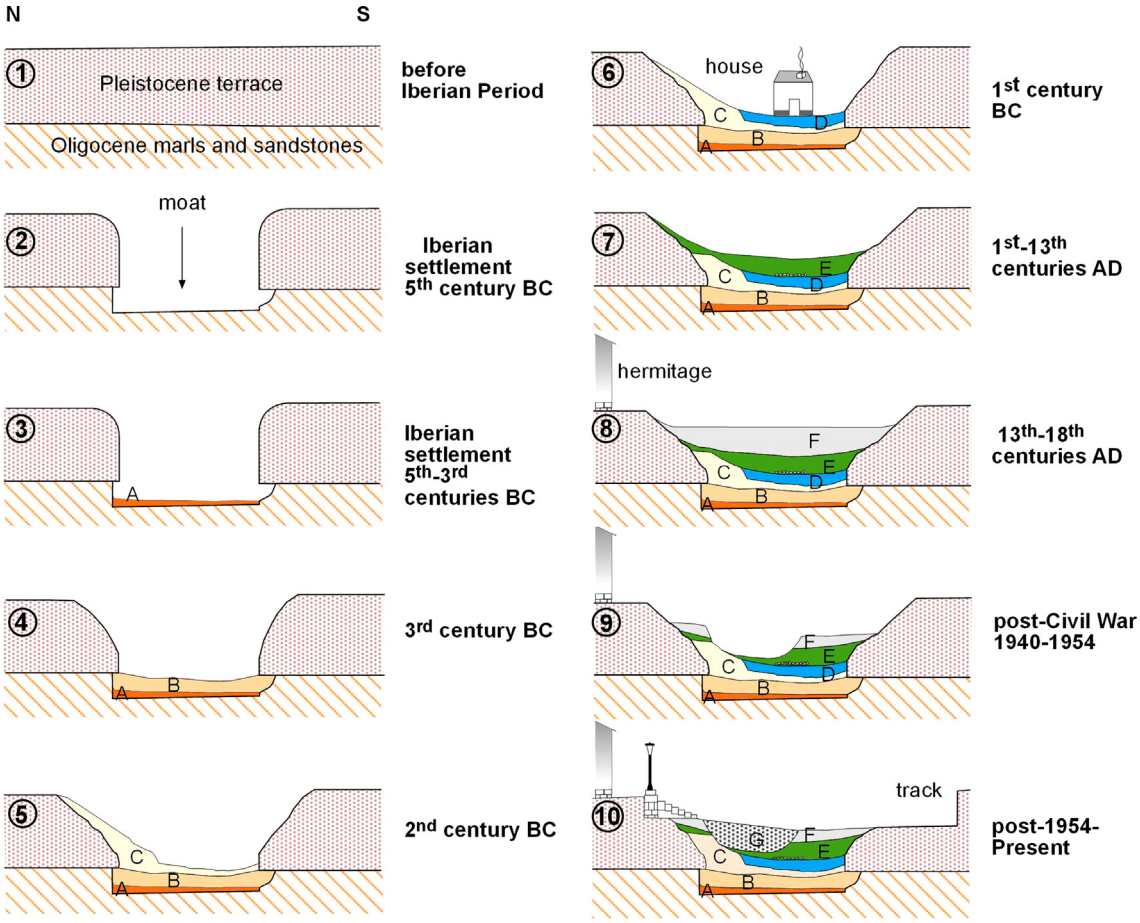

Fig. 7. Distinct evolutionary stages of the moat of Carrassumada reconstructed from sedimentary infill.

excavation of the moat it was possible to establish that the destroyed archaeological site belonged to the Late Bronze/Second Iron Ages.

Two other sites were chosen for the study of the sedimentary infills of these defensive structures. A moat surrounding a well preserved settlement was analysed at Cabezo de la Cruz. It was possible to examine the evolutionary correlation between the dwelling area and the moat. The obtained results enabled us to conclude that in those cases where the dwelling area is not preserved, the infill of the moat can usefully help attempts to reconstruct the site formation process.

With confidence in the method derived from the success of the experience in Cabezo de la Cruz, the same analysis was applied to the data acquired from the excavation of a badly preserved site at Carrassumada with a deep and sealed moat. The aim in this case was to obtain the chronology of the beginning, duration, and final abandonment of the occupied area. Our study has answered these questions, as well as questions about the building characteristics of the moat. The moat is perfectly preserved and is now partially empty of sediments – thus revealing its original visual impact.

Obviously, there is a loss of precision in the documentation of these sites in comparison to what could have been known if better preserved. The fact is that in many cases moats are the only suitable remains for studying the original nature of the site. Of course, in the case of sites without preserved dwelling areas, the best reconstruction requires the preservation of the infill of the moat and the extracted material.

Last, but not least, it must be said that the systematic implementation of this methodology with wider criteria in field survey and site excavation could be of great importance in improving the results of archaeological interventions in semiarid environments – such as the Mediterranean area.

Acknowledgements

This work has been supported by projects CGL2006-08973/BTE, CGL2009-10455, HUM2005-06512 and HAR2009-13866 of the Spanish Government and the European Development Fund. It is a contribution of the Paleoenvironment of the Quaternary Research Group (PALEOQ) and Primeros Pobladores del Valle del Ebro Research Group (PPVE), both of them of University of Zaragoza-Aragon Government; also is a contribution of the Servei d'Arqueologia de l'institut d'Estudis Ilerdencs.

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