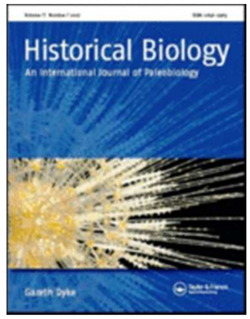

Votive Well or Refuse Tip? Chronicle of an Abandonment: Taphonomic Study of the Fauna of an Iron Age Well-Cistern

Journal:	*Historical Biology*
Manuscript ID	GHBI-2017-0064.R1
Manuscript Type:	Original Article
Date Submitted by the Author:	26-Jun-2017
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Keywords:	Iron Age, Iberian Peninsula, archaeozoological remains, well-cistern, bone colorations, Taphonomy and chemical analyses

Votive Well or Refuse Tip? Chronicle of an Abandonment:
Taphonomic Study of the Faunal Remains of an Iron Age Well-Cistern

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Abstract

The well-cistern of the Iberian Fortress of Vilars (Catalonia, Spain) is a monumental feature dating to the late 5th century BCE (Vilars III-IV phases). Management of water resources is key to interpreting the nature of the Fortress as water was essential not only for human and livestock consumption, but for irrigation, construction and crafts. Moreover, water was integral to the site in both times of peace and war as the structures that guaranteed its provision and management coincide with facets of military architecture (moat). Yet why was the well-cistern backfilled with animal remains and other archaeological material only a few years after its construction? To answer this and other questions, this study follows two main lines of research. Firstly, analyses were carried out on the archaeozoological remains collected inside the feature so as to characterise and interpret its nature. Secondly, taphonomic analyses (macro- and microscopic) were undertaken so as to reconstruct the dynamics of the different accumulations and the premature abandonment of the well-cistern's primary function: supply potable water.

Keywords

Iron Age, Iberian Peninsula, taphonomy, archaeozoological remains, fortress, well-cistern, bone colorations, chemical analyses.

1. INTRODUCTION

The Protohistoric Fortress of Vilars (Lleida) is located in a vast alluvial plain in western Catalonia **(Fig. 1)**. It was occupied from the 8th to the 4th century BCE. Yet it was in the late 5th century, during the Vilars III (450/425-350 BCE) and Vilars IV (350-300 BCE) phases, that the site reached an unequaled state of complexity as it underwent successive transformations affecting, in particular, its defences. A key endeavour was digging a flooded moat along its exterior. The second major transformation was sinking in its centre of a large well-cistern (9 x 6 m by 9 m deep) accessible by a narrow ramp. This last monumental feature, the focus of this study, saw use at the end of the 5th century until its abandonment in the last quarter of the 4th century BCE. Its construction demanded a major effort on behalf of the site's inhabitants (excavation, transport of stones, lining of walls) and the sacrifice of a large space in the heart of the enclosure (Junyent *et al.* 2012).

The management of water resources is a key element to interpreting the Fortress and its dominant role in the territory. This resource served for human and livestock consumption, for irrigation and for other functions essential to the community linked to construction and craftwork. But the need of water in the heart of the enclosure reflects the perception of a threat by the fortresses' occupants, notably the threat of siege (Junyent *et al*. 2009-2010). Apart from these elements, the question remains as to why this monumental feature was backfilled with animal remains, pottery, metal objects, wood and other objects only a few years after its construction? Moreover, what activities generated these archaeological finds and what elements and factors need to be taken into account when analysing the faunal remains found in this type of structure? This study aims to answer these questions based on archaeozoological analyses of the assemblages in both the well-cistern (sector 7/1) and its access ramp (sector 7/3). To interpret the dynamics behind the origin of these archaeological features (e.g. Valenzuela and Gardeisen 2005; Fiches 2012; Fernández-Jalvo and Andrews 2016,155-166), this study places a special emphasis on data gleaned from the colours and chemical composition of the faunal remains.

Fig. 1

2. METHODS AND MATERIALS

The study was divided into several steps. The first involved anatomical and taxonomic identifications and classifications of the materials based on the reference collections of the Laboratory of Archaeology of the University of Lleida (Spain) and the Laboratory of Archaeology of the CNRS-UMR 5140 (Montpellier, France). This initial step was completed with diagnostic criteria from different atlases and catalogues (Schmid 1972; Barone 1976; Boessneck *et al.* 1964; Boessneck 1980; Payne 1985; Fernandez 2001; Halstead *et al*. 2002; Wilkens 2002; etc). Secondly, the study focused on the assemblage's taphonomic processes and degree of preservation based on macromammal anatomical depictions and the presence or absence of anthropic marks. This step was completed by a qualitative analysis of the intensity to which the bones were affected by taphonomic agents; "0" equivalent to total conservation of the cortex and "4" corresponding to total alteration (Helmer 1991; Valenzuela 2008). The aim of this step was to establish the state of preservation and the representativeness of the samples. Thirdly the study analysed the bone's most common post-depositional alterations such as weathering[1] (Berensmeyer 1978), roots (Binford 1981), traces

1 The atmospheric alterations suffered by the bones prior to their deposition fall into the general category of "weathering".

of carnivores (Binford 1981; Bridault 1994; Lyman 1994), trampling[2] (Behrensmeyer *et al.* 1986; Haynes 1986; Olsen and Shipman 1988) and carried out a classification of their wide variety of colours **(Fig. 2)**. The classification of colours is as follows:

- White: bones for the most part from the superficial layers of the well-cistern and hence affected by dissolutions and minor decalcifications (Villalaín Blanco 1992, 140).

- Red/dark brown: hues usually appearing during phases of oxidation when organic matter is subject to rapid transformation (Franchet 1933, 484). These transformations can also include alterations due to iron and manganese oxidation.

- Black/grey: hues that are either uniform or, in certain cases, in the form of stains. That are characteristic of the enclosing sediment (Buxó and Piqués 2000, 5: cited in Valenzuela 2003, 151) resulting from the combination of different types of hydrated iron oxides when in humid conditions (Fedoroff and Courty 2002, 296). These hues are common to reduction atmospheres of certain stratigraphic levels that are permanently below the level of the water table (Franchet 1933, 484).

- Red and orange spotting: spots on the bone surface occur when a certain amount of oxygen is retained in the sediment provoking oxidation of the irons and precipitation in the form of iron oxides (Courty 1989, 180).

- Black/grey spotting: spots on bones that are mainly interpreted as remains of manganese oxide that appear in certain temporal humid environments characterised by cycles of oxidation and reduction (Courty 1989, 185). The presence of these types of oxide in wells and cisterns can be linked to faunal remains in anatomical connection since decomposition took place in situ after deposition, at times in combination with fluctuations of the groundwater level.

An essential aspect of the study was contrasting the macroscopic observations of the bone surfaces with the results of chemical composition analyses carried out by electron microscope mass spectrometer. The different colours, in fact, are not always linked to identical chemical compositions. Hence only the combination of the two methods can yield precise interpretations.

Fig. 2

This type of integrated analysis was carried out on a total of 12 bone samples[3] and concretions from the well cistern (7/1) and its ramp (7/3). The different stratigraphical units (SU) of these two features served as references to analyse the processes of formation and deposition of the feature's backfill and to quantify the following values: number of remains (NR), number of determined remains (NRD), number of non determined remains (NRND)[4], number of indeterminable remains (NRind) and the minimum number of individuals (MNI). The results of

2 Human and animal trampling can produce marks on bones. To wit, an area of great concern with respect to bones recovered on archaeological sites is the similarity of trampling marks to butchery marks. It is essential, then, to distinguish the characteristics of each either in terms of groove morphology, patterning and distribution of traces, or associations with other types of surface modifications (like polishing) in order to separate trampled bones from cut bones.

3 The samples were selected according to their context and the macroscopic appearance (colour and concretions) their cortex. This study therefore is a first test whose results will condition further analysis.

4 Only determined to anatomical level.

the NRD were put to test so as to avoid an over representation of the more common elements (teeth, metapodials, phalanges, vertebrae, rib fragments), it is the number of pondered remains (NRp)[5]. Since this study forms part of a broader research project (Nieto 2012) on subjects such as age of livestock, and management and age of death, combined with detailed analyses of the stratigraphic units, structures and spaces by chronological phase, certain data are not considered. This work focuses therefore on data gleaned from the taphonomic study with the goal of interpreting the nature of the archaeozoological assemblages, the dynamics of the different deposits in the different archaeological layers, and the processes regarding the well-cistern's use and abandonment. This study therefore takes into consideration three different processes in the well-cistern's different stratigraphic levels:

1.The spread of the volume of remains (NR) of the fauna and pottery (the most representative artefacts).

2.The anatomical and taxonomic composition of the faunal groups.

3.The identification of the taphonomic agents.

3. DESCRIPTION OF THE WELL-CISTERN (CS-47)

The well-cistern of the Vilars fortress is a large, relatively complex structure in the centre of the site about 9 m deep, cut through layers of Oligocene marls. It is organised into two distinct sectors: well-cistern (sector 7/1) about 6-7 m in diameter and its access ramp (sector 7/3). The walls of each are lined with stones.

3.1. The stratigraphy of the well-cistern (sector 7/1)

Before abandoning the fortress, the inhabitants backfilled the feature with a thick layer (4 m) of stones and earth (SU 7002 = 7056 = 7070). This last backfill covered a thick greenish level rich in organic matter comprising a series of gradually deposits of mud and archaeological waste (SU 7058 = SU 7071). It is noteworthy that this greenish layer has a morphology very similar to that of SU 7053 at the base of the access ramp (see below). A local accumulation of sand (SU 7059 and SU 7069) at the base of the ramp covered a grey level (SU 7078) rich in organic matter. Below the green levels is the deepest stratum studied so far, a grey layer of organic rich mud (SU 7072).

3.2. The stratigraphy of the access ramp (sector 7/3)

The access ramp was built in two rungs (SU 7057 and SU 7066) on a preparation layer of brown clays (SU 7076). The preparation layer was covered by two levels of small stones (SU 7074 and SU 7084) that facilitated circulation. These were covered by a grey stratum (SU 7073) which appears to correspond to a level of sedimentation produced by circulation. This was followed by a thin layer of clays marked by construction material (SU 7060) that constitutes the level of use of the ramp. This was covered by a silty, very dark brown heterogeneous stratum containing a great amount of organic material resting on a second layer of stone paving. Covering the two steps was another thin layer of

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[5] The number of pondered remains (NRp) is calculated by dividing the number of remains of each bone present (by species) in the studied set by the number of this anatomical element in the skeleton of the animal. For example, if there are NR = 100 ribs of sheep finds, then this number will be divided by 26 (the total amount of ribs in this species) to attain the NRp. If the finds are radiuses, then the NR is divided by two, and if they are lumbar vertebras, they are divided by six, and so forth. The formula is then: **NR of the anatomical element / number of this type of bone in the skeleton**.

stones (SU 7055) which were, in turn, covered by an organic layer rich in archaeological material (SU 7053). This level ended up spread along the bottom of the ramp, even intruding into the well-cistern (sector 7/1). Finally was a thick layer of reddish brown sand (SU 7052) comprising organic matter and small fragments of burnt earth deposited during the feature's abandonment.

4. RESULTS

4.1. Distribution of the faunal accumulations in the different sectors

Of the 13,485 faunal remains in the different features of the Fortress, 1,572 (18.3%) come from the well-cistern (CS-47). These latter are subdivided into 941 bones that could be determined taxonomically (NRD), 431 could be determined anatomically (NRND) and 199 that remain indeterminable (NRind) **(Fig. 3 and Fig. 4)**. It is noteworthy that the dynamics of the well-cistern's backfill differed greatly from that of other features of the Fortress (houses, streets, storage areas, workshops). Its major phases of accumulation of materials and natural sedimentation (26.1%) and abandonment (28.8%) yielded the greatest quantity of archaeological artefacts at the site. These accumulations are followed by the finds in the circulation levels of the access ramp (18.4%).

Fig. 3

The archaeological artefacts observed in the sector 7/1, comprise mostly ceramic and faunal remains **(Fig. 4)**. This is seconded by metal objects, construction material, lithic artefacts, malacofauna, organic matter, ashes and charcoal (Nieto 2012, 341). The well-cistern's upper, abandonment level is marked by a thick backfill containing the second largest quantity of materials, while the quantity of objects in its earliest sedimentary deposits is meagre. The stratigraphy of the feature's access ramp (7/3) is much more complex as its layers contain fauna and pottery linked to circulation **(Fig. 5).**

Fig. 4 and Fig. 5

As can be seen in **Fig. 4**, sector 7/1 of the CS-47 contained a great amount of artefacts concentrated at the base of the ramp and in levels directly below it. This accumulation presumably points to a deliberate deposition of materials originating from a single point in space (the ramp). Especially noteworthy is the great number in SU 7071 (=7058) that is contemporary to the finds on the ramp (SU 7053). These stratigraphic units precede an upper layer of backfill linked to the well-cistern's abandonment.

The faunal remains were mixed with a large amount of pottery with a high percentage of local wheel-thrown (water vessels, painted Iberian ware, Iberian oxidised and reduced ware) and hand-made ware (coarse and polished ware with plastic and incised décor). The assemblage is completed by a low percentage of imported materials (Attic black-figure, Grey monochrome, Attic red-figure, Punic amphorae). The pottery's fragmentation and typological variety, as well as the dominance of local ware, suggests that these vessels were deliberately cast into the feature.

4.2. Anatomical and taxonomic composition of the assemblages

Several anatomical elements evidence the favourable conditions of preservation of the faunal assemblages and a low level of fracturation: the high index (59.9%) of identified remains (NRD) and a low index (12.7%) of indeterminable remains (NRind)[6], the presence of bones of very young animals (0.5%) at times in a foetal state (0,9%), fragile bones such as ribs, sternum fragments (2.2%), a low quantity of splinters (9.2%), small elements (isolated teeth 7,6%, sesamoid 0.2 %), tarsal bones (0.4%), calcaneum (0.6%) and astragali (0.5%).

The comparison of the anatomical composition of the different bone assemblages from the well-cistern (7/1) and the ramp (7/3) reveal interesting results. Firstly, a main difference is that the lot from the well-cistern comprises a great number of antlers, while these elements are practically absent from the ramp **(Fig. 6)**. The antlers are located in two different SU (SU 7071 = 4 and SU 7086 = 1), while bovid horns, on the contrary, are more dispersed (SU 7067 = 1, SU 7071 = 3, SU 7072 = 1, SU 7078 = 3, SU 7086 = 1). Secondly, the ramp contains many fragments and splinters of humeral shafts certainly resulting from trampling. The portrait of the other elements, as listed in **Fig. 6**, is practically identical except for the dominance of skull elements (antlers, cranium). This may be attributed to a higher volume, fragility, and thus higher fragmentation, of this parts of the anatomy (e.g: Simpson 2011). The degree of fracture of the cranium is very high explaining the inability of identify many fragments. All parts of the skull are represented in different levels of percentage (occipital 4.8%, zygomatic 0.7%, nasal 0.7%, frontal 4.1%, incisor 2.6%, temporal 1.8%, maxillary 4.8%). There is predominance of mandible fragments (49.5% - 35.6%) and undetermined skull fragments (34.2% - 37.9%) in both sectors of the structure. In fact, the total skull and jaw fragments are equivalent in numbers, and no particular identification is possible except for a slightly higher percentage of the occipital bone. Its robust nature could explain the better conservation.

Fig. 6

Other parts of the skeleton, while present, are less represented. For the rest of the skeleton, from the overall percentages of sectors 7/1 and 7/3, both the anterior extremities (scapula 6.8% -4.8%, humerus 1.9% -1, 7%, radius 2.4% -5%, metacarpal: 1.3% -0.2%) and the posterior extremities (coxal: 1.5% -2.5%, femur: 2.8% -3.3%, tibia: 1.9% -3.7%, metatarsus: 1.7% -1.7%) are represented. In this sense, the domestic triad species are represented by all the anatomical elements. It is noteworthy that they are more greatly represented by long bones of the limbs that contain more meat (caprines: radio-femur-tibia; bovids: scapula, radius, femur; suids: scapula, humerus, radius, tibia) with a greater representation of mandibles, probably due to the consumption of the part of the cheek and perhaps the tongue, an element that was highly prized **(Fig. 7)**. Horse bones (NR = 80) appeared in the 7/1 sector of the cistern distributed in three consecutive units (SU 7058, 7086, 7078) and seem belong to the same adult individual (around 4 years old). This individual was represented by the skull and bones of the anterior and posterior extremities. These elements recall a pattern of consumption very similar to that of triad domestic animals.

Fig. 7

The taxonomic data number of finds (NR) in the well-cistern (7/1) and its ramp (7/3) point to caprines as the most common species (27.1% and 59.8%) followed by bovines (25.4% and

6 The index is higher in the well-cistern (65.8%) than in the ramp (47.4%). The same tendency is noted for the NRindet with 15.6% in the well-cistern and 6.5% in the ramp.

24.3 %) and suidae (4.3% and 11.7%)[7]. The assemblage is completed by a few horse bones in the well-cistern (7/1). The comparisons of the number percentages (NR) with that of the number of individuals (MNI) reveals certain notable disparities. Caprines, for example, are more common in the well-cistern, followed by bovines and suidae, while suidae in the ramp, are in second place, surpassing the number of bovines **(Fig. 6)**.

Regarding wild fauna, deer (30.2%) is undoubtedly overrepresented in the well-cistern (7/1) due to the high fragmentation of antlers, while it has only a token presence (2.5%) in the ramp (7/3). From the perspective of minimal number of individuals (MNI), deer represents, respectively 14.5% of the well-cistern and 1.8% of the ramp. Other species such as rabbit (0.1%-0.8%), dog (1.4%-0.4%) and wolf (0.1%-1.8%), in turn, are rare **(Fig. 6)**. Remains that are identified at the anatomical level - but not taxonomically – suggest distinct contrasts between the two zones. The well-cistern at 58.8% contains a high number of large animals, while the opposite is the case of the ramp (20.3%) **(Fig. 6)**. Another difference between the two features is that the well-cistern contains horse remains, while this species is absent in the ramp.

Firstly, an important notion to bear in mind is that the faunal remains of the different sectors of the well-cistern are interpreted as consumption waste intentionally cast into the feature at different moments in time. The reasoning behind this notion is based on the following:

- Cutting marks on bone surfaces are found in all stratigraphic units and in all species of the domestic triad (*Ovis aries*/*Capra hircus*; *Sus domesticus*; *Bos taurus*). The cutting marks evidence both the disarticulation processes of the different anatomical parts (such as deboning and severing) probably to facilitate cooking and a better allocation of the meat portions (for more detail see **Fig. 7**). For other species such as horse, dog and deer, there are especially traces associated with disarticulation, in spite of the absence of marks directly related to the removal of flesh. Yet consumption of these last three species cannot be ruled out, and their consumption, in fact, is quite probable taking into account the find context.
- A wide range of domestic (caprines, bovines, suidae, canines, equines) and wild (wolf, deer) species.
- No individuals are whole in anatomical connection.
- All age groups are represented (foetus/newborn, young, young adult, adult).
- Although all types of anatomical parts are in the well-cistern, long bones associated with larger amounts of consumable meat appear to dominate.
- The presence of what appears to be different equid bones is interpreted as remains of consumption because the skeleton is not complete, not in anatomical connection, and certain pieces such as those between the occipital bone and the spinal cord show cutting marks associated with the process of disarticulation (see Nieto 2012, 345).
- There are a total of 11 dog bones (sector 7/1: NR=10 and sector 7/3 : NR=1) in the different stratigraphic units (SU 7056=7; 7058=1; 7067=1; 7068=1 and 7076=1) with the greatest grouping in SU 7056 (NR=7). The anatomical elements correspond to extremities (humerus, scapula, coxal, metacarpus V, femur, tibia), to axial skeletons (rib, axis) and to a jaw. The 10 remains correspond to a MNI of four different individuals. Hence the presence

7 It is noteworthy that these proportions contrast with the small number of finds (422) from the other settlement features and the street of Vilars III-IV phases (caprines 80%, suidae 19% and bovines 11%). In fact, since 80% of the Vilars III structures were destroyed by modern agricultural workings, the portrait of the fauna (apart from that of the well-cistern) is very incomplete.

of dog skeletal remains, contrary to other domestic species, is negligible. These bones at Vilars raise the possibility that dogs were occasionally the object of consumption as was the case at other Iberian and Celtic settlements of the Iron Age (e.g. Yvinec 1987; Méniel 2006; Horard-Herbin 2014; Belarte and Valenzuela 2013; Pons and Colominas 2015). Hence dogs could have followed the same order as other small domestic animals (Horard-Herbin 2014). But the absence of calcined and cutting marks on dog bones, and the fact that most dog remains vary in age (from foetus/newborn to adult) and are found principally in a single level (SU 7056), appear to negate dog consumption. Hence the interpretation of dog remains recovered in certain features and domestic spaces in Iron Age sites is complex. On the one hand is the low number of finds, and on the other, is the question of the polyvalent nature of the species (Gardeisen *et al.* 2011; Horard-Herbin 2014; Olivier-Foix 2014). These factors complicate the interpretation as there are possibly other explanations linked to symbolic or ritual spheres (Belarte and Valenzuela 2013; Pons and Colominas 2016), actions of consumption (Horard-Herbin 2014) or the disposal of carcasses taking advantage of the rubbish tips near the settlement (Valenzuela and Gardeisen 2005).

Secondly, it is also noteworthy that different types of antler and bone tools (and tool roughouts) cannot be considered consumption waste but craftwork rejections. The artefacts fashioned from antlers come from deer sheddings (except for one hunted individual). It is noteworthy that layer SU 7071 contains a concentration of practically whole deer antlers devoid of their hardest segments most valued for tool making. This bolsters the idea of manufacture rejects. Besides the antler tools, the finds include a polished bovine rib (SU 7068) and a long polished humeral shaft of a large animal (SU 7071) corresponding to unidentified tools.

Traces of cleaning the well-cistern visible in the stratigraphy indicate that the earlier bone assemblages could have been disturbed and removed. Hence it is impossible to confirm if the original bone depositions comprised whole animals in anatomical connection (e.g. horse and dog), as the single case of a dog or wolf pup without cutting marks. Yet the notion of whole deposits must be viewed with caution as the evidence points to the second use of the structure as a refuse tip and not for votive or ritual offerings. The possibility of use of the well-cistern as a votive feature was contemplated due to numerous examples of votive offerings of animals in wells in and outside the Iberian world: 1. Several votive wells in the cemetery of Gadir (Cádiz) contain bones of different species mixed with pottery linked to the first moments of a funeral banquet (Niveau 2008). These finds are placed in the framework of ceremonial rites and not refuse cast-offs (Niveau and Ferrer 2004; Niveau 2008: cited in Cabrera, 2010, 196, BD-03); 2. The phenomenon of sacrifice and disposal of animal waste in wells is also recorded in the Phoenician-Punic world (Cardoso *et al.* 2016); 3. The Iberian silos at Mas Castellar de Pontos (Girona) saw reuse as votive deposits (presence of a dog's head) (Pons 2015); 4. The coast of Languedoc also offers spectacular examples such as at the site of *Lattara* (Montpelier, France) (Valenzuela and Gardeisen 2005) where the deposits (including, interestingly, a whole horse in anatomical connection) are not interpreted as votive, but as waste; 5. A very remarkable example at the *oppidum* of Argentomagus (Saint-Marcel, France) consists of a large group of wells and pits unparalleled throughout Gaul containing many layers of faunal remains (not in anatomical connection), as well as other archaeological materials. The appearance of unusual artefacts (coins, weapons, imported pottery and ex-votos) has led the authors to see these features as sacred (Allain *et al*. 1987). 6. The great pit/cistern (FS.1130) of the site of Monédière (Bessan, France) dating to the 5th century BC contained a large quantity of ceramic vases (notably imported greek ware) mixed with faunal remains. The remarkable nature of these deposits has persuaded the authors that the find is the result of a massive consumption of drink and meat, possibly the celebration of a banquet or similar act (Curé *et al.*, in press). In this sense, many authors have worked on characterising sets of bones linked to ritual activities or symbolic/collective consumption (banquets) (Poux 2002; Morales-Pérez 2008,18-20; Méniel 2008,129; Albizuri 2011; Huber and Méniel 2015; etc.) Distinguishing these singular acts is not simple as they will vary according to context (site typology and chronology). One thing common to all authors is the need to first characterise the profiles of daily consumption of a site in order to subsequently detect if there are assemblages with particular and/or different profiles. In any case, the profiles of CS-47, as noted above, adhere to all the characteristics of a daily consumption of waste.

4.3. Effects of the taphonomic agents on bones

Alterations of skeleton remains provide valuable information regarding their depositional environment. A series of different actions brought about by humans and carnivores, as well as those provoked by post-depositional factors, are identified in the study **(Fig. 8)**. Alteration by atmospheric agents (cracks, flaking, cortical alterations), in fact, had a minor impact on most of the bones indicating that they were possibly secondary depositions (corroborated by the few traces linked to carnivores) and/or the variability of the groundwater level that would have had an effect on the content of the upper levels of the well-cistern's backfill. The degree of alteration of the bone cortex with values between 0 and 1 **(Fig. 8)** indicate that the assemblage did not suffer a differential preservation. The remains in the interior of the well-cistern (7/1), in fact, point to alterations produced mainly by the variability of the water table **(Fig. 8)**. These variations are evidenced as follows:

Fig. 8

Presence of dark brown bone cortex

Between 70-88% of the bones reveal an optimal mineralization and a uniform dark brown cortex (Fig. 7), that can appear as overall black surface staining, indicative potentially of total immersion in water or wet sediment (Fernández-Jalvo and Andrews 2016, 156). Diagenetic agents can alter the chemical composition of buried skeletal tissues (Lyman 1994, 421). Several studies provide a model of chemical modification based on the concept of diffusion, a process triggered when mobile chemical elements migrate from high to low areas of concentration until attaining equilibrium. Thus, when the skeletal tissues differ in chemical composition from the sediment's matrix, the bones rich in chemical elements tend to decrease as they take on components of their surroundings (Whimer *et al*. 1989, 244-245). The presence of dark brown colouring in some levels of the well-cistern (7/1), therefore, points to the existence of stable reducing atmospheres (with a neutral and/or slightly alkaline pH) rich in manganese and iron particles **(Fig.10a)** that enrich the bones' chemical composition.

The analysis of the percentage of the number of remains (NR) with this type of colouration throughout the different stratigraphic levels **(Fig. 9)** reveals a band comprising 46.6% of the assemblage in the upper layer of the well-cistern's backfill (SU 7056) indicative of the maximum level attained by the water table after the feature's abandonment. Yet it is not possible to identify the moment when this abandonment took place.

Presence of iron and manganese nodules

Most of the layers toward the base of the well-cistern contained bones bearing black spots on their cortex interpreted as manganese oxide. Their numbers among each stratigraphical unit range from a minimum of 1.6% (SU 7058) and a maximum of 6.4% (SU 7071) **(Fig. 9)**. These observations are from electron microscope analyses as these features are not visible macroscopically. All reveal a strong presence of both iron and manganese oxide **(Fig. 10a and 10b)**.

Fig. 10a and 10b

The presence of nodules of Mn/Fe indicate hydromorphic atmospheres characteristic of soils subject to intense seasonal changes. During wet phases the Mn/Fe content is reduced and mobilised, while during the dryer aeration phases the Fe and Mn oxidise and precipitate[8]. Furthermore, manganese precipitation is also associated with the decomposition of organic matter during diagenesis (Berner 1981; Parker and Toots 1970). This could explain the presence of certain limbs in anatomical connection or presenting dermal tissue remains (consistent with consumption waste), and/or the deposit of other plant remains in the well-cistern. Another fact that bolsters this hypothesis is the macroscopic observation of black spots on diaphyses and metaphyses, yet absent on articular surfaces suggesting that the manganese staining occurred when the elements were in anatomical connection (López-González *et al.* 2006). These types of chemical alterations also offer indirect data regarding the environment and context of bone depositions. This is the case of the pH[9] of the water as Mn oxide precipitates in neutral and/or alkaline soils or environments marked by a high Eh value (above 0.4) **(Fig. 11)**. Thus we can infer that the pH of the well-cistern must have been neutral as otherwise it would not have favoured activation of the microorganisms responsible for the decomposition of the organic remains because these microorganisms do not tolerate conditions far beyond the neutral value (pH 7).

Fig. 11

The combination of the different elements indicate that the fauna specific to stratigraphical units 7058, 7071 and 7067 of the well-cistern clearly reveal the fluctuations of groundwater level as precipitation of manganese oxide is present on the bones up to the level of SU 7078. This indicates that the faunal remains found their way into the feature during periods when the water level was high and therefore would have been subject to hydrolysis. Furthermore, the precipitation of manganese, in addition to the limestone concretions, reveals a particular oxidising environment (humid conditions without being completely submerged) favouring precipitation. In short, although the groundwater level would have decreased considerably during the summer, the well-cistern would never have dried out completely and its base always retained unpotable water due to stagnation and the presence of dissolved organic matter.

Presence of micronodules of barium

8 It is noteworthy that manganese always reduces to higher Eh values than the iron meaning that when the soil is moist, manganese will be the first to mobilise, whereas in conditions of desiccation it will be the last. It is therefore the most mobile element. This is illustrated in Fig. 9 where the possible variations of the Eh values are represented in the case of a soil subject to two different changes in humidity with a brief hydromorphism (blue line) compared to a more intense hydromorphism (yellow line).

9 pH is a value that indicates whether a product or material is acidic (pH < 7), alcaline (pH > 7) or neutral (pH = 7).

The electron microscope revealed a high presence of barium in several bones **(Fig. 10a and 10b)** from stratigraphical units 7058, 7053 and 7078. Barium, an element similar to calcium, occupies the eighteenth place in terms of abundance in the earth's crust. At 0.04%, it represents a value between other alkaline earth metals (calcium and strontium). This element is highly concentrated in plants and shellfish, but very low in meat (Whitmer *et al*. 1989, 209). It must also be kept in mind that due to the low solubility of its salts, it is virtually nonexistent in aquatic environments (Arnay Rosa *et al*. 2008, 834). Its presence at the base of the well-cistern therefore probably indicative of plant matter (fungi, algae and plants) suggesting a high biological activity.

Presence of calcareous concretions

Calcareous concretions[10] result from the precipitation of soluble salts on the surface of bones and teeth derived from sediments and transported by groundwater. Surface calcification (precipitation of calcium carbonate salts) is very usual among archaeological remains as calcium carbonates are common in soils. When they are present in small amounts (e.g. 1%), they can raise soil pH average above neutral (value above 7) and sustain a high level of biological activity. The level of calcification in the case of the well-cistern was not particularly high, but most of the bone surfaces were affected by these rather plastic and clayish concretions when the water level rose **(Fig. 9)**. In the cases of clay or silt in suspension, the concretions were hardened with calcium carbonate and took on either a greyish or brownish colour depending on the impurities and the surrounding environment. This could explain the grey colour characteristic of the silt, and the reducing atmosphere levels toward the base of the well-cistern.

Electron microscope analyses of the concretions on the bones reveal they are composed for the most part of calcium (Ca) accompanied by traces of iron (Fe), silicon (Si), magnesium[11](Mg), potassium[12] (K) and sodium[13] (Na) **(Fig. 10b)**. These result from a direct contact of the bones with the sediments. This composition therefore evidences a high alkaline environment resulting from the metal alkaloids in the sediment (and possibly in the natural environment), as well as the presence of organic plant and animal decay. All of these elements would have favoured a characteristic grey tint on the calcareous concretions.
These types of concretions are indicators of groundwater level fluctuations as calcium carbonates are the first substances to develop on bone surfaces in an oxidising atmosphere (desiccation) (Rivas-Barzola 2008, 46-47). They are present in a maximum of 31.1% of the samples from SU 7058, one of the uppermost layers of the base of the well-cistern. From top to bottom the percentages of the units decrease drastically, i.e. from 17% in SU 7071 to 3.4% in SU 7078, the lowest layer **(Fig. 9)**. The backfill layer (SU 7056) also contained concretions on 15.1% of its samples, a value that singles out the maximum level of the water table. The

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10 Calcareous concretions were determined by hydrochloric acid (Hcl) tests carried out by the restoration laboratory of the University of Lleida. Yet these tests only revealed the presence of limestone particles and further analyses are needed to determine other potential components.

11 Magnesium is not isolated in its natural state, but forrms part of many compounds, mostly oxides and salts. It is an insoluble element that responds to hydrochloric acid and therefore reacts when tested on the calcareous concretions.

12 After calcium and phosphorus, potassium is the most common mineral in most living beings such as cereals, meat, vegetables, fruits and legumes.

13The most important sodium salts in nature are sodium chloride (rock salt), sodium carbonate (soda and trona), borate sodium (borax), sodium nitrate and sodium sulfate. Sodium salts are found in seawater, salt lakes, alkaline lakes and mineral springs.

stratigraphy of the access ramp (7/3), in turn, raises many issues, notably the origin of its backfill **(Fig. 12)**. The types of fauna in this feature are the same as described above in the well-cistern (7/1).

Fig. 12

Although there are a number of different types of taphonomic agents, one is particularly noteworthy. Archaeozoological analyses indicate that bones in several stratigraphic units present a taphonomic portrait that is almost identical to that of the hydromorphic levels of the base of the well-cistern. This regards SU 7053 in particular (linked to SU 7058 and 7071 of the well-cistern 7/1) **(Fig. 9 and 12)**. In this case 50% of the bones reveal a characteristic dark brown cortex and very high level and mineralization and calcareous concretions (5.1% of the cases). These hydromorphic indicators are also present in the layers covering the ramp (SU 7073, 7074, 7076 and 7077), although at a lower rate **(Fig. 12)**. These taphonomic situations lead to two hypotheses:

1. The water table would have invaded part of the ramp rendering it unusable for a long period of time.

2. The well-cistern was periodically cleaned. This notion, advanced by the archaeologists who excavated the feature, could explain the greenish silt found on the ramp that is identical to a deposit at the base of the well-cistern.

The absence of bones in certain stratigraphical units of the ramp (7052, 7060 and 7062) altered by the hydromorphic environment is one of the main factors that allows ruling out the first hypothesis. The remains of the stratigraphical units below 7053 would have been affected by the same alterations if the groundwater had flooded the ramp. The following notions are evidence of cleaning and sanitising the well-cistern's base:

- The apparent cross-mending (belonging to the same individual) of two wolf bones bearing identical alterations (Nieto 2016): an atlas vertebra from the ramp (SU 7058) and a scapula from the base of the well-cistern (SU 7078).

- The electron microscope analysis of samples from both the well-cistern (SU 7058, 7071 and 7078) and the ramp (SU 7053) reveal that all the bones, regardless of their stratigraphy, bear identical macroscopic abnormalities, as well as a virtually identical chemical composition (small variations of concentrations from unit to unit).

- The presence at the base of the well-cistern, as well as on the ramp, of grey-green clay and silt deposits characteristic of hydromorphic and reducing atmospheres.

Therefore, it can be safely inferred that some of the faunal remains collected on the ramp originated inside the well-cistern. This can also be evidenced by the small size of the bones and bone splinters on the ramp that presumably remained *in situ*, without hindering passage, while the larger obtrusive fragments would have had to be removed.

5. DISCUSSION

From the combination of results of the three lines of study, it can be inferred that most of the faunal remains were deposited during the life span of the well-cistern. Hence most were subject to a hydromorphic[14] environment resulting in the following:

- *Water saturation:* a reducing atmosphere from an excess of water in the soil over a long period of time. The water arrived either through seepage (groundwater) in the form of rain.

- *Absence of dissolved oxygen*: an environment where water is not stirred regularly causing the microorganisms to consume the oxygen giving rise to a reducing atmosphere.

- *Presence of dissolved organic matter*: soils poor in organic matter, even when saturated with water over a long period of time, do not show hydromorphic traits. This is characteristic of fauna in organic-rich soils.

- *High temperature*: the lowering of the water table and the rise of the water temperature during the summer months favours the increase of biological activity. This type of hydromorphic activity develops at 5 ^{o}C.

- *pH not excessively acidic*: Fe and Mn precipitate in neutral pH or slightly alkaline soils or in slightly moist and/or dry contexts (indicator of water table variability).

- *Oxidising/reducing atmosphere*: Mn and Fe have to pass through either short or long phases of hydromorphism so as to first dissolve before they can precipitate on the bones during oxidation periods.

Alterations by atmospheric agents (fissures, flaking, cortical alteration) also had an impact on most of the bones and serve as evidence of a possible secondary deposition (also corroborated by a few traces linked to carnivores) of certain faunal remains. It is also possible that the variability of the water table level affected the upper levels of the base of the well-cistern. The layers showing the highest percentage of alterations are SU 7056 and 7067 (although only containing 18 remains) and 7068. These alterations, resulting from sudden changes in dry/wet environments or exposure to the elements over a relatively long period, are not representative and would not have hardly affected the faunal remains which usually reveal an excellent state of mineralization. Hence these alterations are only mentioned briefly in this section. The action of roots is also insignificant in the layers toward the base of the well-cistern as roots are concentrated in the upper levels of backfill/abandonment (SU 7056).

This leads to the initial questions of why was refuse cast into a feature intended to provide the settlement's inhabitants with drinking water, and why was the well-cistern's base periodically cleaned? A first response is that the feature, for an unknown reason, was not fulfilling its function. A second possibility is that its water was contaminated and no longer potable. Three factors could have provoked this situation:

14 Hidromorphia is a state of permanent or temporary water soil saturation resulting in reducing conditions that have significant effects on soil (Aguilar et al. 2007).

- Salinity: A hypothesis in a recent study on water seepage between the Vilars moat and the well-cistern is that the groundwater crossed a salt-rich aquitard and attained the well-cistern with a high degree of salinity (Poch et al. 2014) rendering it undrinkable for people and livestock. In addition, the Estany d'Ivars, a lagoon, about 15 km to the north of Vilars, was dry during several summers, reducing the availability of water for the moat.

- Organic waste from livestock, fruit and vegetables: Concentrations of organic material result in a high percentage of phosphates in low, stagnated water levels provoking a rapid growth of algae. Populations of algae, in turn, require a large quantity of oxygen, a situation favouring reducing atmospheres.

- Manure filtrations: Nitrogen from manure not absorbed by plants is converted into nitrate by microorganisms in the soil and transported by rainwater into the water table. This third factor is unlikely at Vilars as its livestock production was self-sufficient (Nieto 2012; 2016) resulting in a minimal amount of manure filtration into the groundwater.

Although the results of physical-chemical analyses of both the bones and current water table[15] did not detect an anomalous presence of nitrates, they did reveal a high phosphate content. This fact, in addition to a robust presence of manganese and barium, allows supposing the existence of a low water table level and poor water circulation, with the well-cistern infested by algae and contaminated by animal and plant decay. These factors would have brought on an environment necessitating periodic cleaning and sanitation leaving traces like those observed during the excavation. Moreover, during the period before the well-cistern's abandonment, the ramp would have been obstructed by a large number of faunal remains rendering the water undrinkable.

This study offers a very different image of the well-cistern contrasting with previous analyses of soil samples collected in the moat and the well-cistern carried out by Ramon Julià (CSIC: Consejo Superior de Investigaciones Científicas), Santi Riera (University of Barcelona) and Andrés Currás (University of Barcelona) that point out precisely the absence of coprophilic fungi characteristic of decomposition of organic matter and excrements, as well as the absence of faecal algae (Junyent *et al*. 2009-2010). The absence of diatoms and ostracods characteristic of clean water (devoid of parasites) apt for human consumption, suggests a covered well-cistern (protected from light) with a renewal of filtered water guaranteed by the moat in unpolluted and unanoxic conditions (Junyent *et al*. 2009-2010, 161). The earlier research reflects, in fact, the situation of the lowest stratigraphic layers of the well-cistern[16]. Studies of the later abandonment levels containing the remains of fauna, on the other hand, identified five coprolites: four in the interior of the well-cistern (SU 7158, SU 7148) and a fifth at the base of the ramp (SU 7076) (Nieto 2012).

A low water table combined with a well-cistern with stagnant water infested by algae provoking its abandonment cannot only evidenced by taphonomy. Other palaeoenvironmental and

15 A physicochemical analysis of the current water table in contact with the archaeological sediments of the structure was carried out at Salut Publica laboratory of the Health Department of the city of Lleida (Generalitat de Catalunya) to determine its pH so as to rule out potential nitrate or sulphate contamination of the archaeological samples that would have influenced the physicochemical analyses of the bone assemblages as they were permanently under the water.

16 The exact depth and position of the columns of sediment samples collected in the well-cistern are not published.

electrical conductivity of water studies are necessary. Following this line, the results of a $\delta^{13}C$ speleotheme analysis reveals a dry spell in the north of the Iberian Peninsula from 2500 to 1650 cal BP (550 BCE to 300 CE) contrasting with the previous period ranging from 2850-2500 cal BP (900-550 BCE) (Martín-Chivelet et al. 2011). Fluvial research also confirms that this period of Protohistory was characterised by strong hydrological activity and that alluvion accumulations in rivers in different areas of Europe and the Mediterranean (including Aragon) came to an end between 500 and 300/250 BCE (Magny and Richard 1992, 59-60). Anthracological research also evidences a dry period beginning about 500 BCE (Alonso *et al*. 2004). Palynological research of cores from the Estany d'Ivars Lagoon by the team of Ramon Julià, Santi Riera and Andrés Currás point to a very arid environment with a great dry spell at about 320 BCE. In addition, studies of water conductivity indicate that the Aixaragall Stream near Vilars fed both the moat and the well-cistern (Poch *et al*. 2014), and a period of drought could have significantly diminished the level of the groundwater which could have led to contamination, and consequently, abandonment, of the well-cistern.

6. CONCLUSION

Taphonomic and archaeozoological analyses advanced in this paper allow characterisation of the nature, the dynamics of deposition and the taphonomic portrait of the faunal remains subject to hydromorphic conditions in the well-cistern of the Fortress of Vilars. The different studies point to a secondary use of the well-cistern as a refuse tip serving to discard remains of animal consumption and other materials. Furthermore, the findings reject the notion that the well-cistern served for votive or ritual offerings.

The combination of the taphonomic analyses gleaned from macroscopic observations with data obtained from electron microscopy suggest very low, although not totally desiccated, levels of the water table at the moment of the well-cistern's abandonment. This leads to the hypothesis that it's abandonment and transformation into a refuse tip was due to the lack of potability of its water. This study, besides reconstructing the different depositional sequences of the well-cistern of Vilars, serves as a benchmark to identify and reconstruct the taphonomic processes of similar features in other archaeological contexts.

7. ACKNOWLEDGEMENTS

This paper has been suported by the Departament d'Història de la Universitat de Lleida; by the Grup d'Investigació Prehistòrica de la Universitat de Lleida (GIP); by CNRS-UMR 5140 Archéologie des Sociétés Méditerranéennes (ASM-CNRS) (Montpellier, France), by LabEx ARCHIMEDE « Archéologie et Histoire de la Méditerranée et de l'Égypte anciennes » and by ministerial project: *Prácticas agroalimentarias, asentamientos y espacios domésticos. Relaciones y evolución en los llanos sur-pirenaicos (III-I milenios ANE)* (HAR2016-78277-R), Ministerio de Economía y Competitividad (Spain). Timoty Anderson made corrections and translation the text into English.

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Figure captions

Fig.1. **A)** Location of the Vilars Fortress and the well-cistern (CS-47). **B)** Vilars Forteress plan with the different zones and the site chronology. **C-E)** Different aerial views of the fortress. **D)** The CS-47 excavation (sector 7/1) photograph, 2009. **F)** State of the CS-47 in 2008. **G)** Aerial view of the CS-47. Photos: GIP (Grup d'Investigació Prehistorica), University of Lleida (Catalonia,Spain).

Fig. 2. Methodology: **A)** Colours of the bone remains of the well-cistern (CS-47). **B)** Process of bone sampling and preparation for analysis by electronic microscope. **C)** List of the CS-47 (sectors 7/1 and 7/1) stratigraphical units (SU) and inventory of the samples retained for analysis.

Fig. 3. Global representativity (in percent) for the NR, NRD, NRind, NMI of faunal assemblages by units (US) for the well-cistern (7/1) and the ramp (7/3).

Fig.4. Graphic representation of the faunal (top) and pottery (below) assemblages in the units of the well-cistern (sector 7/1).

Fig. 5. Graphic representation of the faunal and pottery assemblages in the units of the ramp of the well-cistern (sector 7/3).

Fig. 6. **A)** Table indicating the percentage of global representativity of the different animal parts the well-cistern (sector 7/1) and the ramp (sector 7/3). **B)** Quantification of the NR, NRND and NMI by taxon of the sectors of the well-cistern (sector 7/1) and their graphic representation.

Fig. 7. Representation of the anatomical elements and the cutting marks of the most numerous species found in the CS-47. The quantification has been realised from the NRp in order to have a more precise image of the importance of every bone in the skeleton.

Fig. 8. Table and graphic representation of the data indicating the different taphonomic agents and the degree they affect the artefacts in the well-cistern (sector 7/1) and the ramp (sector 7/3).

Fig. 9. Sections of the well-cistern (sector 7/1) illustrating the percentages of bones affected by water-related and other taphononic agents.

Fig. 10a. Electronic microscope views of selected samples from sectors 7/1 and 7/3.

Fig.10b. Electronic microscope views of selected samples from sectors 7/1.

Fig. 11. Stability field diagram of Iron and Manganese in [the regions corresponding to] soils that are dry and humid or with stagnant water, to visualise under what conditions these elements precipitated on the fauna of the well-cistern (credits: http://www.edafologia.net/hidro/conceptw.htm; date consulted: 21/03/17).

Fig. 12. Section of the ramp (sector 7/3) illustrating the percentages of bones affected by water-related and other taphononic agents.

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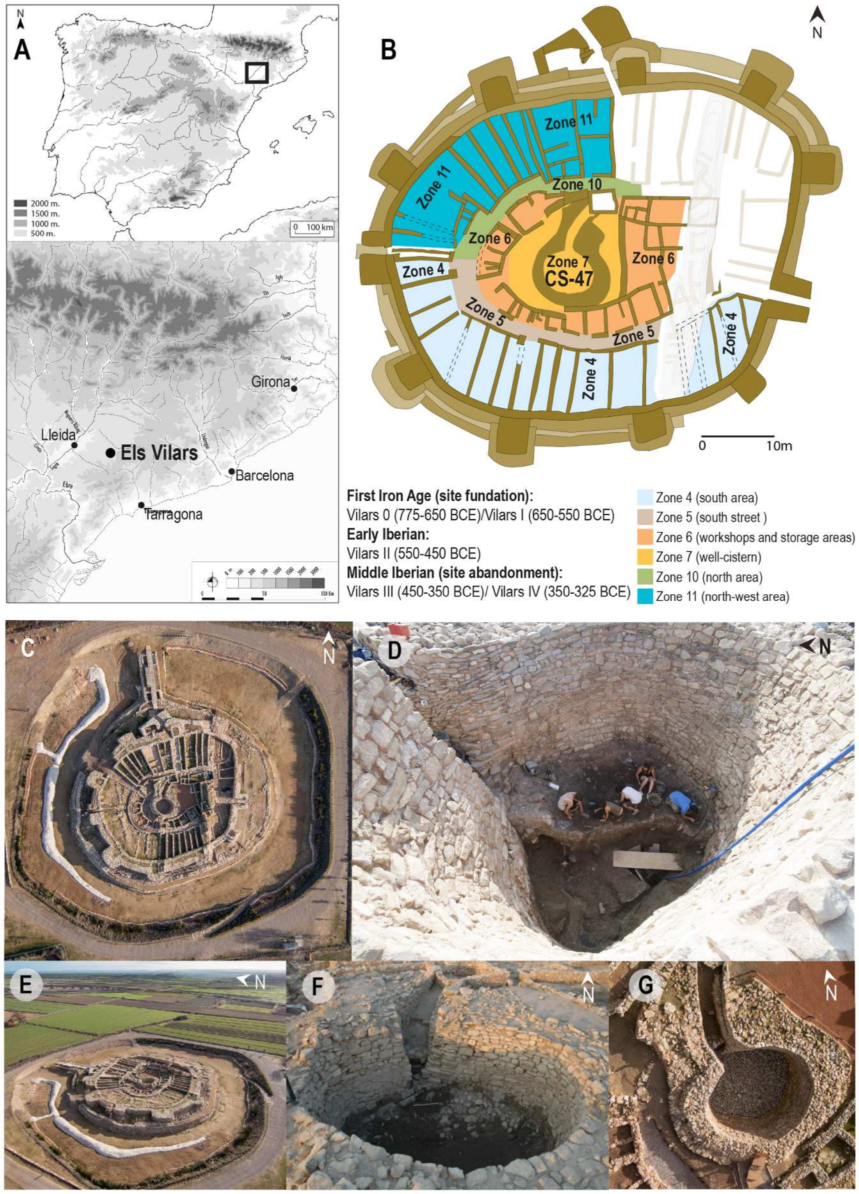

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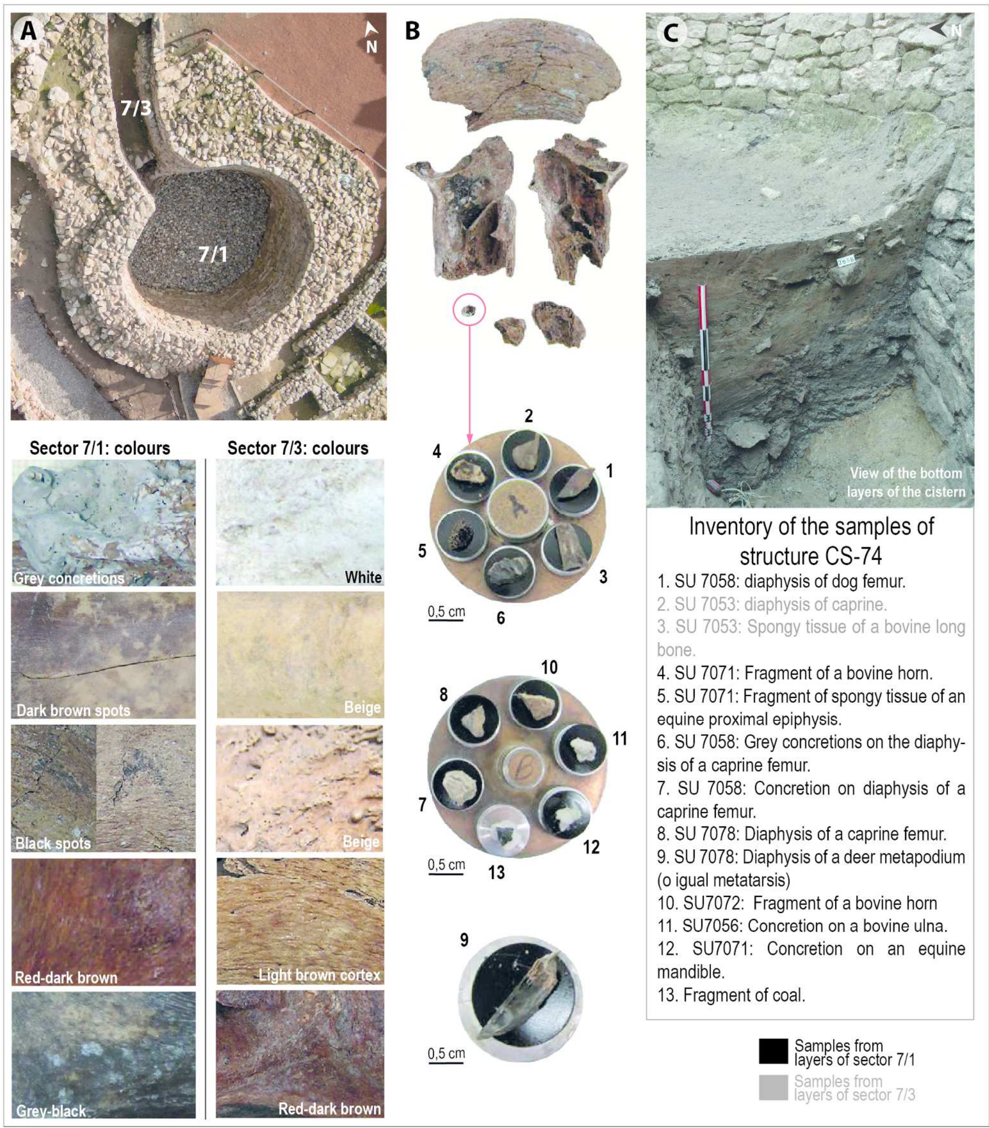
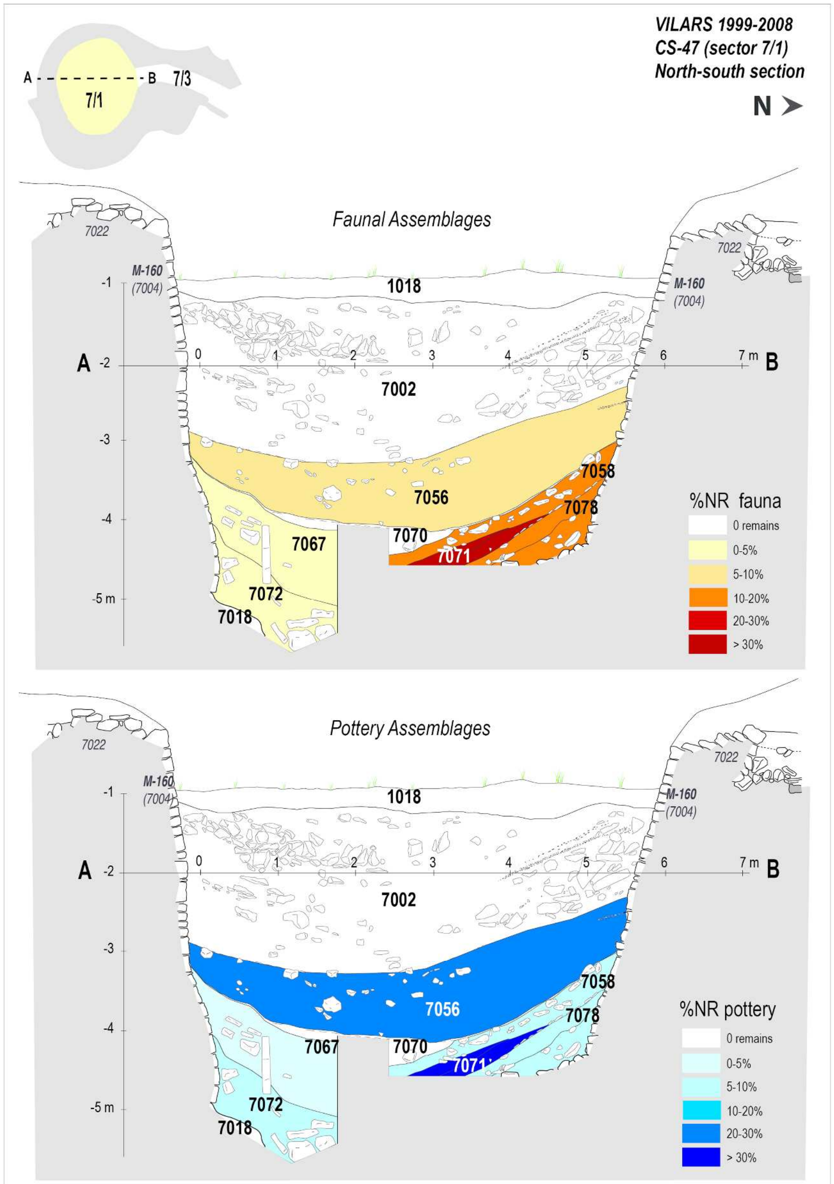


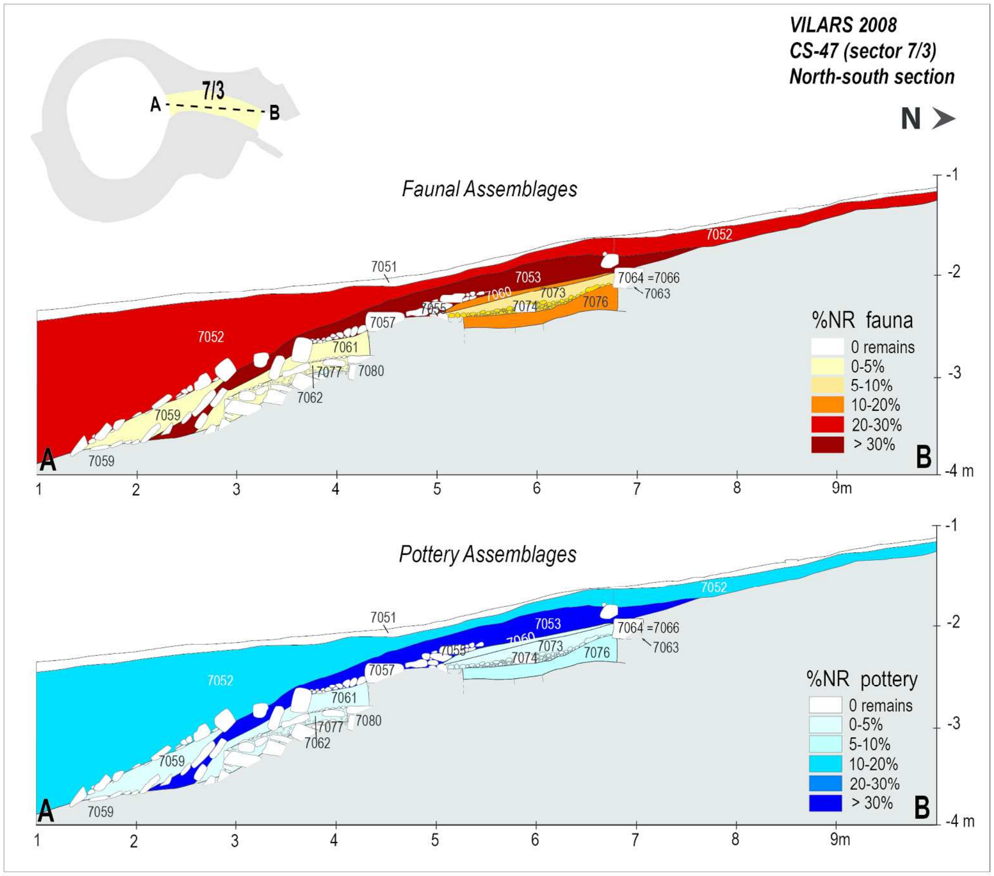
184x209mm (300 x 300 DPI)

SU	Sector	NR	NRD	NRind	NR domestic	NR wild	NMI	NMI domestic	NMI wild
7056	7/1	80	73	7	26	47	10	8	2
7058	7/1	131	103	28	70	33	5	4	1
7067	7/1	18	18	0	18	0	4	4	0
7068	7/1	72	71	1	66	5	6	5	1
7071	7/1	484	443	52	173	259	14	11	3
7072	7/1	46	43	3	28	15	5	5	0
7078	7/1	114	89	25	51	38	7	5	2
7086	7/1	111	61	50	52	9	12	10	2
7052	7/3	115	112	3	70	42	10	8	2
7053	7/3	188	178	10	85	93	11	11	0
7060	7/3	70	70	0	17	53	5	5	0
7061	7/3	5	5	0	3	2	3	3	0
7062	7/3	1	1	0	1	0	1	1	0
7065	7/3	3	3	0	0	3	0	0	0
7073	7/3	35	33	2	15	18	6	5	1
7074	7/3	26	20	6	14	6	4	4	0
7076	7/3	56	44	12	25	19	6	6	0
7077	7/3	5	5	0	2	3	1	1	0
7050	7/1-7/3	7	7	0	5	2	3	3	0
7059	7/1-7/3	5	5	0	2	3	3	2	1
	TOTAL	**1572**	**1384**	**199**	**723**	**650**	**116**	**101**	**15**

141x123mm (300 x 300 DPI)



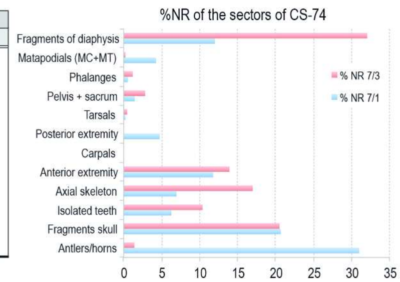
183x263mm (300 x 300 DPI)



198x175mm (300 x 300 DPI)

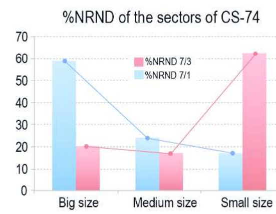
A

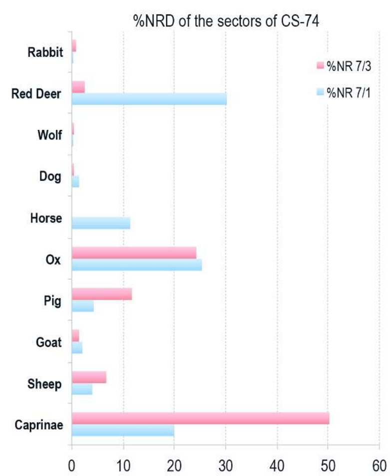
	Sector 7/1		Sector 7/3	
	NR	%	NR	%
Antlers/horns	276	31,0	6	1,4
Fragments skull	184	20,7	87	20,5
Isolated teeth	56	6,3	44	10,4
Axial skeleton	62	7,0	72	17,0
Anterior extremity	105	11,8	59	13,9
Carpals	0	0	0	0
Posterior extremity	42	4,7	0	0
Tarsals	2	0,2	2	0,5
Pelvis + sacrum	13	1,5	12	2,8
Phalanges	5	0,6	5	1,2
Matapodials (MC+MT)	38	4,3	1	0,2
Fragments of diaphysis	107	12,0	136	32,1
TOTALS	**890**	**100**	**424**	**100**

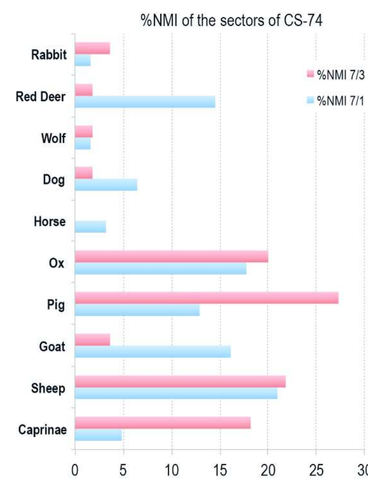


B

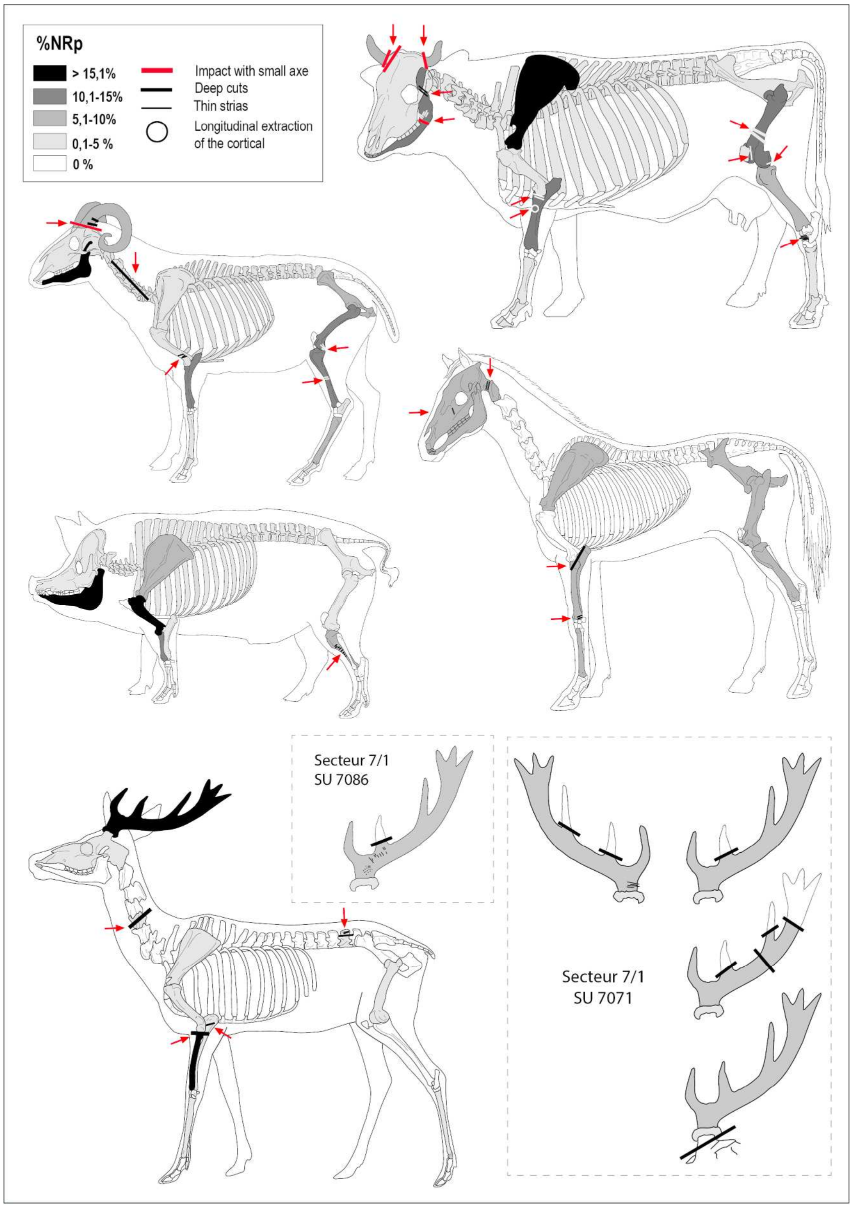
	Sector 7/1				Sector 7/3			
	NR	%	NMI	%	NR	%	NMI	%
Caprinae	140	19,9	3	4,8	120	50,2	10	18,2
Sheep	28	4,0	13	21,0	16	6,7	12	21,8
Goat	22	2,1	10	16,1	7	1,4	2	3,6
Total Caprinae	***190***	***27,1***	***26***	***41,9***	***143***	***59,8***	***24***	***43,6***
Pig	30	4,3	8	12,9	28	11,7	15	27,3
Ox	178	25,4	11	17,7	58	24,3	11	20,0
Horse	80	11,4	2	3,2	0	0	0	0
Dog	10	1,4	4	6,5	1	0,4	1	1,8
Wolf	1	0,1	1	1,6	1	0,4	1	1,8
Red Deer	212	30,2	9	14,5	6	2,5	1	1,8
Rabbit	1	0,1	1	1,6	2	0,8	2	3,6
NRD total	**702**	**100**	**62**	**100**	**239**	**100**	**55**	**100**
Big size	117	58,8			47	20,3		
Medium size	48	24,1			40	17,2		
Small size	34	17,1			145	62,5		
NRND total	**199**	**100**			**232**	**100**		
NRindet total	**166**				**33**			
TOTAL	**1067**		**62**		**504**		**55**	





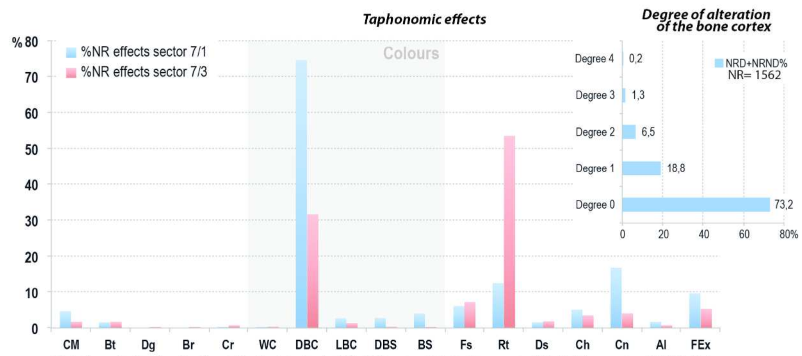


186x267mm (300 x 300 DPI)



185x263mm (300 x 300 DPI)

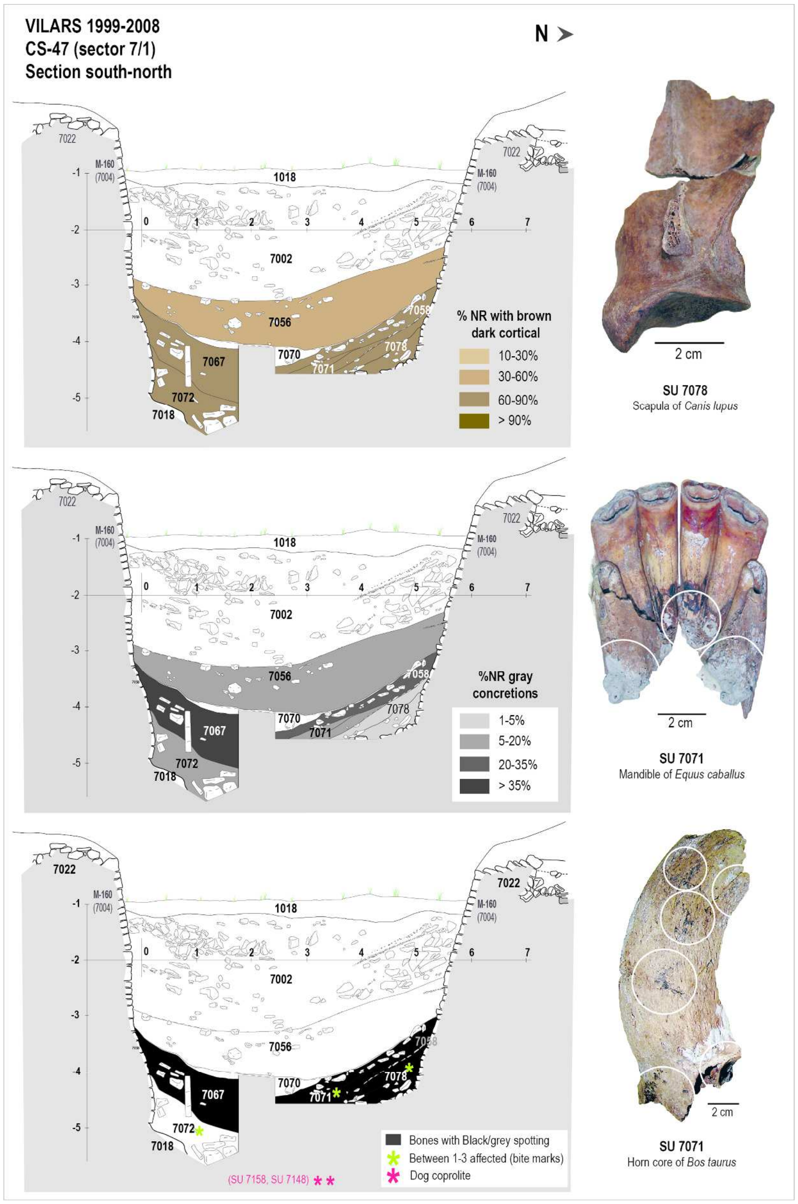
	Sector 7/1	7056		7058		7067		7068		7071		7072		7078		7086		Total NR sector 7/3 = 708	
	Taphonomic effects	NRD=73		NRD=103		NRD=18		NRD= 71		NRD=250		NRD=43		NRD=89		NRD=61		Total NR affected	Total %NR affected
		NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%		
	Cutting marks	2	2,7	3	2,9			3	4,2	16	6,4	2	4,7	2	2,2	5	8,2	**33**	**4,7**
	Bite marks							2	2,8	3	1,2	1	2,3	3	3,4	2	3,3	**11**	**1,6**
	Digested																		
	Burnt																		
	Crushed									1	0,4							**1**	**0,1**
Colours	White cortex			1	1													**1**	**0,1**
	Dark brown cortex	34	46,6	77	74,8	12	66,7	63	88,7	206	82,4	29	67,4	74	83,1	34	55,7	**529**	**74,7**
	Light brown cortex			8	7,8	3	16,7	3	4,2	3	1,2	2	4,7					**19**	**2,7**
	Dark brown spots	3	4,1	2	1,9					14	5,6			1	1,1			**20**	**2,8**
	Black/grey spots			2	1,9	1	5,6	4	5,6	16	6,4			3	3,4	2	3,3	**28**	**4**
	Fissured	12	16,4	2	1,9	2	11,1	7	9,9	10	4	2	4,7	3	3,4	5	8,2	**43**	**6,1**
	Roots	14	19,2	35	34	9	50	4	5,6	2	0,8	5	11,6	15	16,9	5	8,2	**89**	**12,6**
	Dissolved	3	4,1											8	9			**11**	**1,6**
	Chipped	6	8,2	3	2,9			2	2,8	16	6,4	2	4,7	3	3,4	4	6,6	**36**	**5,1**
	Concretions	11	15,1	32	31,1	7	38,9	11	15,5	43	17,2	5	11,6	3	3,4	8	13,1	**120**	**16,9**
	Altered													12	13,5			**12**	**1,7**
	Broken during excavation	2	2,7	10	9,7	5	27,8	4	5,6	21	8,4	6	14	15	16,9	6	9,8	**69**	**9,7**
	TOTAL	**87**		**175**		**39**		**103**		**0**		**54**		**142**		**71**		**1022**	



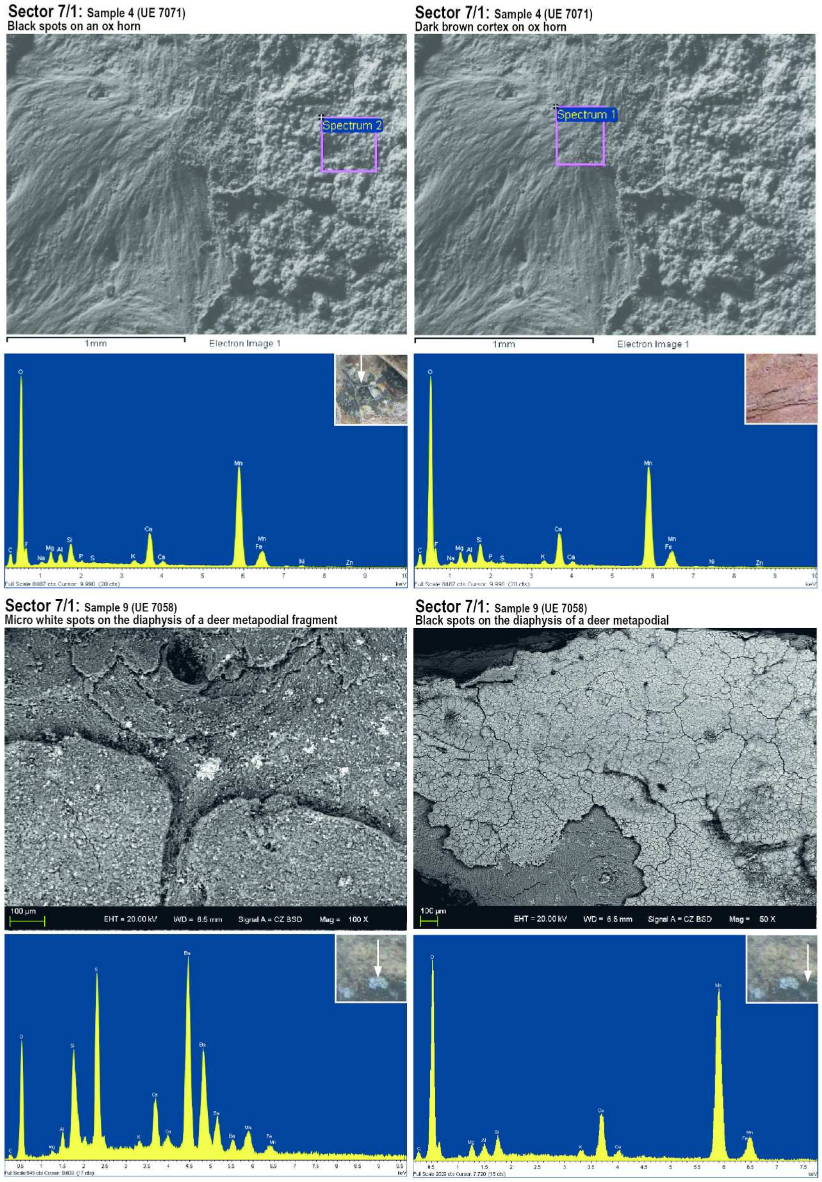
***CM**: Cutting marks, **Bt**: Bitten, **Dg**: Digested, **Br**:Burnt, **Cr**: Crushed, **WC**: White cortex, **DBC**: Dark brown cortex, **LBC**: Light brown cortex, **BDS DBS**: Dark brown spots, **BS**: Black/grey spots, **Fs**: Fisured, **Rt**: Roots, **Ds**: Dissolved, **Ch**: Chipped, **Cn**: Concretions, **Al**: Altered, **FEx**: Fractures excavation.*

	Sector 7/3	7052		7053		7060		7061		7062		7065		7073		7074		7076		7077		7050		7059		Total NR 7/3 = 483	
	Taphonomic effects	NR=112		NR=178		NR=70		NR= 5		NR=1		NR=3		NR=33		NR=20		NR=44		NR=5		NR=7		NR=5		Total NR affected	%
		NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%	NR	%		
	Cutting marks	2	1,8	3	1,7	1	1,4							2	6,1											**8**	**1,7**
	Bite marks	2	1,8	3	1,7	1	1,4							1	3	1	5									**8**	**1,7**
	Digested	1	0,9																							**1**	**0,2**
	Burnt			1	0,6																					**1**	**0,2**
	Crushed	1	0,9			2	2,9	1	20																	**4**	**0,8**
Colours	White cortex																					2	28,6			**2**	**0,4**
	Dark brown cortex			89	50									9	27,3	13	65	37	84,1	5	100					**153**	**31,7**
	Light brown cortex					1	1,4					3	100	3	9,1											**7**	**1,4**
	Dark brown spots										1	33,3	1	3											2	**0,4**	**0,4**
	Black/grey spots																1	2,3							1	**0,2**	**0,2**
	Fissured	15	13,4	6	3,4	2	2,9									4	20	3	6,8	1	20	2	28,6	2	40	**35**	**7,2**
	Roots	84	75	67	37,6	48	68,6	3	60			3	100	13	39,4	17	85	18	40,9	1	20	1	14,3	4	80	**259**	**53,6**
	Dissolved	2	1,8	5	2,8			1	20					1	3											**9**	**1,9**
	Chipped	4	3,6	3	1,7											3	3	3	6,8	3	60			1	20	**17**	**3,5**
	Concretions	5	4,5	9	5,1	1	1,4							1	3	1	5	3	6,8							**20**	**4,1**
	Altered			2	1,1																	2	28,6			**4**	**0,8**
	Broken during excavation	7	6,3	11	6,2									2	6,1	3	15	1	2,3	1	20	1	14,3			**26**	**5,4**
	TOTAL	**123**		**199**		**56**		**5**		**0**		**7**		**33**		**42**		**66**		**11**		**8**		**7**		**557**	

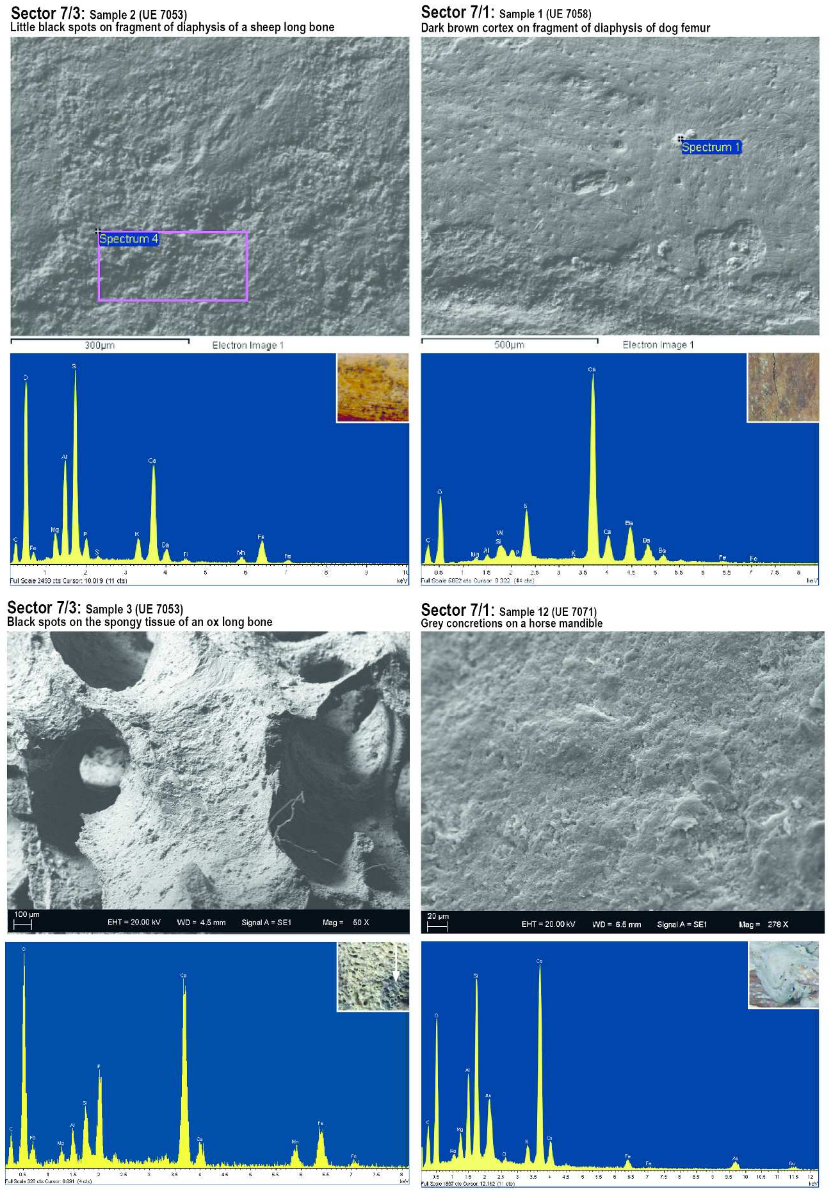
182x257mm (300 x 300 DPI)



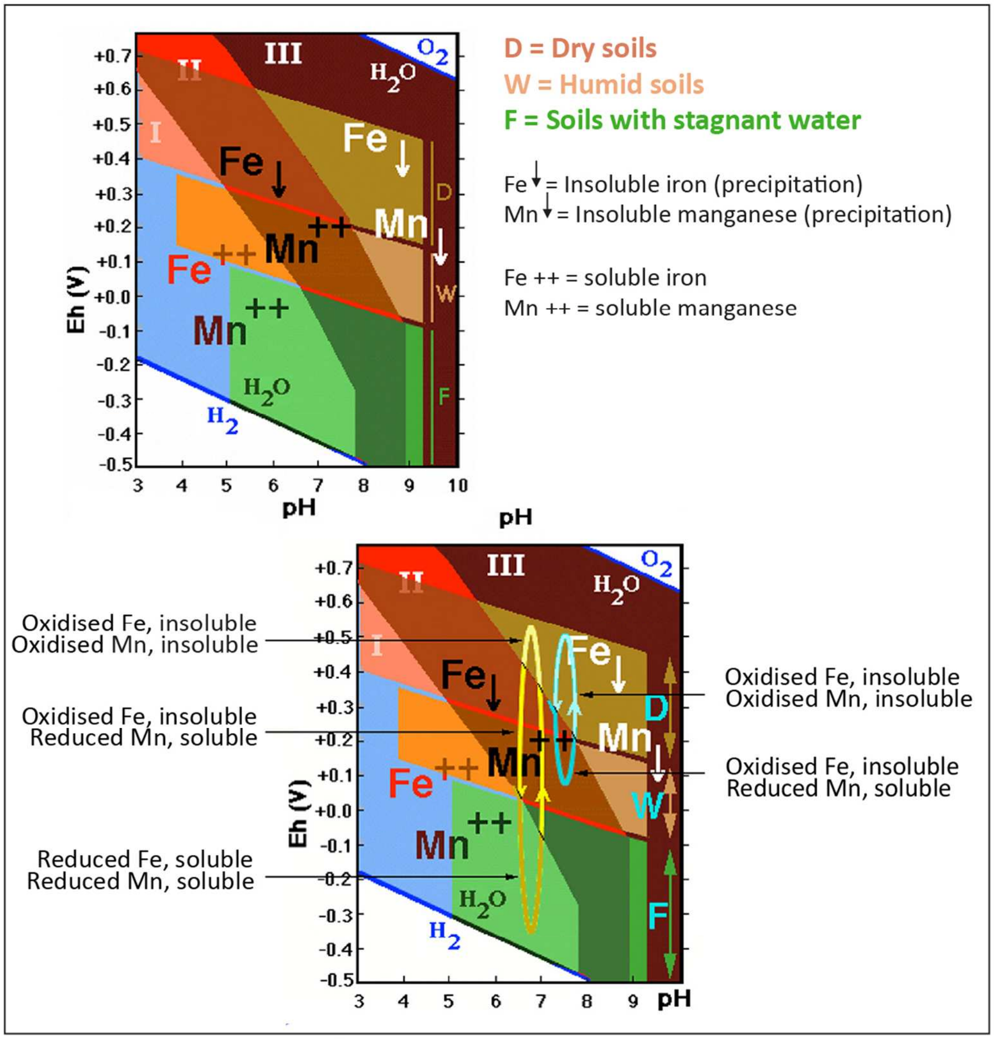
177x269mm (300 x 300 DPI)



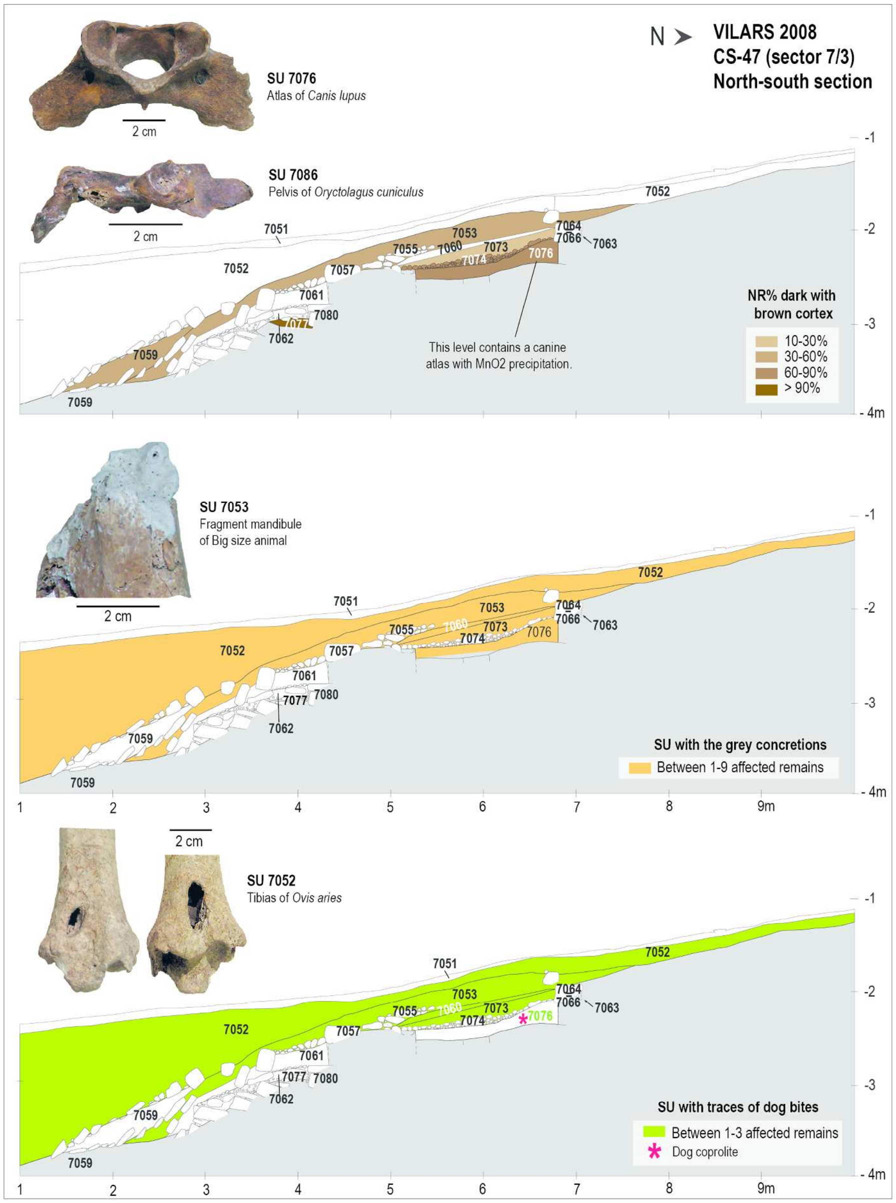
182x259mm (300 x 300 DPI)



181x261mm (300 x 300 DPI)



105x110mm (300 x 300 DPI)



207x248mm (300 x 300 DPI)