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This volume is dedicated to Florin Drașovean at 70 years

Acest volum este dedicat lui Florin Drașovean cu ocazia împlinirii a 70 de ani

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Inside Daub: A Preliminary Study of Burnt Wattle-and-Daub from the Late Bronze Age Site of Sântana–Cetatea Veche

Andrei Mărincean

Abstract: Analysis of fired daub from the third enclosure's defensive wall at the Late Bronze Age site of Sântana–Cetatea Veche (Arad County, Romania) employed a low-cost, portable recording method using a smartphone, kitchen scale, and photogrammetry. From 124 documented fragments (78.7 kg total), impressions were identified from woven rods, posts, planks, vegetal temper, and rare human handprints, including preserved dermatoglyphics. Rod and post diameters correspond to the structural features documented in excavation, while chaff temper indicates measures to improve daub stability and resistance to cracking. Three-dimensional modelling proved effective for preserving fragile material, revealing subtle curvatures, and enabling virtual reconstruction of timber elements. The results show that daub analysis can yield detailed insights into construction techniques, resource use, and human agency in fortification building, even when undertaken outside laboratory conditions.

Keywords: Sântana–Cetatea Veche; Late Bronze Age; daub analysis; wattle and daub; fortifications; photogrammetry; construction techniques; archaeobotany; dermatoglyphics; experimental archaeology.

Introduction

The archaeological excavations at Sântana-Cetatea Veche have revealed large quantities of ceramic building material. The daub in question was affected by a large-scale fire, and makes up the largest part of the archaeological material collected during the excavations. Due to the aforementioned fire, the daub is, for the most part, well preserved: on its surface one can find visible impressions made by the fortification's wooden structural elements as well as by the people who built it. Pottery sherds and complete ceramic ware have been found near and inside the fortification. In this paper I will try to answer several questions mainly pertaining to the fortification system itself. Although much more in-depth studies have been done on the fortification system, such as C14 and dendrochronology of the wood and a large-scale magnetometry which encompasses all enclosures, this article is a case study on what preliminary data can be extracted from daub without sending the material to a laboratory for analysis. It details a methodology which can be applied in the field or in the poorly-equipped storage room, by looking at the daub temper along with the aforementioned structural elements.

Archaeological Context and History of Research

The archaeological site of Sântana–Cetatea Veche, located in Arad County, western Romania, is among the most impressive Bronze Age fortified settlements in the region. Situated in the outskirts between the town of Sântana and the village Zimandu Nou, the site spans an extensive area and represents a regional centre of power attested by the sheer size of the earthworks and buildings, and by the variety and quantity of metal objects discovered on site, including intricate gold pieces[1]. The amount of manpower required to construct such a settlement also implies a hierarchical organisation, and the evidence presented by the destruction of the fortification systems by an outside force implies the emergence of organised military forces in the region.

The site has piqued the interest of antiquarians in the late 19th century, when a large gold hoard was discovered (1888). However, with the exception of a detailed description of the "old fort" by Sándor Márki, and despite the appeals for investigation instigated by the Hungarian Archaeological Society in Budapest, immediate research of the site was not undertaken. Constantin Daicoviciu,

[1] Sava *et al*. 2019, 191-195.

director of the Archaeological Institute in Cluj, also tried to initiate archaeological research at the site, with no luck. After WWII, with the restructuring of the archaeological institutions in Romania by the communists in the 1950s, young archaeologists Egon Dörner and Mircea Rusu took positions at the Regional Museum in Arad, and at the Institute of Archaeology in Cluj respectively. Both born in Arad and lifelong friends, they started collaborating on archaeological research at Sântana-Cetatea Veche. No data was published, however, from the archives of the Museum of Arad we now know that the first small-scale excavations were conducted in 1952, and the evidently Bronze Age pottery revealed that the site, previously thought to be an Avar ring settlement, was in fact a prehistoric settlement[2]. Four trenches were opened in 1963 by the aforementioned archaeologists joined by Ivan Ordentlich from the County Museum of Oradea. Excavating the fortification systems unequivocally dated them to the late stages of the Bronze Age[3]. In the past couple of decades, research initiated in 2008 by Florin Gogâltan (Institute of Archaeology and Art History in Cluj- Napoca), Victor Sava (Museum of Arad) together with Tobias L. Kienlin (University of Bochum) and Dorel Micle (West University of Timișoara) the first magnetometric surveys were initiated. In 2018, the geophysical survey area of 102ha covered the whole fortification (Fig. 1). It was carried out by Dr. Arno Patzelt & Partner[4] and confirmed the existence of at least three fortification systems, which since the 1963 investigations have been designated as enclosures I, II and III. From 2019 to 2023, systematic excavations have been carried out each year, targeting the fortification systems, the large multiphased structure (so-called "structure nr. 1") and the largest of the three tumuli (cca. 10.000 sqm[5]) just outside of the south-eastern part of enclosure III.

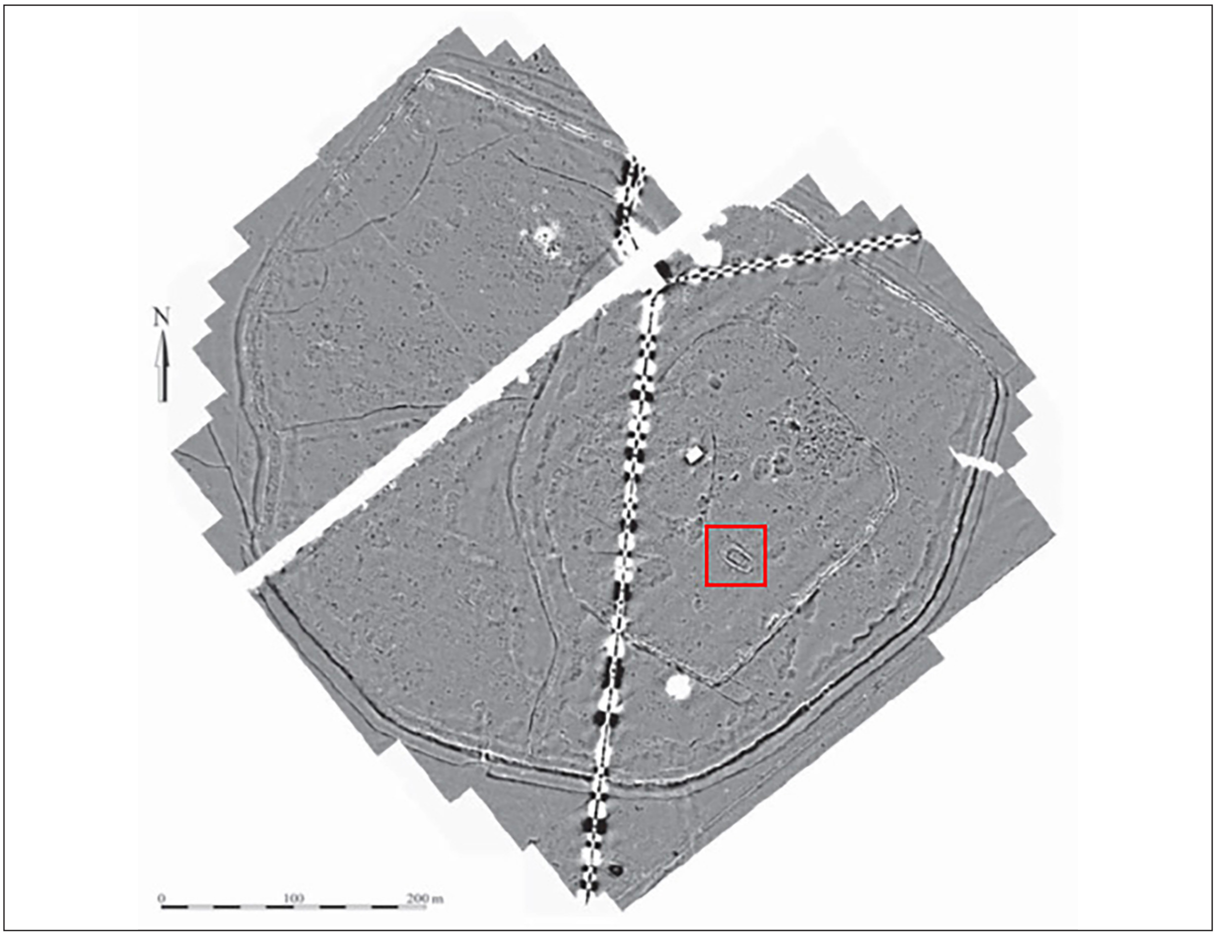

Fig. 1. Magnetometric survey carried out in 2018; from Gogâltan *et al.* 2019.
Red square marks the so-called structure nr. 1.

2 Sava *et al*. 2019, 191-195.
3 Horedt 1967a, 149; Horedt 1967b, 21; Rusu 1969; Horedt 1974, 224 no. 19; Dörner 1974, 224 no. 19; Dörner 1976, 42-4.
4 Sava *et al*. 2019, 191-195.
5 Gogâltan *et al*. 2023, 329-332.

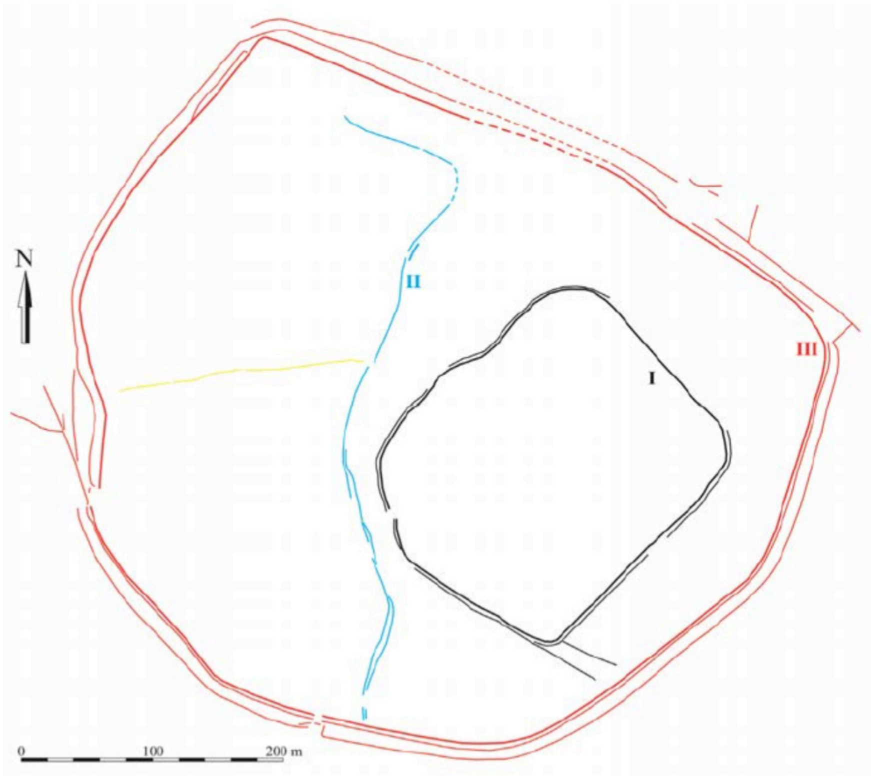

Fig. 2. The three enclosures, and their designated numbers; from Gogâltan *et al*. 2019.

The Fortifications at Sântana - Analogies, Social and Geographical Contexts and Construction

Among the most important characteristic features of the Bronze Age in Europe are the fortified settlements. They are found in most developed regions of the Bronze Age in Europe and are generally located in geographical positions that offer various advantages: resources, transportation/trade routes (rivers), strategic positions (hills). As larger communities emerged during the European Bronze Age, competition for resources created a need for defensive structures to protect settlements from potential raiders. Different groups likely adapted their fortifications to local conditions, using materials that were readily available and familiar. In mountainous areas or near rock quarries, stone was the preferred choice, while in regions where stone was scarce or difficult to obtain, communities relied on wood and earth instead.

The current territory of Romania hosts the settlement of Cornești-Iarcuri. With four enclosures covering a total area of 1765 hectares, it is considered the largest fortified settlement of the Bronze Age in Europe[6]. The fortifications consist of concentric earthworks. The settlement was inhabited for a long period and is attributed to the Cruceni-Belegiš culture[7]. Anthony Harding suggests that the major fortification period occurred after the Vatina settlement phase of the site. The dating of the first fortification phase is uncertain, but the second phase is believed to have occurred around 1400 BC, with the next outer rampart being built approximately a century later[8]. AMS radiocarbon determinations from enclosure III demonstrate that the fortification was constructed and used between the 15th and 13th centuries BC[9]

Something to keep in mind pertaining to Bronze Age settlements is that, of course, not all of them were fortified. Some Bronze Age tells were not fortified. Among them is the Otomani culture site in Füzesabony, Hungary[10]. The fortification elements from this period generally consist of ditches,

[6] Micle *et al*. 2006; Micle *et al*. 2008.
[7] Heeb *et al*. 2016, paragr. 1.
[8] Harding 2017, 11.
[9] Gogâltan *et al*. 2019, 210; Sava *et al*. 2019, 126.
[10] Szathmári 1992, 134.

ramparts, and palisades. In most fortified tells, an "acropolis" can be found. There is no data on the fortification of satellite settlements outside the tells[11]. The notion of a "central settlement" in a certain area exists, for example, in the case of the Feudvar settlement, research shows that there is no other similar settlement in terms of complexity within an area of 17 km long and 7 km wide. In the case of settlements in Slovakia, the estimated distance between them is about 8-20 km[12]. In Hungary, in the case of the Százhalombatta settlement, four fortified sites, eight early Bronze Age settlements, and 18 middle Bronze Age settlements have been discovered within a 22 km area, suggesting a hierarchy of settlements with the center at the tell of Százhalombatta. The economic, social, religious activities, fortification system, occupied area, and adjacent settlements within this area indicate a difference in status between these settlements. The prosperity of these main tells is attributed to the control of communication routes. The existence of fortifications presupposes a clearly structured social organization[13].

The Mureș River's quaternary delta, the Arad Plain, is situated between the Mureș and Crișul Alb rivers and is the place where the Mureș River emerges at the mouth of the Șoimoș-Lipova gorge. The middle portion is generally high and flat, and towards the western portion, a lower marshy area is followed by a high tabular plain area. The central part can be defined as the area between Socodor, Sântana, Sâmbăteni, and Arad. Aerial pictures and the results of several field investigations carried out between 2007 and 2009 revealed that the fortification's position had been chosen strategically. The Mureș River flooded the Arad Plain up to about 20 km away from its current channel, close to the southern portion of Sântana, until the beginning of the 19th century, when work to drain and embank the river began[14].

According to these viewpoints, the fortification was situated in the perfect location, 1.8 km away from the northernmost Mureș river branch, keeping it safe from floods and marshes. According to Sándor Márki's writings, up until the 18th century, the entire region was covered in elm forests (Ulmus minor), which are typical of areas with marshy plains. However, later on, deforestation took place to make way for agricultural development. A terrible fungus also decimated the trees[15]. In actuality, an uprooted elm tree is supported by two lions in the Arad County coat of arms. The historian István Ferenczi offers one potential reconstruction of the historical environment:

„All the way from Mukacevo city (from sub-Carpathian Ukraine) to the present-day capital of Yugoslavia, for months in a row a pond was spanning alongside the Tisa River and also alongside the inferior river flow of all the Carpathian tributaries. Only during the dry mid-summer time did the waters retreat within the river bed, leaving behind large marshy areas for the rest of the year."[16]

The fortification from Sântana would have been a key control point of the Mureș Defile, Șiria Hills, and farther out, of the metalliferous region of the Apuseni Mountains. It was situated 15 km west of the Zărand Mountains, 25 km south-east of the Mureș departure from the mountain region, and 1.8 km far from the old marsh. A day's walk could be used to complete the round-trip route between the Mureș exit onto the plain and the earthwork, which is a relatively short distance to cross on foot[17].

The 2009 excavation campaign's goal was establishing the stratigraphic profile of the site as well as studying the structure of the fortification system and collecting all archaeological data on the contexts that would be affected by the future gas pipeline. As such, three sections were laid out (Fig. 3); S01 was initially 80 x 4 m, but the width was later extended to 6,5 m in front and behind the vallum, while S02 and S03 both had the same dimensions of 10 x 1,5 m. S02 had to be extended by two expansion areas to fully reveal complexes Cx02 and Cx03, whereas the uncovering of Cx04 in S03 warranted its expansion by 1,5 m in length and 2 m in width, bringing the total surface excavated in 2009 to 453,5 sqm.

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11 Gogâltan 2011, 10.
12 Molnár, Imecs 2006, 31.
13 Herrmann 1982, 11-31; Kristiansen 1991, 19-20.
14 Gogâltan, Sava 2010, 11.
15 Marki 1882, 119.
16 Ferenczi 1993, 44.
17 Gogâltan, Sava 2010, 12.

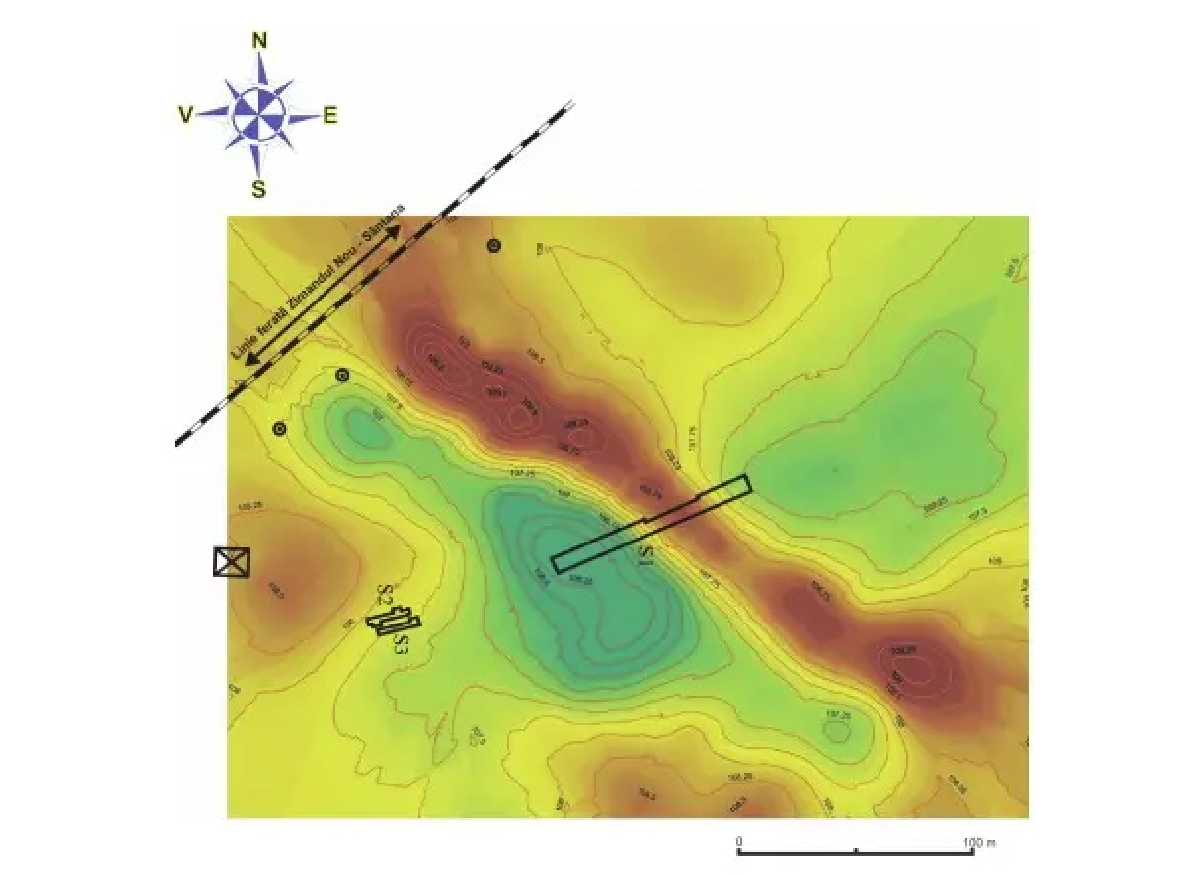

Fig. 3. The 2009 excavation plan. Image from Gogâltan, Sava 2010.

The discovery of a complete vessel (Fig. 4) in the defense ditch reveals the third fortification's age, placing it in the late Bronze Age. The third enclosure also overlaps a Eneolithic settlement, as attested by the Baden culture complexes discovered in the sections. With a NEE-SWW orientation, S01 cuts the vallum and fortification ditch, and in addition an earth displacement ditch with the purpose of raising the vallum was found behind the fortification as well[18].

The vallum is well preserved and at a width of around 27 m with the height at 2,44 m at its highest point, it has impressive dimensions. To raise it, a „core" was first built, with a width of 14 m at the base and 10,4 m towards the top, consisting of a wood beam bed strengthened by a layer of stone, then covered with layers of rammed earth. This core was then encased in a 5 cm thick layer of yellow clay, and subsequently covered in more layers of rammed earth.

On top of the vallum, rather than a simple wooden palisade, a wattle and daub wall was raised: three rows of poles interwoven with withies (or some other kind of flexible slender branches), filled with clods of clay, the resulting wall then loamed at least five times[19]. Burnt clay sling projectiles were found on the outside

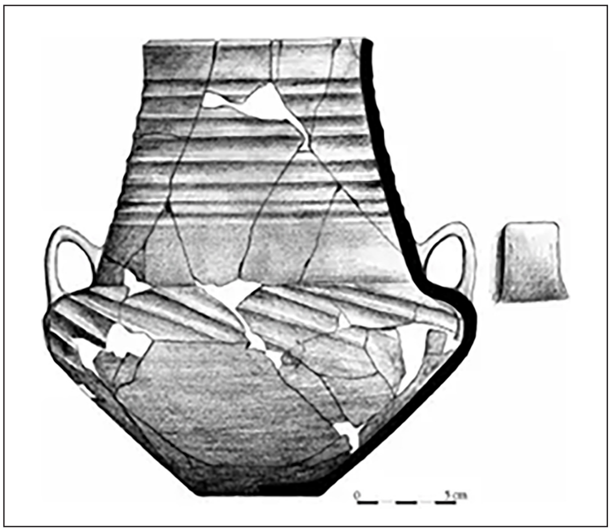

Fig. 4. Vessel found in the defense ditch. Image from Gogâltan, Sava 2010.

[18] Gogâltan, Sava 2010, 29.
[19] Gogâltan, Sava 2010, 33.

of the wall, attesting to a conflict, probably also related to the fire that burned and preserved the fortification.

The defensive ditch has an opening of 10,2 m and a depth of 2,86 m. It has a V shaped section with the outward slope being steeper than the inward one. Measurements for the three enclosures are as follows: Enclosure I (≈800 × 600 m), Enclosure II (≈1,100 × 900 m), and Enclosure III (≈600 × 400 m), each with ramparts, palisades, and ditches[20].

Using the average dimensions from the excavation for the ditch, namely a depth of 2.86 meters and a width of 10.20 meters, we arrive at a result of 105,894.36 cubic meters. To compensate for the difference in earth needed to raise the rampart, excavation was also done behind it. Based on measurements of this trench from the excavation, namely a depth of 2 meters and a width of 29 meters, the volume would amount to 210,530 cubic meters. These numbers are purely indicative but put into perspective the immense effort required for the construction of Enclosure III's fortification.

Methodology

The daub fragments were collected throughout the 2009 Sântana-Cetatea Veche campaign, during which sections of the third enclosure's palisade and ditch were excavated, the third enclosure being the largest of the three. Enclosure IV has since been discovered having a perimeter of approximately 15,735 meters and covering an area of about 1,722 hectares, it is the largest fortification at the site; however it is also the worst preserved among all enclosures, thus it is not possible to estimate its volumes as with the others[21]. The archaeological material discovered includes a reconstructable vessel found in the ditch of the third enclosure's fortification, which, when used to date the defence system, places it towards the end of the Bronze Age[22]. Moreover, whole vessels, metal objects and ceramic sherds belonging to this time period were discovered in the earthen layers which make up the vallum.

Most of the archaeological material collected during this campaign was daub. For its analysis I've implemented an ID number convention: each individual fragment receives a code formed by combining the year it was collected, letters pertaining to the type of material and a 4-digit number (for example, 2009CH0001 wherein CH stands for „*chirpici*", i.e., daub). This convention's use could be further extended for each campaign year, and for different types of material (e.g., 2019BZ0001 for bronze fragments collected in 2019 etc.).

Each fragment was weighed and studied to determine the presence of structural element impressions (posts, planks, rods from the woven lattices), vegetal or wood grain impressions, and human palmar/digital and papillary ridge imprints. Representative fragments for each category were chosen to be photographed. For the photographs, an older DSLR (Nikon D3300 w/ kit 18-50 lens) which was available for use at the time, but proved inadequate, was abandoned for a smartphone. Most modern smartphones have decent camera quality and macro lenses, the latter being especially useful for photographing small details like chaff or papillary ridge imprints.

Due to the fragments' irregular shapes and varying dimensions, polyurethane foam sheets were used to bring the photo scale to the height of the daub facet being photographed, and also for stabilizing the pieces themselves. For 3D modeling, a lightbox and a rotating tray were used to take the photographs, then the Abound app (formerly called Metascan) for photogrammetry and Blender for the final touches. Agisoft Metashape was also successfully used for photogrammetry processing but due to hardware limitations, abound cloud processing deemed to be more efficient. The methodology was designed to require as few devices and tools as possible, to be able to be carried out in the field or in temporary accommodation. As such, preliminary data can be collected using only a smartphone and an inexpensive kitchen scale for the most part. The digital kitchen scale proved to be accurate enough, as few fragments weighed under 100g.

Daub is somewhat friable and prone to keep breaking apart when handled. This fact can be mitigated by scanning the fragments and creating 3D models of them through photogrammetry. This allows for analysis of larger structural imprints such as rod or post impressions to be conducted on a computer rather than having to handle and continually deteriorate the material. The 3D models are also created

[20] Gogâltan *et al*. 2019, 199
[21] Gogâltan, Sava 2012, 64.
[22] Gogâltan, Sava 2010, 28.

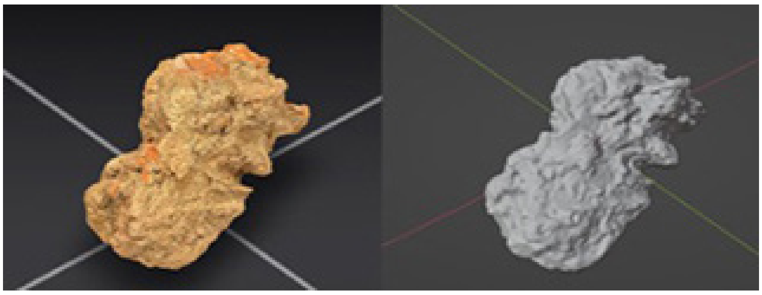

Fig. 5. Fragment 2009CH0112, showing rod impressions. Left shows the 3D model textured but with no shading, right with shading but no texture.

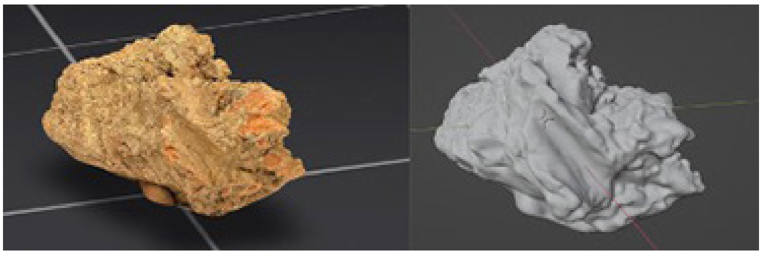

Fig. 6. 2009CH0112, different angle.

in scale, so measurements can be made on the digital model as well.

In the different viewing modes of lighting and textures, different details of the fragment can be viewed. For example, the rod imprints seem to be easier to see when removing the texture but adding shading.

Using 3D modeling it would be possible to reconstruct the wooden structure bit by bit, if enough fragments with intersecting structural elements were found. 2009CH0112 for example also has a post imprint.

When attempting to place a cylindrical object to the 3D modelled daub post imprint using Blender, it would not fit right, due to the fact that the post imprint was slightly curved, in a way that was very difficult to tell with the naked eye. 3D models can reveal some details which might otherwise be missed.

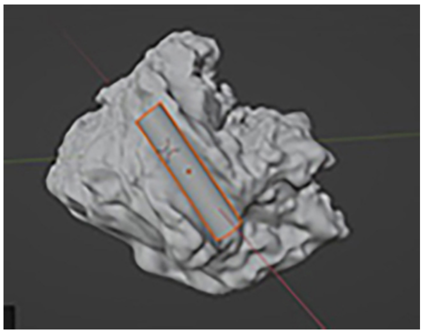

Fig. 7. 3D modelled cylinder placed in the imprint.

The applications of 3D modelling in this way are limited by the size of the imprints and details captured. Fingerprints and vegetal temper are too fine to be captured by the photogrammetry process. For these details, Reflectance Transformation Imaging would most likely be a better approach. Reflectance Transformation Imaging (RTI) is a

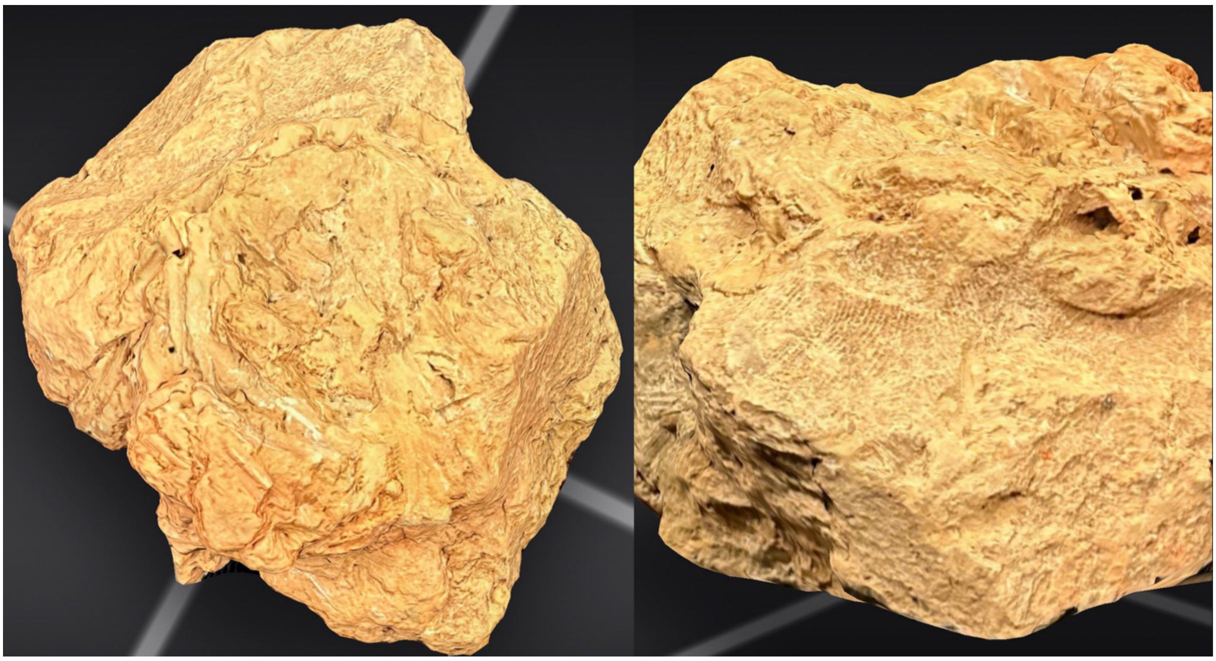

Fig. 8. 3D model of 2009CH0034, from two different angles, showing the temper on the left and the friction ridge impressions on the right.

Fig. 9. 3D model of 2009CH0120. Multiple views, showing how easy it is to get different angles on imprints after scanning.

simple, non-invasive imaging method for examining and cataloguing the surfaces of cultural heritage objects. Using this method, an interactive file is created from a source picture collection. With a variety of computational advances, it enables the viewer to evaluate the visual appearance of an object in various lighting situations, accentuating and disclosing properties of the imaged object[23].

Another limitation is of course the fact that one side must be sacrificed during this type of 3D scanning. The side chosen as „bottom" will not be photographed, therefore the 3D model will have an incomplete side with missing polygons and stretched textures.

Fig. 10. 3D model of 2009CH0033. Different angles, showing a „good angle" as well as the „bottom" of the model.

Choosing a more featureless side is one way to resolve this issue, without circumventing it entirely. This is not a problem with most fragments, as most will have at least one such side.

Results of preliminary study

There are a total of 124 fragments which were collected during the 2009 campaign, 27 of which were marked *passim* and 97 of which were collected from the palisade itself. The total weight of the materials, each weighed individually, was 78.722 kg, with the smallest fragment collected weighing only 20 g and the largest 3842 g. Weight ranges were chosen to better visualize the data, first increasing in increments of 100, 150 grams, then 250, 500 and 1000 grams. Most fragments collected seem to fall into the 100 → 250, 250 → 500 and 500 → 1000-gram ranges, with a few outliers under 100 g and over 1000 g and a single fragment of almost 4000 g (Fig 11). If nothing else, this data shows our tendency to collect material with a selection bias of size, especially when it abounds, and to select those pieces

[23] Conservation Wiki. n.d.

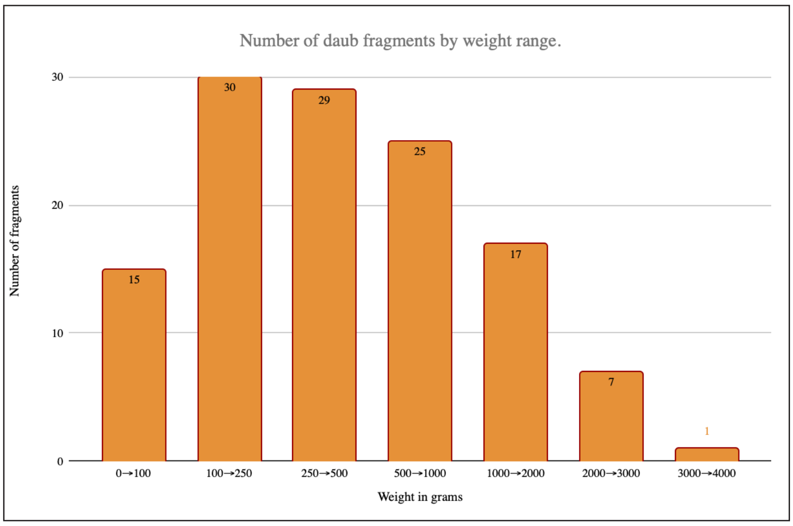

Fig. 11. Number of daub fragments by weight range.

which are more interesting, especially since not all of the daub material can be collected in most part due to logistics issues.

The sample size examined represents the entire material, 124 fragments which were collected during this campaign. It was analysed over a somewhat short period of two weeks, during which it was kept in the storage area of the Institute for Archaeology and Art History Cluj-Napoca, brought from the Museum of Arad.

The process of handling such materials is not without its nuisances, as the weight of the material adds up quickly in the usual cardboard storage boxes, which also tend to break due to its weight. Moreover, the material itself becomes especially dusty in storage and during transportation, so either handling it with gloves or taping some foil over the laptop keyboard is recommended.

Spritzing with an inexpensive misting bottle filled with water seemed viable at first, but proved to be counterproductive due to the subsequent trickling of dirty water from the material. Direct submerging of the material in water is also unsuitable, because lesser burnt fragments, or parts of bigger fragments may dissolve in the water. The most efficient way to clean the material, which was notably supposedly washed at some point since 2009, proved to be by using dry brushes to dust and gently scrub the material.

Fig. 12. 2009CH0111, example of daub fragment with no distinguishable imprints, two sides of the same fragment. Calcareous material is present on one side.

The data resulted from the analysis was introduced into a Microsoft Access database, with parameters including ID number, archaeological context, weight, type of impressions visible (rod, post, plank, hand, vegetal, none) and some additional measurements or parameters for each type (rod diameter, post diameter, clear hand prints, unclear hand prints, burn degree) as well as commentary, box number, camera used to photograph the fragment and the photo numbers.

Although most if not all the daub shows signs of secondary burning, some fragments show signs of much higher heat exposure than others, some even undergoing a process of vitrification. Those who show a change in the daub's color have been marked as such, with the results visible in Fig. 13.

The first criteria for which the daub was analysed is whether or not the fragments present imprints. Imprints refer to the visible marks, patterns, or impressions left on the surface of the daub material. These imprints can be caused by various factors such as the texture of the structural elements used, the inclusion of temper (such as straw or organic fibers), or the intentional or unintentional marks

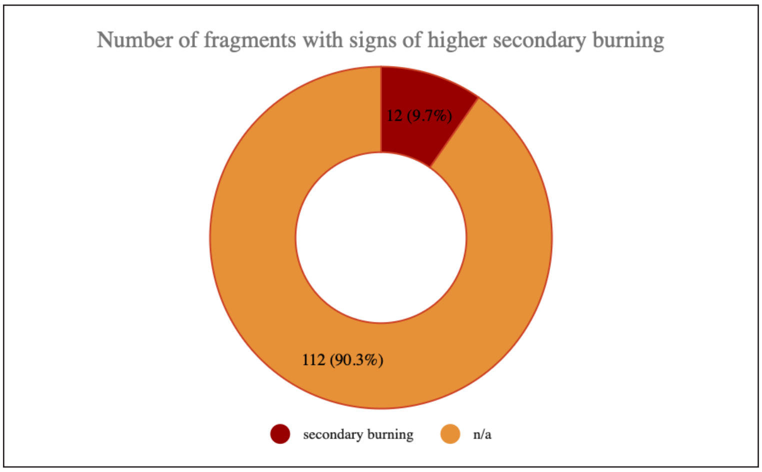

Fig. 13. Number of fragments with signs of higher secondary burning.

Fig. 14. Fragment 2009CH100 shows black coloration as a result of burning.

made by human hands during the construction process. These imprints provide valuable archaeological evidence and can offer insights into construction techniques, materials, and the individuals involved in the creation of the daub structures. Disregarding the type of impressions, most fragments collected have marks that fall into at least one aforementioned category of imprints. As such, the number of fragments which do have said imprints present on their surfaces make up for 69.4% of the total material analysed, at 86 fragments, as shown in the chart below (Fig. 15).

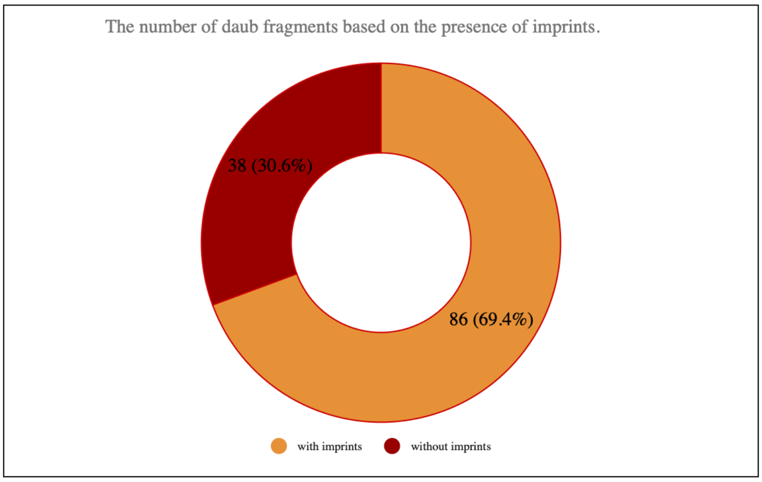

Fig. 15. Number of daub fragments based on the presence of imprints.

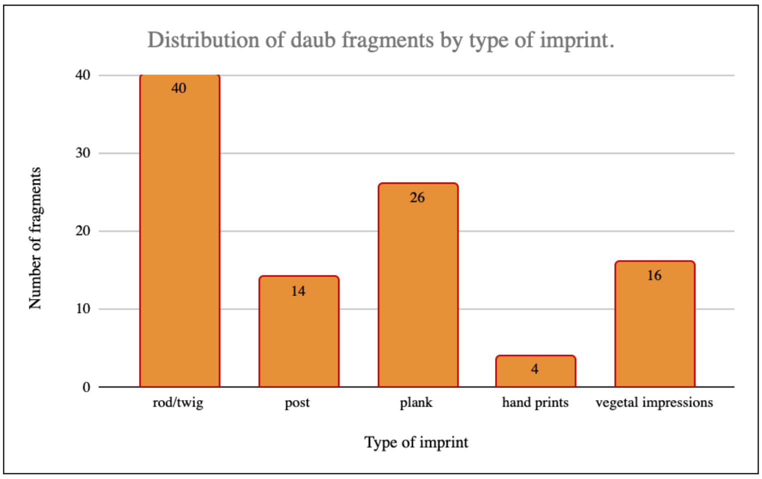

Fig. 16. Distribution of daub fragments by type of imprint.

The type of imprints falls into several categories, namely rod/twig impressions, post impressions, plank impressions, hand print impressions and vegetal impressions. The rod/twig impressions were left by the thin, flexible wooden elements that form the lattice of the wattle structure, the wooden structure on top of which the daub is added. The post impressions are most likely left by the posts of the wattle structure, the ones that support the woven, intertwined rods and the same ones that left the postholes excavated in 2009. Planks may have been used to stabilize the structure in some places, but the later discovery of triangular postholes in different parts of the site have caused me to cast some doubt on my initial categorisation of the imprints as resulting from planks, but for the purpose of this study we shall continue to refer to them as plank impressions. Hand prints are the rarest of them and represent impressions left by human hands while building or maintaining the structure, and last but not least the vegetal impressions were left mostly by the temper used in the daub mixture. Of the fragments which show visible prints, their distribution into the aforementioned categories is shown in Fig. 16.

The first category of impressions is also the most numerous, as 40 rod impressions were identified on the daub fragments. This is most likely due to the sheer number of rods needed to weave the structures between the poles. Statistically there are much higher chances of rod imprints remaining due to the high number of rods that were daubed. The wood used in such structures would usually be some type of willow tree, due to the length, straightness and flexibility of its branches. The diameter of these imprints seems to be consistent with modern coppiced *Salix* species used for wattling. Coppicing is the practice of cutting trees to a stump nearly at soil level, to exploit many species' ability to produce young, straight shoots. This new growth is harvested, and the cycle can begin again.

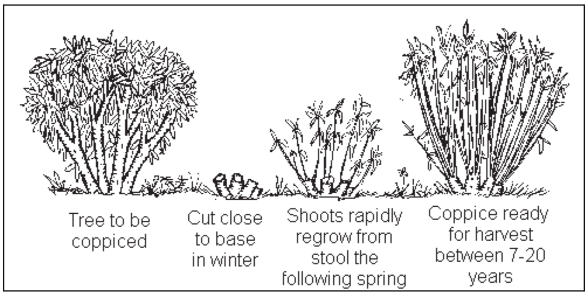

Fig. 17. Coppicing process. Image taken from Wikimedia Commons.

With branches growing over 2 m in length and the diameters ranging between 20 to 40 mm[24], it is possible that the type of rods used in the fortifications were of this origin. Other woods used in wattling include hazel, maple and birch[25], but as seen in the next chart (Fig. 18), more of the rod impressions fall into the 20 mm diameter category than the others, and we know that the area was mostly marshland up until the anthropization process started sometime in the 18th century[26] and most *Salix* species <<*fill the voids of nature (who detests it, as everyone knows): dead branches and islands, wet embankments, marshy wastelands*>>[27]. In any case, further archaeobotanical analysis is required to determine the exact type of withies used in the wattle structure.

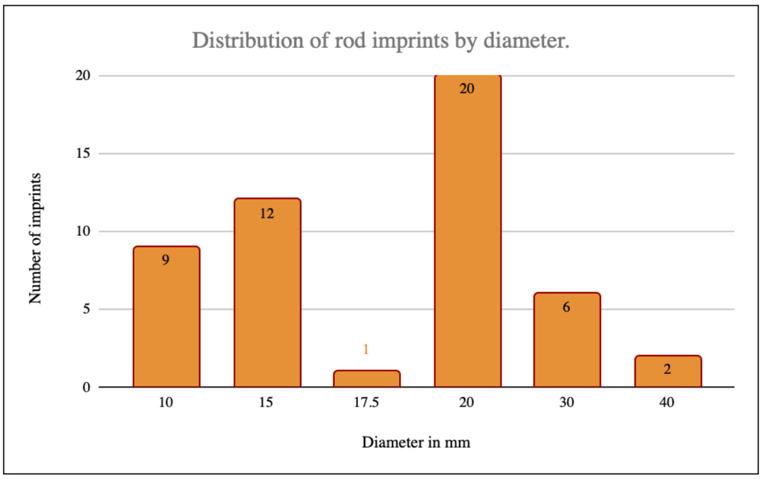

Fig. 18. Distribution of rod imprints by diameter.

Fig. 19. Example of rod imprints on daub. This particular fragment, 2009CH0100 shows two imprints whose directions are almost perpendicular.

The wattle structure is also comprised of posts, which are implemented into the vallum for the withies to be weaved between. Imprints of such poles have been discovered in the daub analysed. Their diameters were estimated using a rim chart, in the same manner it would be used to estimate pottery diameters. The results vary between 8 cm and 18 cm (Fig. 20), which seem to correlate with the post holes in the third enclosure at Sântana-Cetatea Veche.

These posts are arranged into two rows, the posts in each row being relatively close to each other. Placing them in this manner must have provided some sort of structural advantage, consolidating

[24] Pleasant 2007, 125.
[25] Graham 2004, 25
[26] Sava 2015, 13.
[27] Rumelhart, Vidal 1991, 121.

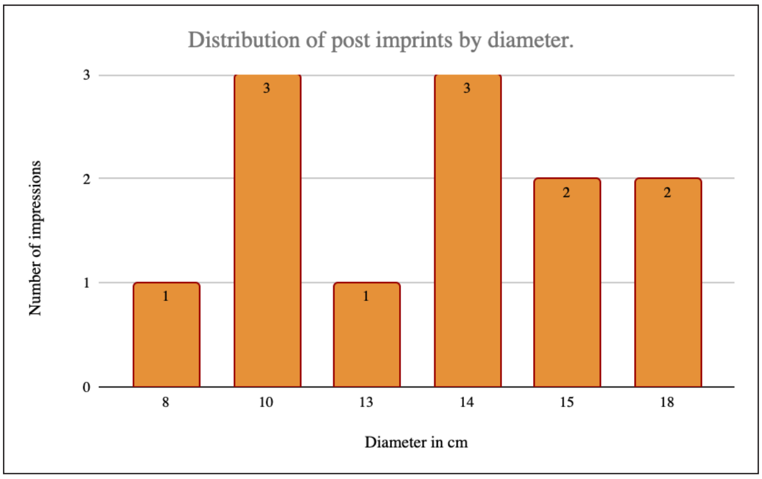

Fig. 20. Distribution of post imprints by diameter.

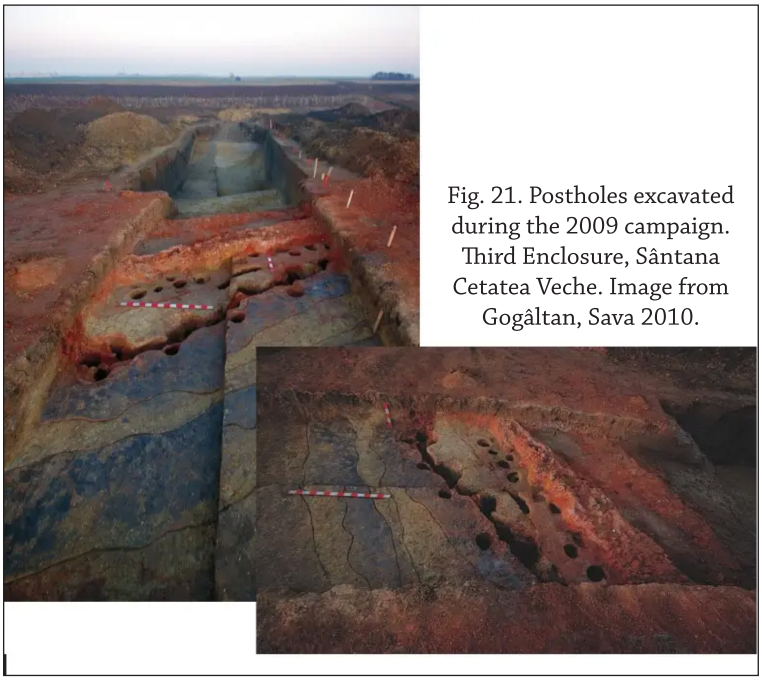

Fig. 21. Postholes excavated during the 2009 campaign. Third Enclosure, Sântana Cetatea Veche. Image from Gogâltan, Sava 2010.

Fig. 22. Postholes in their implementation ditch, on the vallum. Sântana Cetatea Veche 2018. The smaller postholes fall into the diameter ranges as well. Picture from Gogâltan et al. 2019.

the whole structure thus making it sturdier. The space in

Fig. 23. 2009CH058.

Fig. 24. 2009CH0058, showing the curvature of a post impression from a different angle.

Fig. 25. 2009CH0036, a small fragment with a big imprint. The large angle of the imprint curvature seems to suggest a pole, but as with lip pottery fragments, if it shows too small a portion of the circumference, the diameter is difficult to calculate and might yield inaccurate results.

between the two rows would have been filled with daub, which is likely the source of most hand prints – the people who built the defensive structure would grab chunks of daub using their hands and throw it in between the rows of wattle before plastering it with more daub and clay on the outside.

Planks were also used in the defensive structure[28], intertwined between the poles. However, as mentioned before, in some places, triangular poles would be used as well, which would have been larger tree trunks split lengthwise to obtain several poles smaller in diameter. Such poles would have exposed wood grain akin to planks, so would most likely leave some very similar imprints into the daub. Nonetheless, for the purpose of this study, all flat imprints showing wood grain have been referred to as plank imprints. 25 such imprints were identified on the daub analysed, although not much else can be said about them at this time. Archaeobotanical analysis of the wood grain would likely yield some results as to confirm the type of wood used to fashion said planks.

Fig. 26. The curvature of a post imprint in fragment 2009CH0063 shows that the post would have had around 15 cm in diameter.

Fig. 27. Photograph of daub with wood grain imprint (2009CH0062).

Fig. 28. Detail of wood grain (2009CH0062).

[28] Gogâltan *et al*. 2019, 202.

Fig. 29. Fragment 2009CH0062 from another angle, shows wood grain on this side as well.

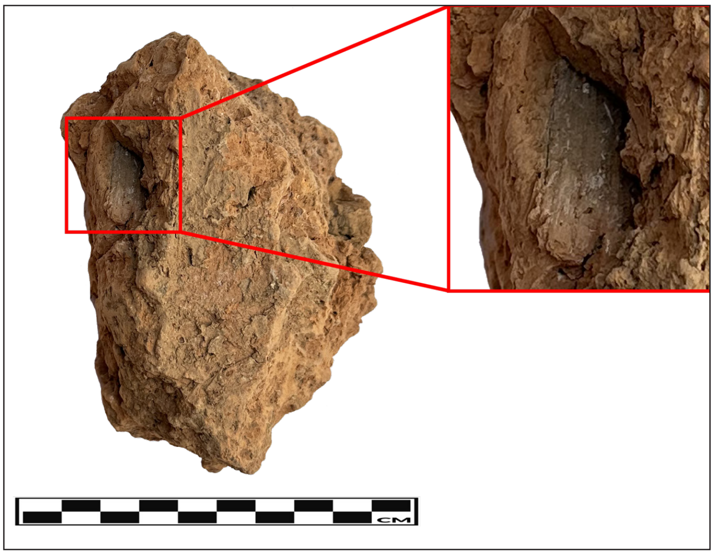

Fig. 30. Fragment 2009CH0060. Wood grain is visible in the niche.

Fig. 31. Detail of 2009CH0060 wood grain, with different lighting.

Hand prints represent one of the most interesting type of imprints one can find, on daub or otherwise. They are much rarer than their structural counterparts. There are only 4 fragments collected during the 2009 excavation which were identified as having some sort of hand print, and out of the 4, only 1 shows actual papillary ridges.

Fig. 32. 2009CH0063, previously shown from another angle, also shows a wood grain imprint similar to that of 2009CH0060.

Fig. 33. Fragment 2009CH0032, right: highlight which shows a possible finger indentation.

Fragment 2009CH0032 (Fig. 33; 34) was the first to be identified as having a possible imprint left by human hands. A human finger can be vaguely made out on its surface. Due to its irregular shape, it was categorised as a finger imprint rather than as a rod imprint. The curved bases of coppiced rods represent another possibility for the imprint's origin, though unlikely due to its relatively small diameter for a base. A possible pole imprint is also visible on lower left side of the fragment in Fig. 33 and on the middle-left section in Fig. 34

Fig. 34. Fragment 2009CH0032, another angle. Righ: highlight which shows the location of the possible finger indentation.

Fragment 2009CH0033, (Fig. 35) shows three semi-parallel indents that have irregular shapes, i.e., they do not present the regular rod cylindrical shape. They look somewhat like the result of pressure being applied to daub by pressing the hand against it, with fingers extended.

Fig. 35. 2009CH0033, showing possible semi-parallel finger imprints.

Fig. 36. 2009CH0120, showing imprints identified as being left by pushing inwards with extended fingers.

Fig. 37. Fragment 2009CH0034, showing epidermal ridge impressions on the left side.

Fragment 2009CH120 (Fig. 36) shows what appear to be imprints left by pushing inwards with extended fingers, repeatedly, along a line. In the picture above, that imaginary line would be delimitated by the ridge of "pinched" clay to the left of the finger prints. The ridge seems to indicate that the pressure was applied towards it, in a repeated motion, due to the way it has deformed. This could have been done in an attempt to stuff or seal a certain element of the defensive structure.

If the previous fragments (2009CH0032, 2009CH0033, 2009CH0120) imprints' origins seem to be somewhat uncertain, fragment 2009CH0034 shows clear epidermal ridge impressions, observable in Fig. 37 on the left side of the fragment.

The ridges visible on 2009CH0034 are most likely *triradius* imprints. *Triradii* are Y shaped groups of ridges on the base of the palm of the hand, at the base of each finger. These would have been left while handling the daub during the construction of fortification III.

Dermatoglyphic analysis is used for several purposes, primarily in the field of forensic science and biometrics (e.g., biometric authentication, for example unlocking a mobile device via fingerprint). The epidermal ridges and patterns of the hand are called *dermatoglyphics*. They are established by the end of the second trimester of pregnancy and have also been considered in studies on diverse neurodevelopmental problems, due to the fact that they develop during fetal months 3-4 which coincide with a critical phase of brain development[29]. Dermatoglyphic analysis can be used in Archaeology in order to assess an individual's approximate

29 Wang *et al*. 2008, 602.

Fig. 38. Fragment 2009CH0034, detail.

age, but it is not without limitations, for example control groups and modern databases must be adjusted for different factors such as people being somewhat smaller in prehistory than today[30]. Data provided by biometrics applications such as fingerprint scanners, correlated with anonymised user data such as age and biological sex might prove useful in the analysis of ancient friction ridge impressions. With

30 Strozyk *et al*. 2019, 222.

access to such a database, it would be possible to use data such as ridge width, depth and the distance between ridges correlated with the aforementioned user data, for comparison with the ancient friction ridge imprints. It is however necessary to first establish a comprehensive database of ancient friction ridge impressions recovered from sites of comparable chronological context.

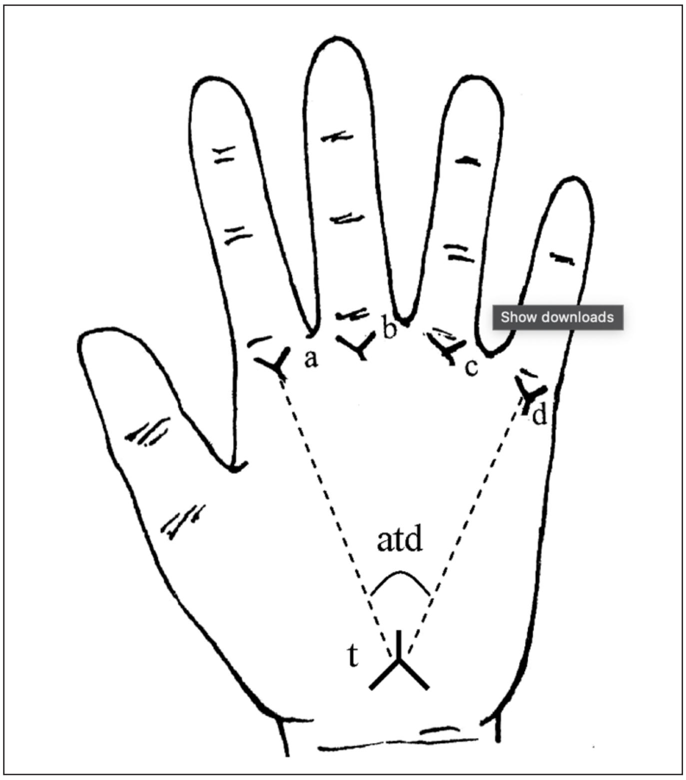

Fig. 39. Example of palmar dermatoglyphics. a, b, c, d, t are *triradii*. Image from Wang et al. 2008.

The process of adding an organic material to the mixture of clay used to make daub is referred to as tempering daub. Tempering daub was done to improve its performance as a building material and to improve its properties, as untempered and especially unburnt clay is very friable. Adding tempering materials increases the strength of the daub and makes it more durable and resistant to cracking and crumbling, especially important in the context of building a defensive structure. It also helps mitigate the fact that clay has a tendency to shrink and crack when drying due to the evaporation of moisture from its composition. By adding the organic material,

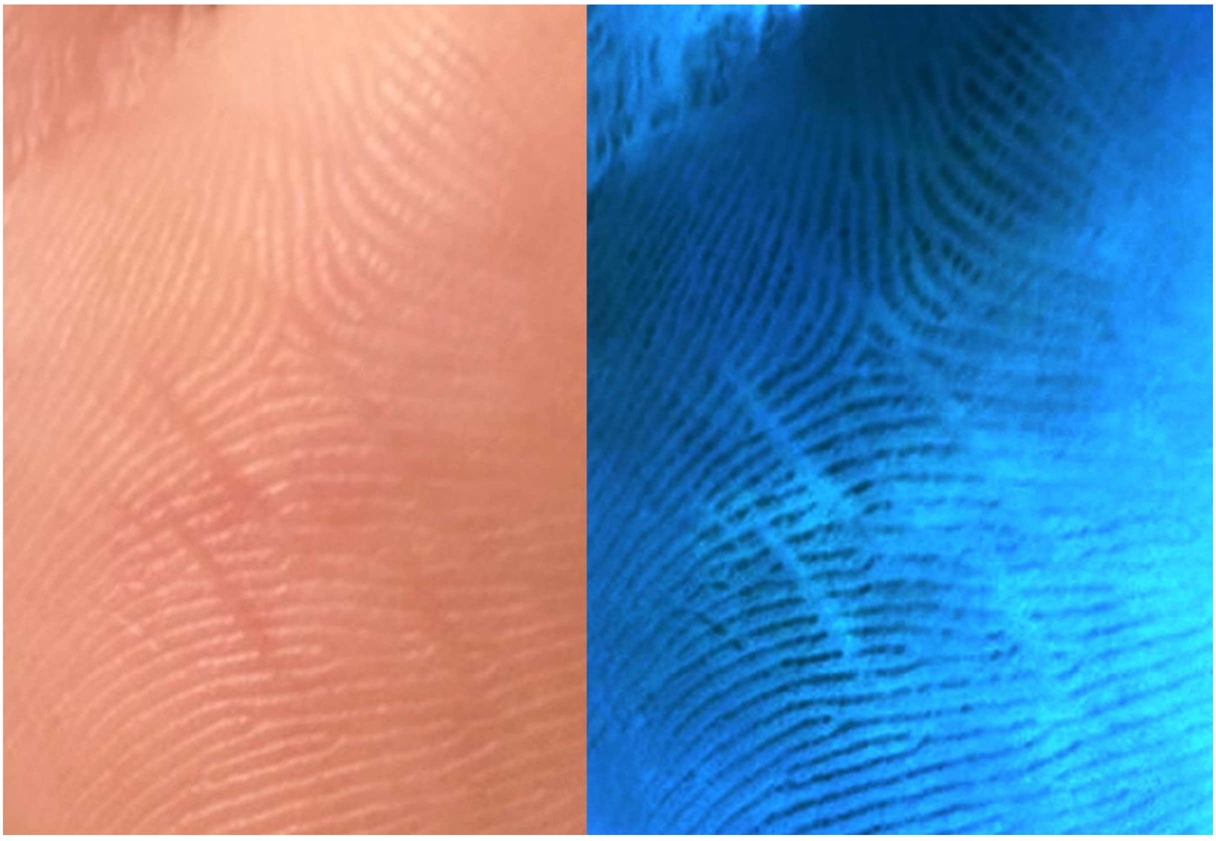

Fig. 40. Example of triradius a, author's right hand. The right side has been color-inversed and edited for a clearer view of the triradius pattern.

the daub mixture would shrink more uniformly, thus minimizing the risks of cracks and structural damage. It would also help with insulation, a factor more important when constructing dwellings. Specific tempering materials vary by region and resources available, like all of the building materials, and are chosen for their accessibility. The daub of the third enclosure at Sântana-*Cetatea Veche* seems to be tempered by adding chaff or other vegetal origin material into the daub mixture, although few of the fragments collected show vegetal impressions on their surfaces. That is not to say that the rest of the daub was untempered, but it goes to show that the organic material was not well preserved inside the daub. The burning of the structure helped maintain some of the impressions made by the plant material though, and as such, out of this sample size we have 16 fragments which show signs of vegetal imprints, the percentages being noted in the following chart (Fig. 41).

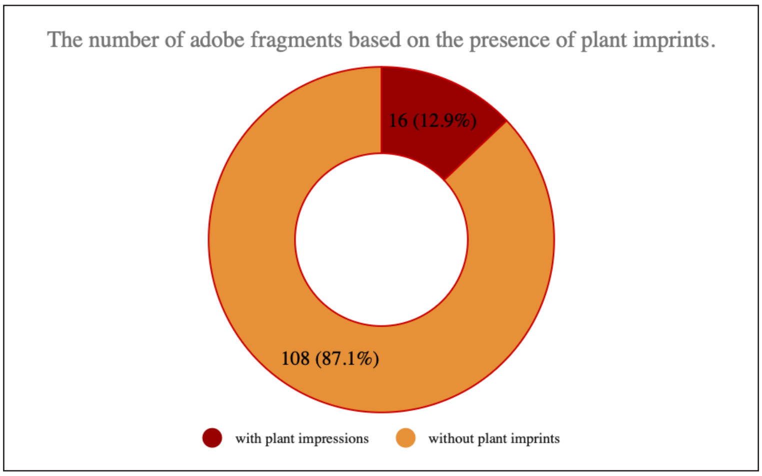

Fig. 41. The number of adobe fragments based on the presence of plant imprints.

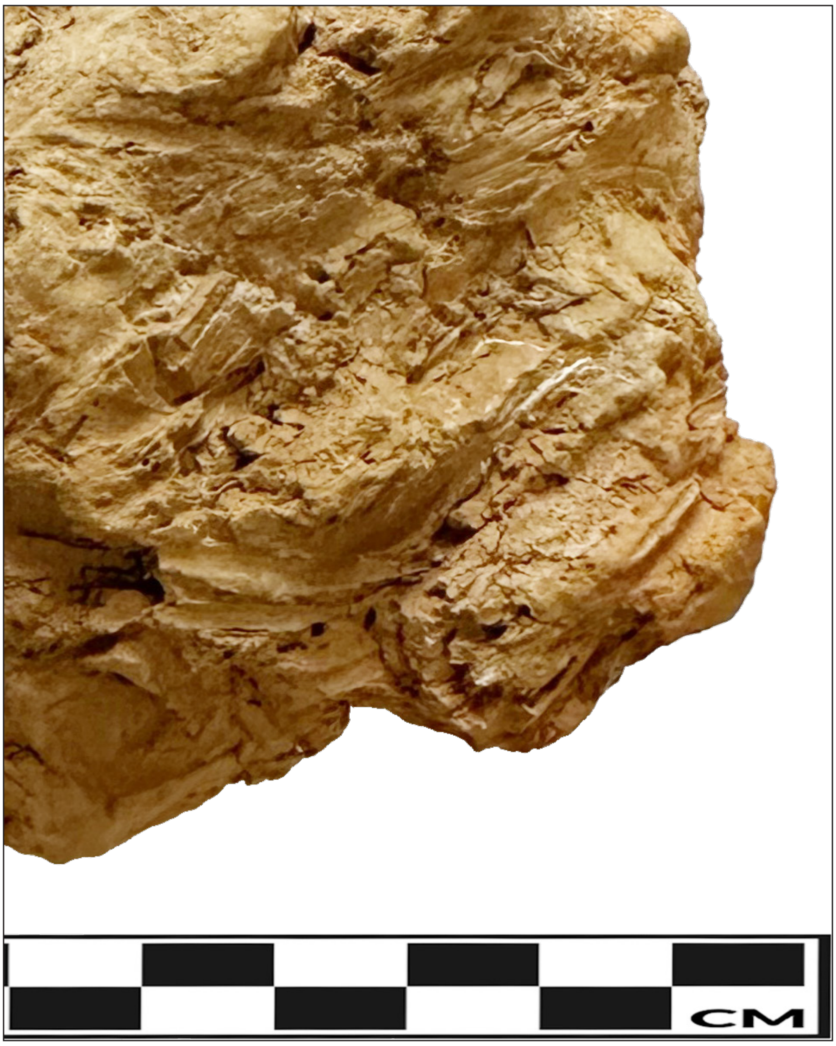

Fig. 42. Detail of 2009CH0034, showing imprints left by vegetation used as daub temper.

Discussion

The analysis of daub has the potential of revealing many aspects of a settlement, its structures, its people and its environment. The analysis of structural imprints and temper reveal details about the biosphere, what types of wild vegetation (for example grasses or reeds, trees used for their wood) grew in the area had at the time, which can be useful for landscape archaeology, or it can offer insights into the agricultural practices – chaff used as temper can show what grain was being cultivated as a source of food. The imprints left by human hands can be analysed and used in correlation with data offered by human remains to ascertain the primary characteristics of the societal structure. Who were the individuals who built the structures? How old were they? Kathryn A. Kamp, in her article called *Where Have All the Children Gone?: The Archaeology of Childhood* which appeared in Journal of Archaeological Method and Theory Vol. 8, 2001, shows that there were children among the ancient Puebloans, who would create pottery for domestic use. The subject of childhood in archaeology is often overlooked, even though children play a large role in shaping any society – people make decisions intended to increase the wellbeing of their children, they care for them as attested by material culture objects such as feeding vessels, and perhaps friction ridges belonging to children could tell us something about their education. Leaving prints on pottery and daub structures, perhaps children would learn about the world around them through touch and would learn essential skills by modelling pottery. The imprints found at Bruszczewo belonged to persons aged 12 – 16[31]. In any case, young people seem to have had an active role in shaping the settlement life.

The wood grain from planks can be analysed to ascertain the type of wood used, along with the rods and posts. Rod imprints are, of course, the most numerous, due to the number of withies needed to build a wattle and daub structure. There are fewer post impressions than expected among the samples analysed, but this may be due to the way daub falls apart and breaks down, larger pieces being outliers as shown in the weight chart, and large pieces are needed to preserve big enough parts of a pole's circumference for it to be properly analysed.

Primary daub analysis can be conducted with nothing more than a modern smartphone and good weather. Some of the photographs in this paper were taken in a lightbox, but some were taken outside in natural light. Smartphone camera lenses have come a long way, and prove useful in cataloguing

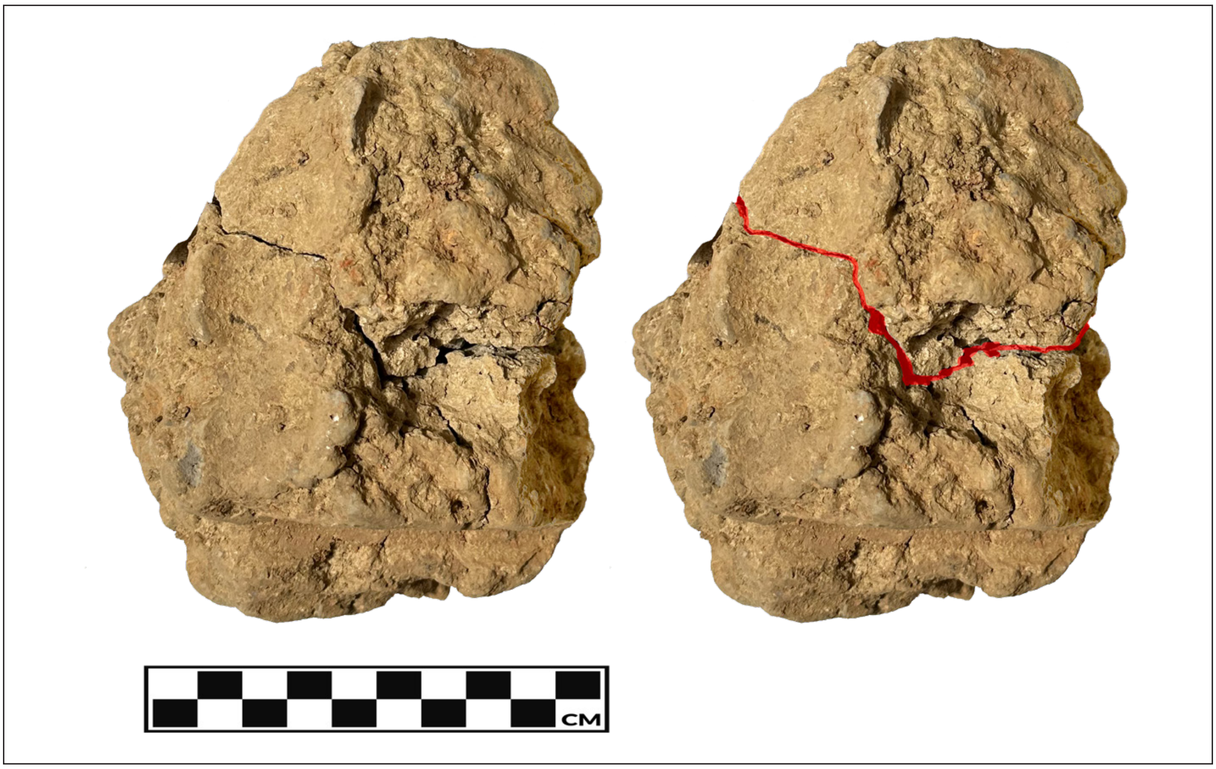

Fig. 43. Fragment 2009CH0119, with crack highlighted in red on the right.

[31] Strozyk *et al*. 2019, 222.

small details such as vegetal temper and friction ridge impressions. Of course, macro lenses and professional cameras would provide better results, if one has access to them. Microscopes would have several applications, such as measuring the friction ridges and the space between them to assess biological data referring to the individual who left the imprint, and analysing chaff and wood grain from an archaeobotanical viewpoint. But establishing a preliminary database for future works or collaboration can be done with as little as a kitchen scale and a smartphone.

An interesting case study revealed itself in the form of a fragment, 2009CH0119, which had cracked sometime at some point during the whole process of excavation, collection, storage, analysis and photography, yet has remained in one piece until the latter. When pulled apart, it shows what could, at first, be misinterpreted as a plank corner on one part of the whole.

The separation of the two pieces of 2009CH0119 have resulted in one of the pieces having a 90-degree angled area, that could be at a first glance misinterpreted as a plank edge imprint. However, the surfaces of this fake imprint lack the wood grain

Fig. 44. Fragment 2009CH0119 separated into two pieces.

Fig. 45. 2009CH0119, two pieces, slightly different angle.

imprint that would be visible in the case of a true wooden plank imprint. This is especially valid in such cases as plank imprints, with daub cracks tending to have somewhat sharp angles; most likely rounded imprints of posts and rods are safer from this type of misinterpretation. Nevertheless, this proves the need for attentive inspection of imprints to avoid misinterpretations and skewing of data.

Photogrammetry is useful, although not entirely necessary (for building a database, that is). It represents a good method of digitally preserving these fragments, as they are very likely to deteriorate while being handled. In the future of daub analysis, the use of RTI (reflectance transformation imaging) could prove useful. RTI is sa Computational Photography assisted technique, which uses multiple lighting conditions to capture a set of images, from a fixed camera position (SCML or single camera multi light data acquisition method), with the aim of virtually and interactively revealing the characteristics of an imaged surface[32]. This technique has been used on artefacts such as ancient roman brick stamps in order to record and represent subtle surface details[33]. This technique could be valuable not only for analytical purposes but also for the development of a comprehensive shared database among researchers investigating sites that are contemporary with one another. This technique allows users to view digital copies of the surfaces of objects on a computer, without having to have the original material. This may help, for example, with archaeobotanical identification, where transporting of the material would be impractical. Archaeobotanical experts could then analyse the vegetal imprints digitally, in very high detail.

Another aspect worth examining in relation to the construction of the defensive wall is the possible presence of a roof or covering above the structure. A roof was mentioned in past publications regarding the fortification[34]. The need for such a structure would be evidenced by the friable nature of the wall itself, which would need protection from the elements (especially rain and water infiltration which could then freeze and cause structural damage). Such a roof would most likely be constructed out of thatch, wood and other materials commonly used for roofing dwellings and other structures in this time period. One argument to support this theory is the fact that the whole palisade was burned, and as we know dried out thatch is highly flammable organic material. Over time, thatched roofs develop their own biome supported by the material's moisture retention, consisting of various bacterium and fungi, which along with the moisture itself would render the thatch more fire resistant, but even so, in the event of exposure to wildfires or, in our case, most likely deliberate setting on fire by a group of attackers, thatched roofs are highly flammable and burn at temperatures of over 200 °C[35].

In an experiment carried out to see how fast thatch would catch on fire at different wind speeds, researchers caused a controlled burn on a model thatched roof by exposing it to firebrand and artificial winds of 3 and 6 m/s (roughly 10 km/h and 20 km/h, otherwise catalogued as a Light Breeze and a Moderate Breeze respectively, on the Beaufort Wind Scale). The model assemblies were constructed by Japanese construction companies licensed in traditional thatched roof assembly fabrication techniques, and the water reeds used had an average moisture content of 10% on a dry basis[36].

For wind speeds of 3 m/s, the water reed roofing collected firebrands and multiple firebrands may be seen inside that penetrated under the surface of the roofing assembly[37]. This can cause smouldering of the inside layers of the roofing and spread without any detectable smoke.

At 6 m/s winds, similar to the studies at 3 m/s, there was no smoke before the onset of fire, and once it did, the thatched roofing assembly promptly caught on fire. The following images demonstrate that, 20 seconds after the initial ignition, the flame had reached the roofing assembly's peak, had also pierced through it and could be seen from behind the structure[38].

Of course, the materials used would vary by area and timeframe, but the experiment remains relevant nonetheless due to the structure tested rather than the materials themselves, as well as its demonstration of how rapidly fire can spread on such a construction. Thus, in combination with the wooden structure of the defensive wall, deliberate ignition of the structure would theoretically be possible, although more research on exact conditions (meteorological or otherwise) of such a fire is

32 https://www.conservation-wiki.com/wiki/Reflectance_Transformation_Imaging_(RTI)
33 Earl *et al*. 2010, 2046.
34 Gogâltan *et al*. 2019, 209.
35 Thatch Advice Centre. n.d.
36 Suzuki, Manzello 2019, 2.
37 Suzuki, Manzello 2019, 35.
38 Suzuki, Manzello 2019, 36.

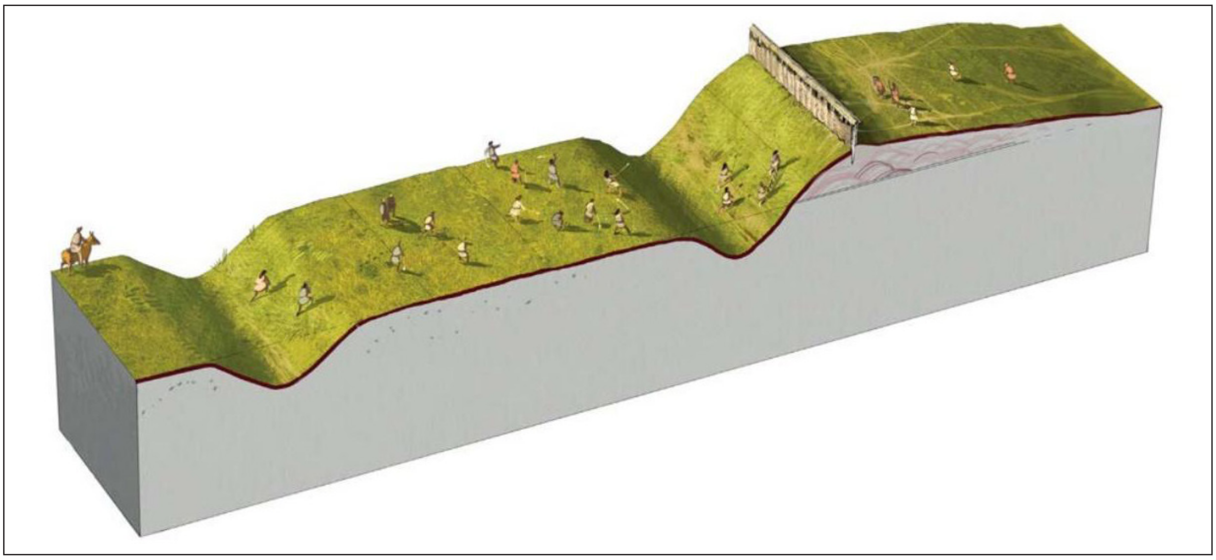

Fig. 46. Reconstruction of a battle outside Enclosure III (after R. Olteanu), image from Sava *et al*. 2019.

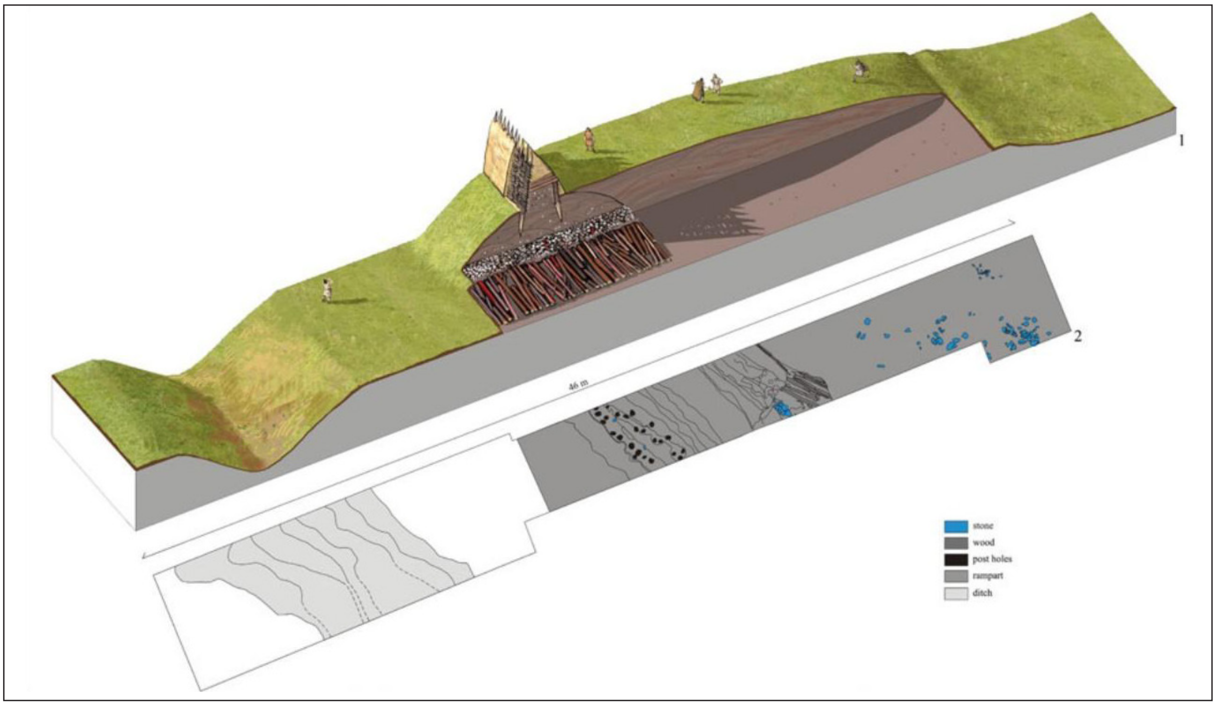

Fig. 47. Reconstruction of the fortifications of Enclosure III, image from Sava *et al*. 2019.

needed. Reconstructions of the third enclosure's defensive structures by R. Olteanu feature such a thatched roof[39].

The defensive structure was certainly burned, as attested by the daub being burnt sometimes to the point of vitrification, and conflict is attested by the presence of sling projectiles in the fortification of enclosure III. Temperatures from the burning roof would have been enough to set the wooden parts of the structures alight as well. This represents, at the moment, the most plausible explanation.

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39 Sava *et al*. 2019, 215.

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