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TORBA FLOORS FROM THE MALTESE ISLANDS: A PRELIMINARY ANALYTICAL STUDY

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ABSTRACT

This study analyses twelve selected mortar and plaster floor surfaces, called *torba*, dating to the 4th and 3rd millennia BC, from three Neolithic sites in the Maltese Islands: Skorba, Santa Verna and Taċ-Ċawla. Traditional geoarchaeological methodologies of soil and sediment micromorphology as well as spectroscopic techniques of Fourier Transform Infrared Spectroscopy (FTIR) have been applied. The results suggest that *torba* is more varied than previously thought, providing a more nuanced picture of differing flooring materials. Both earthen-based as well as lime-based torba were present at Neolithic sites in the Maltese Islands. The analysis revealed that most of the *torba* material was unfired earthen material consisting of *terra rossa* and calcite. Nevertheless, two *torba* floor samples were lime-based involving the heat-treatment of *terra rossa* and calcite. This lime-based torba was obtained for mortars and plasters as early as the Neolithic period in the Maltese Islands.

KEYWORDS: Malta, Neolithic, torba, floor, thin-section micromorphology, FTIR.

1. INTRODUCTION

In the past, humans made a wide array of materials, such as stone tools, ceramics, glass and metal objects. Among these materials, mortars and plasters played a central role from prehistory until the modern day (Ali et al., 2022; Artioli et al., 2019; Ingham, 2010; Salama et al., 2017). Mortars and plasters have been used in different ways because they are versatile products. For example, they have been employed as construction elements, decorative items and artefacts. These multiple applications have drawn the attention of various research fields ranging from history to civil engineering (Elsen, 2006). This meant that mortars and plasters have been studied following diverse approaches depending on the research questions (Elsen, 2006). Three main fields, namely material science, conservation and archaeology, have witnessed a constant development in the past decades (Elsen, 2006). This was due to: the need for sustainable building resources, the search for non-damaging materials for preservation and a renewed interest in ancient construction materials and techniques (Al Sekhaneh et al., 2020; Artioli et al., 2019; Elsen, 2006; Theologitis et al., 2021). Particularly, archaeology analyses these finished products to gain information about technology, mechanisms of manufacture and their socio-economic ramifications (Elsen, 2006). In the Maltese Islands, *torba* is described as a calcareous mortar and/or plaster material mainly used for flooring from prehistoric until modern times (Cassar, 2010; Clark, 1998; Trump, 2002). *Torba* is characterised by different properties such as durability, hardness and weatherproofing (Clark, 1998; Trump, 2002). These characteristic features meant that *torba* has often been misidentified as bedrock during archaeological excavations (Trump, 2002). Despite this issue, archaeological evidence showed that *torba* was extensively present at both temple and settlement sites (Ashby et al., 1913; French & Taylor, 2020; Malone et al., 2009; Malone et al., 2020a). Even though uncovered, *torba* floors were never studied in detail. This research aims to enhance our understanding on *torba*. The primary goals are clarifying the nature of these floors and addressing the hypothesis related to them. For this purpose, soil and sediment micromorphology and spectroscopic techniques (FTIR) are applied. While micromorphology is re-examined and re-assessed, the use of FTIR represents a novel contribution to previous work on *torba*.

2. THE MALTESE ISLANDS

2.1. *Geographical and geological setting*

The Maltese archipelago occupies a strategic and central location in the Mediterranean basin being situated between Sicily, about 96 km, and North Africa, around 290 km away (Chatzimpaloglou et al., 2020; Schembri, 1997; Fig. 1). The archipelago consists of three main islands, namely Malta, Gozo and Comino, and several minor islets (Chatzimpaloglou et al., 2020; Schembri, 1997; Fig. 1).

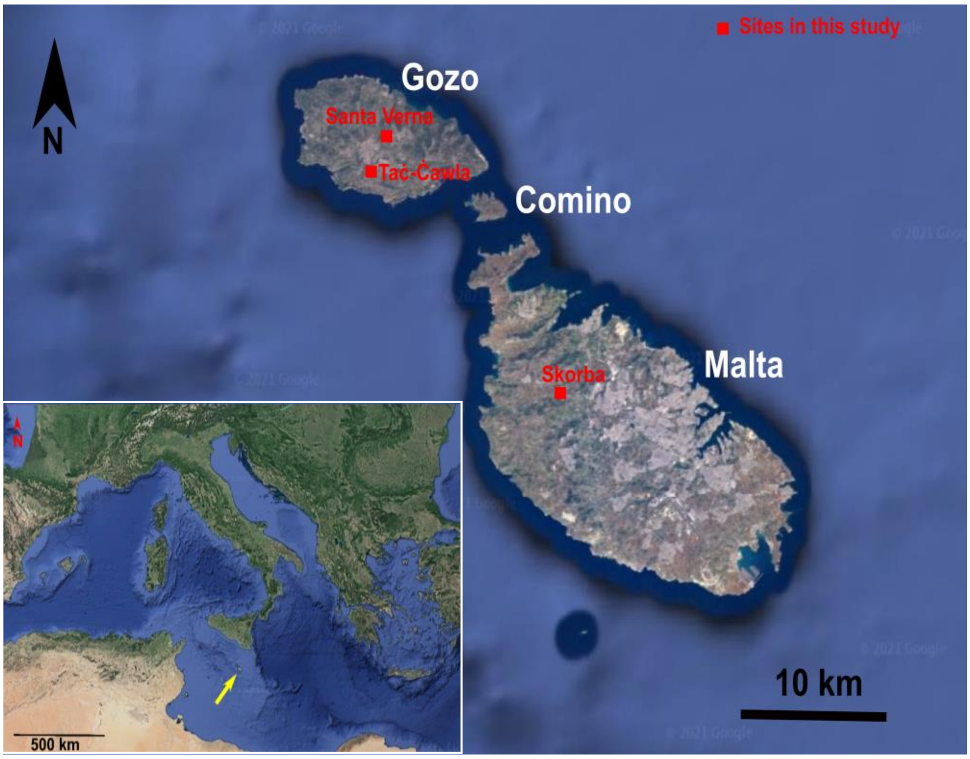

Figure 1. Maps showing the location of the Maltese Islands in the Mediterranean basin and the sites under examination (Map base© Google Maps; M. Quilici).

Collectively, they cover a surface area of 316.75 km^2 with Malta and Gozo being the largest, at 245.86 km^2 and 67.1 km^2 respectively (Chatzimpaloglou et al., 2020; Schembri, 1997). The Maltese Islands are characterised by five Oligo-Miocene rock formations of marine sedimentary origin arranged in strata like a 'layered cake' (Chatzimpaloglou et al., 2020; Schembri, 1997). From youngest to oldest, these are: Upper Coralline Limestone; Greensand; Blue Clay; Globigerina Limestone, further subdivided into Upper, Middle and Lower; and Lower Coralline Limestone (Chatzimpaloglou et al., 2020; Schembri, 1997). Furthermore, three main soil types, deriving from the parent rock material, are recognised: Terra soils or Red Mediterranean Soils, which include *terra fusca* and *terra rossa*, Xerorendzinas, and Carbonate Raw Soils (Cassar, 1997; Chatzimpaloglou et al., 2020; Schembri, 1997).

3. BRIEF HISTORY OF *TORBA* RESEARCH

3.1. *Hypothesis of* torba *preparation*

Initially, the process of *torba* production was merely described as 'limestone pounded hard' (Ashby et al., 1913: 5). Between the 1990s and the 2000s, it was hypothesised that *torba* floor preparation involved four steps:

1. crushing limestone into a powder;
2. mixing the limestone powder with water;
3. application of the mixture in layers over a rubble foundation;
4. drying and setting (after Clark, 1998 and Trump, 2002: 77).

It has been indicated that the limestone employed was Globigerina Limestone because of its softness (Cassar, 2010; Clark, 1998; Trump, 2002). The result would be a concrete-like material (Trump, 2002).

3.2. *Previous analyses on* torba

Torba floors have been subjected to micromorphological analyses (French & Taylor, 2020; Hardisty, 2009). For instance, Hardisty (2009) examined one *torba* floor sample coming from Structure 1 at the domestic early Neolithic site of Għajnsielem Road, while French & Taylor (2020) identified and analysed several *torba* floor samples from various sites, such as Skorba, Santa Verna, Ġgantija and Taċ-Ċawla. These studies highlighted that *torba* floors are typically compact and homogeneous, containing very fine (<2 mm) organic and anthropogenic inclusions, such as micro-charcoal, bone, shell and pottery sherd fragments (French & Taylor, 2020; Hardisty, 2009). However, the main focus of the geoarchaeological investigations was not *torba*. Actually, Hardisty's (2009) analysis was a pilot study that enriched the archaeological evidence and excavations at Għajnsielem Road site, while French and Taylor's (2020) examination was primarily focused on palaeosols to reconstruct soil development, vegetation, land-use and anthropogenic impacts throughout the Holocene. Thus, *torba* floors were not investigated in detail by micromorphological techniques.

It is evident that widespread *torba* floors remain poorly studied in the Maltese Islands. The lack of in-depth archaeological and scientific examinations on *torba* samples led to a common acceptance of the main hypothesis on *torba* floors preparation without comprehensively testing the assumptions. Above all, the nature of *torba* is unclear. While the definition of *torba* as 'calcareous' suggests lime, the main *torba* hypothesis does not specify. Hence, there is a big research gap regarding the material itself.

4. MATERIALS AND METHODS

4.1. *Materials*

This current work offers a preliminary analysis of a total of twelve samples of which five are thin sections and seven are small bulk samples. The samples are all of *torba* floors, dating back to the 4th and 3rd millennia BC from the sites of Skorba, Santa Verna and Taċ-Ċawla. These were obtained as part of the *FRAGSUS* (Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory) ERC funded project (French et al., 2020; Malone et al., 2020a).

(A) (B)

Figure 2. Location of micromorphological block samples (white boxes) and small bulk samples (white dots) from Trench A profiles at Skorba. A: section 1, profile A–B; B: section 2, profile D–E (after French & Taylor, 2020: 183, Fig. 5.10).

At Skorba, the excavation trench in 2016 was situated on the southwest side of the temple site (Brogan et al., 2020). The examined material is from temple contexts. *Sample 26* involves both a thin section and small bulk sample, coming from Trench A, section 2, profile D-E, context 26 at around 70-80 cm in depth (Fig. 2). Finally, *Sample 26 plaster spot* is a thin section that has the same connotations of the former, but the depth ranges between 75-82 cm (Fig. 2).

At Santa Verna, six trenches were opened in 2015 within or on the periphery of the temple (McLaughlin et al., 2020). The material under study was sampled from three main test trenches inside the southern part of the monument (French & Taylor, 2020; Fig. 3). Hence, all the samples are from a temple context. *Sample 4/1* comprises a thin section and a small bulk sample from Trench E, profile 4, context 65 at a depth of 40-44 cm. *Sample 4/2* is a thin section from Trench E, profile 4, context 79 at a depth of 68-75 cm. *Sample 28* and *78* are two bulk samples respectively from the Ashby Sondage, profile 2, context 28 between 65-70 cm in depth and Trump Cut 55, profile 3 context 78.

At Taċ-Ċawla, the 2014 field investigations excavated a large area of the site, focusing primarily on a zone where a Neolithic structure was recorded (Malone et al., 2020b; Fig. 4). In this case, the samples are from a settlement-domestic context. *Sample 48 1/2* is a thin section coming from the Horton-Trump Trench, profile 1, coming from context 158 between 59-73 cm deep. *Sample 238* and *250* are two bulk samples that were taken from context 238 and 250 respectively of Level 2 extramural deposits, adjacent to the Horton-Trump Trench and the Main Quadrant. Finally, *Sample 186* is a bulk sample from the respective context number in Box Trench (BT) 5.

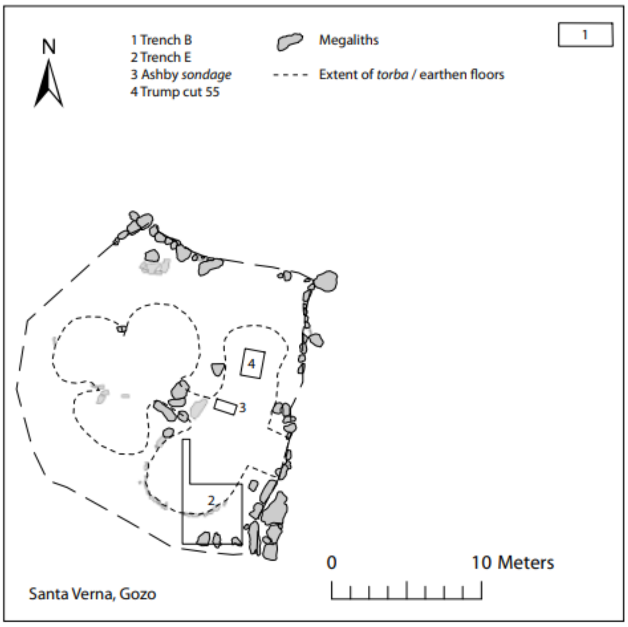

Figure 3. Santa Verna site plan showing the main features of the site and the location of four 2015 trenches, of which three produced the material under study (after French & Taylor, 2020: 166-167, Fig. 5.2).

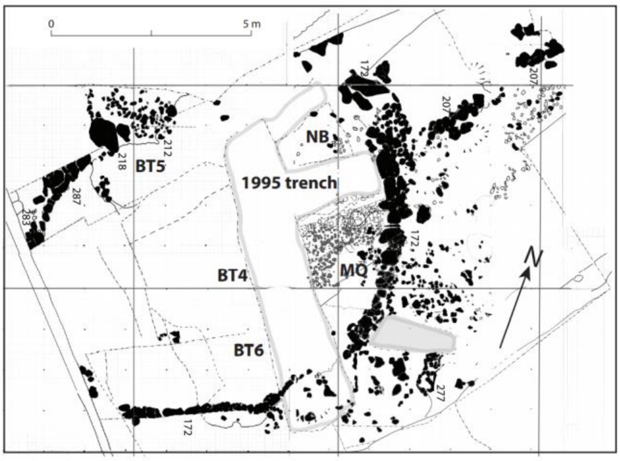

Figure 4. Taċ-Ċawla plan showing the location of principal trenches and wall contexts of the Neolithic structure (after Malone et al., 2020b: 54, Fig. 3.11).

4.2. *Methods*

This study employs two methods: soil and sediment micromorphology for the study of the five thin sections; and FTIR for the examination of the seven small bulk samples (Table 1).

4.2.1. Soil and sediment micromorphology

Soil and sediment micromorphology has been extensively used to examine building materials (Karkanas & Goldberg, 2017). Thin section slides with thickness of 30 μm were made following the conventional methodology illustrated by Murphy (1986) and Courty et al. (1989), which was adapted by French and Rajkovača (French & Rajkovača, 2015: 97-100). The slides were examined using a Leica Laborlux 12 Pol polarizing microscope with magnifications ranging from x4 to x25, using cross polarised light (XPL) and plane polarised light (PPL), with photomicrographs taken using Q-Capture Pro software and camera system. The micromorphological descriptions apply the terminology devised by Bullock et al. (1985) and Stoops (2003; 2021).

4.2.2. FTIR

FTIR was used to examine the bulk samples, particularly to highlight the main minerals and their state of atomic order or disorder (Toffolo & Berna, 2018; Weiner, 2010). This technique was chosen because of its fast, cheap and minimally destructive nature (Toffolo & Berna, 2018; Weiner, 2010). Furthermore, FTIR analysis is well-established with extensive libraries being available (Toffolo & Berna, 2018; Weiner, 2010).

The preparation of the sample followed the KBr pellet method. Using an agate mortar and pestle, several grams of sample were homogenized and grinded into a powder by hand. This large amount was employed because the bulk samples were sizable and a representative sample was needed (Weiner, 2010: 277). In the mortar, a few micrograms of powdered sample and about 50 milligrams of KBr were mixed together using a micro-spatula. This mixture was then transferred into a pellet and pressed at 1.8 tonnes for 10 seconds in a Specac hydraulic handheld press. As a result, the thin and disc-shaped layer of sample formed in the pellet was inserted in the instrument to perform the analysis and obtain the spectra. The bulk samples were measured at least three times by repeating the KBr process with another portion of the initial grams of ground sample. The collection of spectroscopic data was provided by the use of a Thermo Scientific Nicolet iS5 spectrometer with iD1 Transmission instrument. The collected spectra ranged between 4000 and 400 cm^{-1} at 4 cm^{-1} resolution. The identification and interpretation of the spectra was supported by the use of OMNIC 9 software in combination with an infrared spectra library of archaeological materials created by the Kimmel Center for Archaeological Science Infrared Standards Library, Weizmann Institute of Science (Kimmel Center for Archaeological Science, 2021). Following this, the spectrographic information is used to evaluate the atomic order and disorder of the mineral.

In the case of *torba*, we would expect the calcitic minerals, or forms of calcium carbonate, to be prevalent. The infrared absorption spectrum of calcite has three main absorption peaks (Fig.5): v3 at 1420 cm^{-1}, v2 at 875 or 874 cm^{-1} and v4 at 713 or 712 cm^{-1} (Chu et al., 2008; Regev et al., 2010; Weiner, 2010). The spectrum of calcite has been studied in-depth by both experimental and archaeological analyses, showing that the relationship of these characteristic peaks result from geological, biological or pyrogenic formation mechanisms (Chu et al., 2008; Regev et al., 2010; Weiner, 2010). This case study employs the v ratio method of Chu et al. (2008). As described by Chu et al. (2008), the ratio v2/v4, calculated by dividing the height of the v2 peak by the height of v4 peak, can highlight atomic disorder. In particular, ratios below 3 are typical for geogenic calcite indicating raw limestone, while ratios around or above 3 represent pyrogenic-anthropogenic calcite suggesting pyrotechnological product (Chu et al., 2008; Weiner 2010). Three repeated measurements of the peaks were taken to accurately calculate the ratio.

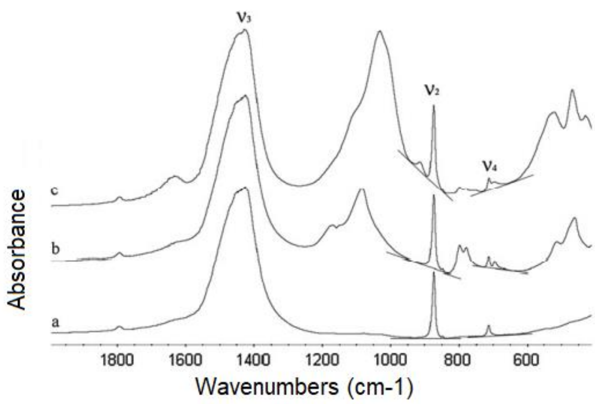

Figure 5. FTIR spectra of calcites highlighting the three characteristic peaks and the appropriate baselines needed to accurately measure the v2 and v4 peaks. Spectrum a: pure calcite; spectrum b: calcite and quartz; spectrum c: calcite and clay (after Chu et al., 2008: 907; Fig. 1).

Table 1. Summary of materials and methods of analysis (M. Quilici).

Site	Trench	Sample	Micromorphology	FTIR
Skorba	Trench A, section 2, profile D-E, context 26	26	✓	✓
	Trench A, section 2, profile D-E, context 26	26 Plaster Spot	✓	
Santa Verna	Trench E, profile 4, context 65	4/1	✓	✓
	Trench E, profile 4, context 79	4/2	✓	
	Ashby Sondage, profile 2, context 28	28		✓
	Trump Cut 55, profile 3, context 78	78		✓
Taċ-Ċawla	Horton-Trump Trench, profile 1, context 158	48, 1/2	✓	
	Deposits, context 238	238		✓
	Deposits, context 250	250		✓
	Box Trench 5, context 186	186		✓

RESULTS AND DISCUSSION

4.3. *Micromorphology and FTIR*

Micromorphology showed some general characteristics of *torba* floors such as a dense and apedal structure, a massive microstructure, the occurrence of calcitic ash, a crystallitic or striated b-fabric groundmass and the presence of planar voids (Fig. 6; Fig. 7). These voids are indicative of shrinkage fractures during drying (Karkanas, 2007). Additionally, the fine fractions of micromorphological units were mainly dominated by calcitic ash, micrite and dusty (or silty) clay, while the coarse fraction highlighted that limestone aggregates were the most prevalent. Very fine to fine organic matter and anthropogenic inclusions occur regularly. This feature probably results from the use of local *terra rossa* soil (see below) associated with Neolithic settlement sites that already contained bone, pottery, shells, foraminifera, dung and other organic matter such as charred/uncharred plant tissues and micro-charcoal.

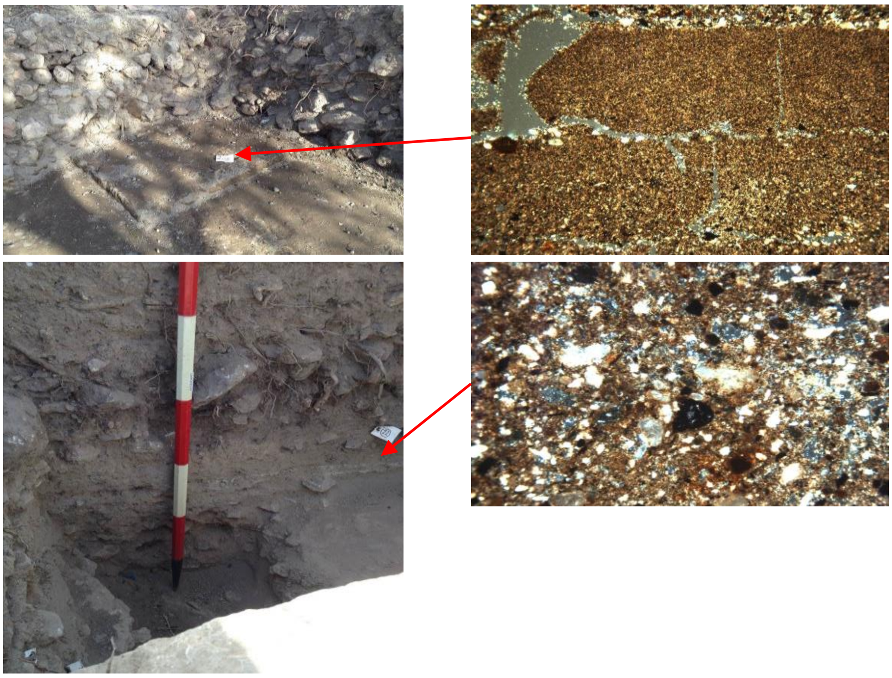

Figure 6. Close-up photograph of the exposed earthen torba floor at Santa Verna temple (upper left) and a photomicrograph of the laminar very fine sandy/silt fabric of sample 78 in Cut 55 (PPL) (upper right). Photo taken with frame width = 4.5mm. A close-up of section 2, profile D-E, at Santa Verna showing the plaster floor levels (lower left; as seen in Fig. 7), and a photomicrograph of the calcitic fine sandy/silty clay matrix of the torba floor above (XPL) below label 22 and above the horizontal plaster levels (lower right). Photo taken with frame width = 4.5mm (C. French).

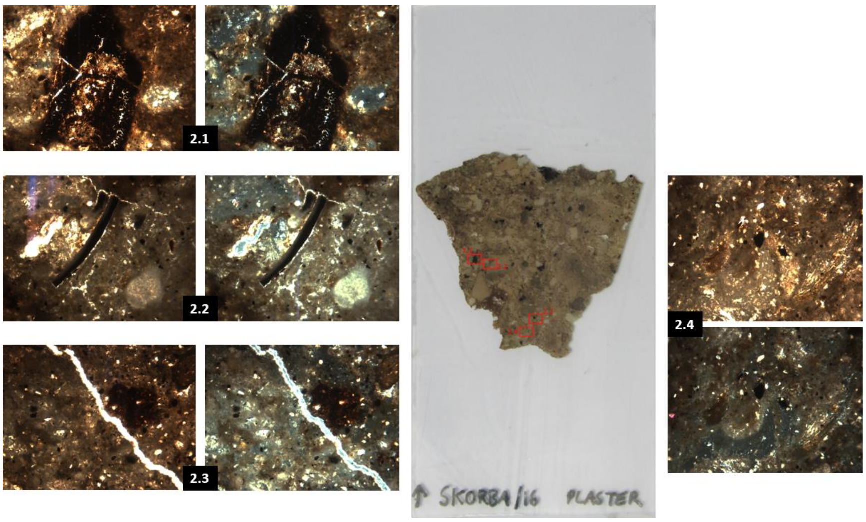

Figure 7. Photo of Skorba Sample 26 Plaster Spot alongside photomicrographs of the sample. The left or above image is in plane-polarized light (PPL) and the right or below image is in cross-polarized light (XPL). 2.1: burnt bone inclusion; 2.2: burnt shell fragment; 2.3: planar void in calcareous 'slurry' of ash and silty soil material with charcoal; 2.4: crystallitic b-fabric. All photos taken with frame width = 4.5mm (M. Quilici).

FTIR indicated that the main components of all the samples were *terra rossa* soil and calcite. The analysis also shows that most of the *torba* floor samples consisted of unheated and geogenic *terra rossa* and calcite because the spectra were not altered and the calcite v2/v4 ratios were well under 3. Therefore, this archaeological evidence demonstrates that non-pyrogenic earthen mortar and plaster *torba* floors were produced. Two *torba* samples - Skorba Sample 26 and Taċ-Ċawla Sample 250 - involved the heat-treatment of these materials as their spectra were altered and their v2/v4 ratios were about 3-3.5 (Fig. 8; Fig. 9). The calcite v2/v4 ratio for atomic disorder indicates that the limestone was heat-treated at least above 700°C for several hours and converted into quicklime (Chu et al., 2008). The alteration of the *terra rossa* in the samples shows that this material was exposed to temperatures around 300°C at Skorba and between 500-800°C at Taċ-Ċawla (Fig. 10). This highlights that the quicklime was still very hot, at least around 300°C in Skorba and around or above 500°C in Taċ-Ċawla, when mixed with water and the local *terra rossa* soil material. This provides evidence for lime-based mortar and plaster *torba* floors. The character of the heat-treatment can be assumed from both field and scientific evidence. It appears that the heat-treatment was in relation to the floor itself as no clear hearths were identified in the field close to where the samples were taken (French et al. 2020; Malone et al. 2020a). Furthermore, the micromorphological structure of the matrix and the FTIR peaks point to a more intentional pyrotechnological product rather than an unintentional and/or accidental occurrence (Chu et al. 2008; Karkanas, 2007). The purpose of the local sediment whether it was intentionally prepared for *torba* production or it was an unintentional mixing addition remains unclear as further data is needed to clarify this (Friesem et al., 2020).

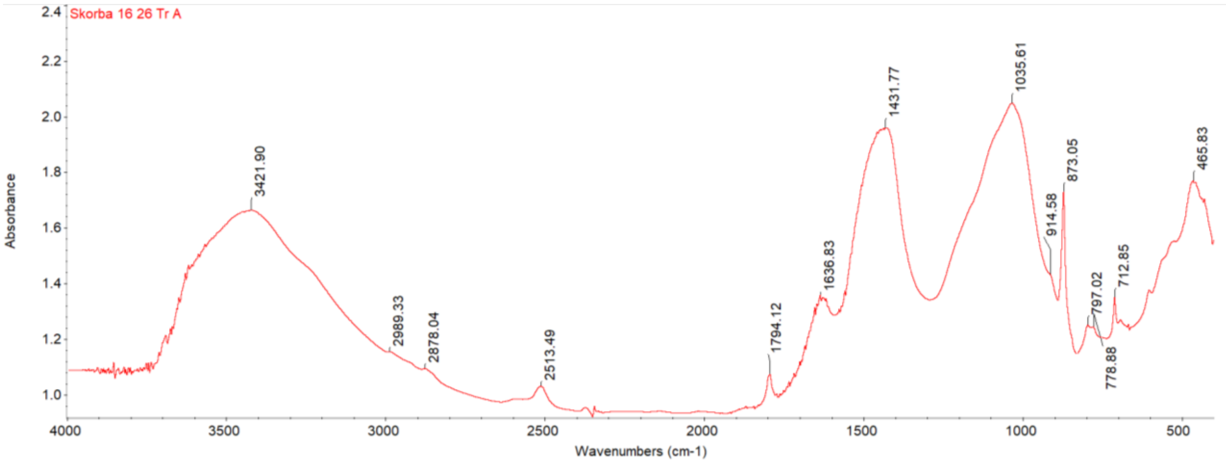

Figure 8. FTIR spectrum of Skorba Sample 26 with annotated peaks (M. Quilici).

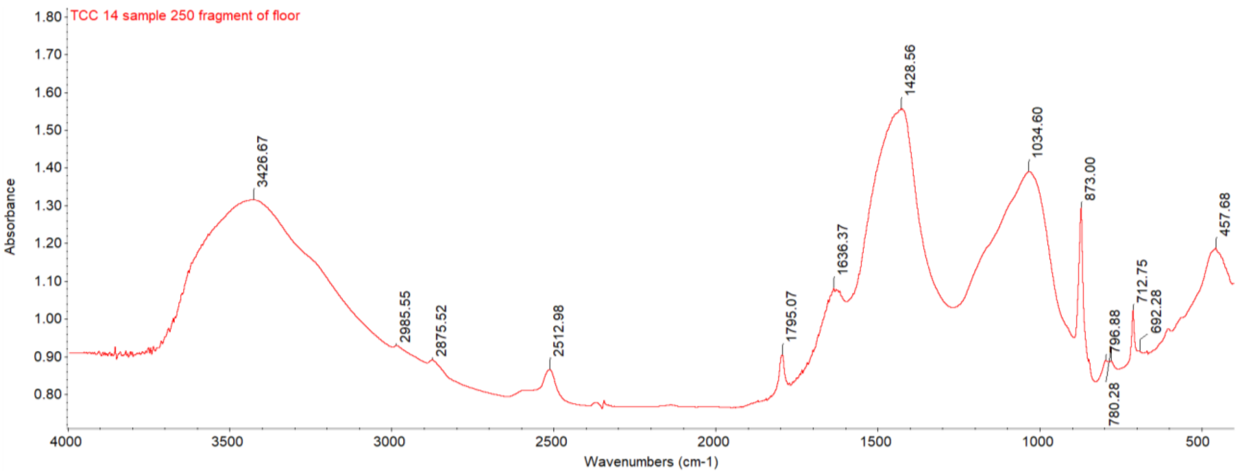

Figure 9. FTIR spectrum of Taċ-Ċawla Sample 250 with annotated peaks (M. Quilici).

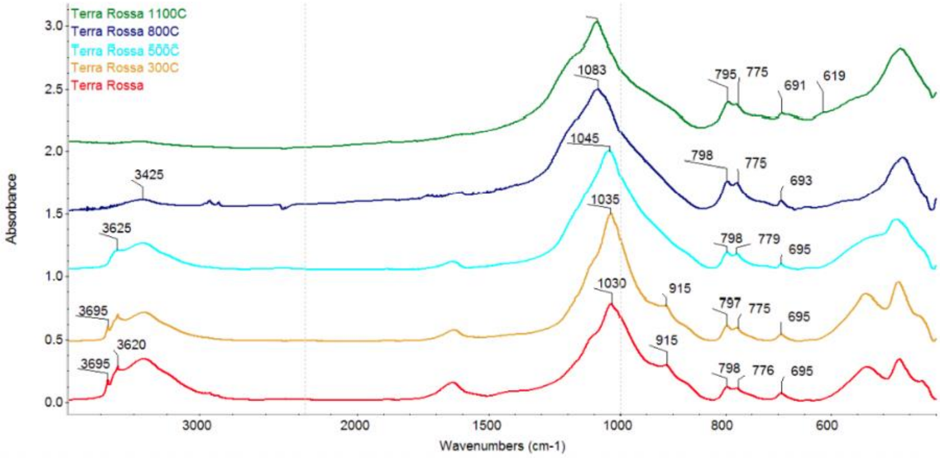

Figure 10. FTIR spectra of geogenic **terra rossa** *(red) and* **terra rossa** *undergoing heat transformation - 300°C (ochre), 500°C (turquoise), 800°C (blue) and 1100°C (dark green) - showing differences in the peaks (after Wallace, 2017: 103, Fig. 28).*

5. CONCLUSIONS

This research reports on a multi-site examination - Skorba, Santa Verna and Taċ-Ċawla - of *torba* mortars and plasters used for flooring in the Maltese Islands dating to the 4th and 3rd millennia BC. As *torba* is described as a calcareous material, lime is usually implied. At the same time, the main hypothesis on *torba* outlined the process of manufacture simplistically without emphasising the nature of the material. As a result, the analysis was carried out in order to clarify the nature of *torba* floors.

This preliminary study provides evidence that *torba* is more diverse and versatile than originally thought. The analysis reveals that both lime-based as well as earthen-based *torba* were present at Neolithic sites in the Maltese Islands. Most of the *torba* material was not fired. Additionally, it suggests that lime-based materials for mortars and plasters were obtained as early as the Neolithic period in the Maltese Islands, with variable heat treatments observed.

Further research on *torba* surfaces by extending the sample size and applying a wider range of techniques and/or experimental approaches will help providing a better understanding of the underlying technological processes for *torba* manufacture. Finally, the current work advises adopting a more accurate terminology like 'lime-based' or 'earthen-based' *torba* during field or laboratory observations in order to become more familiar with the variability and complexity of these materials.

AUTHOR CONTRIBUTIONS

Conceptualization, M.Q. and C.F.; methodology, C.F.; investigation, M.Q, C.F. and P.C.; data curation, P.C.; writing—original draft preparation, M.Q.; writing—review and editing, C.F.; supervision, C.F. All authors have read and agreed to the published version of the manuscript.

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