New Methodological Approaches to the Study of Human-environment Interactions at Shahr-i Sokhta

Girolamo Fiorentino[1], Marco Madella[2-3] and Ignazio Minervini[1]

[1] Laboratory of Archaeobotany and Palaeoecology. Department of Cultural Heritage. University of the Salento.
[2] CaSEs Research Group, Department of Humanities, Universitat Pompeu Fabra, Barcelona, Spain.
[3] ICREA, Barcelona, Spain.
girolamo.fiorentino@unisalento.it; marco.madella@upf.edu; ignaziomine@gmail.com

Abstract

This paper presents the results of the new archaeobotanical analysis carried out at the site of Shahr-i Sokhta, in the light of the new data emerging from the 2019 excavations of 'Building 33' and the new palaeoenvironmental research strategies inside the site (Trench 36) and in the immediate surroundings. The recent research campaign also adopted a multiproxy palaeoenvironmental approach to the study of micro- and macro- plant remains, digging sampling pits in the dry bed of a depression inside the site (the intermediate area) and another pit immediately outside the settlement in the broad dry bed of the river Hirmand

(the off-site area). The site represents a key place for understanding the different aspects of mankind's management of natural resources during the Bronze Age and the different modes of human-environment interaction.

1. Introduction

This paper comes a few years after the first publication on the resumption of the archaeobotanical and palaeoenvironmental investigations in the site of Shahr-i Sokhta, in the light of the new data emerging from the 2019 excavations of ʿBuilding 33ʾ and the new palaeoenvironmental research strategies inside the site and in the immediate surroundings.

The on-site archaeobotanical research adopted a strategy of targeted spatial archaeobotanical sampling in order to investigate the distribution of micro- and macro- plant remains with reference to a functional reading of the spaces of the various loci of ʿBuilding 33ʾ during two of the structure's phases of occupation. New on-site sampling strategies were also applied to the exposed part of a trench dug during previous excavations (Trench 36), in order to stratigraphically investigate other phases of occupation of the site based on systematic sampling of the deposits of discarded material in a midden.

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2. Sampling strategies

The archaeobotanical investigations entailed the adoption of various approaches to sampling and analysis, based on the identification of three different types of area to be investigated (Fig. 1):

- on-site areas lying within the settlement characterised by human activities (with specific intervention during the excavation of Building 33 and investigations in Trench 36);

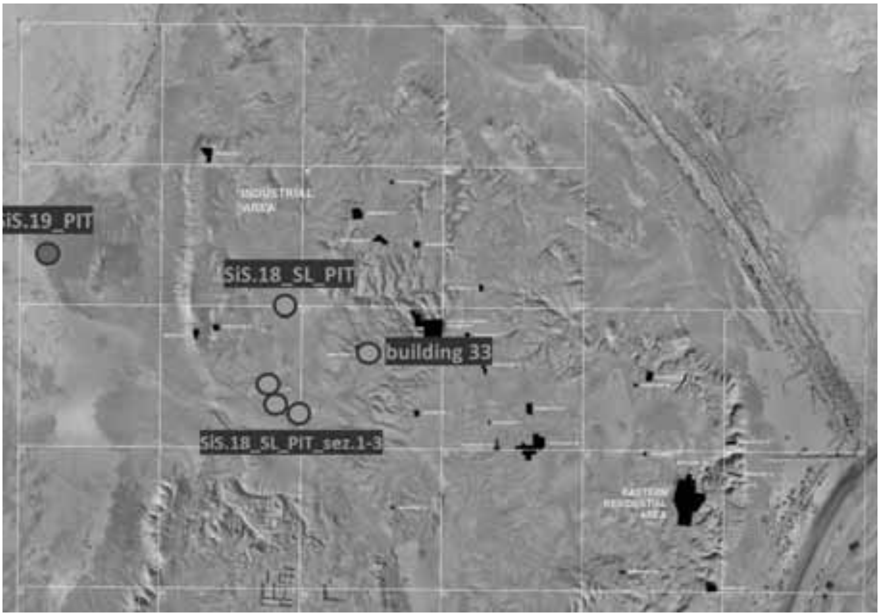


Fig. 1: view of the site of Shahr-i Shokta with the areas subject to archaeobotanical and palaeoenvironmental investigation.

- off-site areas more directly influenced by palaeoenvironmental and palaeoclimatic regional dynamics, especially the bed of the River Helmand (with stratigraphic trenches outside the settlement);
- an intermediate area, i.e. an area that was plausibly influenced by environmental variations but was also directly affected by the settlement's human activities (with a trench inside the depression next to 'Building 33', which may have functioned as a reserve of water for the settlement).

On-site investigations: Building 33

During the excavation of 'Building 33', in the 2017, 2018 and 2019 campaigns, a series of standard-volume sediment samples (5 litres) were taken. Concentrations of combusted remains, identified by visual inspection, were also collected. The sampling approach sought to take account of the stratigraphy of the phases of occupation and the spatial distribution of the remains.

The sediment gathered was dry-sieved through 4 mm, 1 mm and 0.5 meshes, in accordance with the procedures established during the 2017 campaign (Fiorentino - Minervini 2019). On the basis of the functional division of the various sectors of ʿBuilding 33ʾ proposed by E. Ascalone (2019: 19-37), the recovered remains were then grouped into three sectors for the subsequent analyses:

- the kitchens in the northern part of the building (L.34; L. 36; L. 37)
- the staterooms in the central part (L.19; L.21)
- the residential sector (upper levels of L.19; L.6)

The spatial sediment sampling was intensified in the course of the 2019 campaign, especially in loci 156, 149 and 142, all outside ʿBuilding 33ʾ. An area 4 m by 3 m was marked out and subdivided into squares of 60 cm by 60 cm. The objective was to better determine the function of the spaces and recover those types of plant remains with the greatest information potential (phytoliths and starch grains) (Fig. 2).

A further distinction was made between samples pertaining to the structure's two different phases of occupation, separating material from the building's older

Fig. 2: systematic spatial sampling in the area of Building 33 for the analysis of micro-remains.

phase (period III – phase 5b/4: L.15; L.16) from that of its more recent phase (period III – phase 4-3).

On-site investigations: Trench 36

Archaeological excavations in the site of Shahr-i Sokhta are traditionally characterised by large deep trenches, enabling vertical stratigraphic verification, in various parts of the site, which have made it possible to investigate and determine the periods and phases of occupation. These are significant stratigraphic contexts that can also provide key information on diachronic variations in the use of plants and the dynamics of formation of midden deposits. Middens are characterised by homogeneous patterns of accumulation of plant remains in terms of the dynamics of use-reuse-discard, and they contain high concentrations of organic residues of various kinds. Studying them can thus provide a long-term view compared to the contextual synchronic analysis associated with the systematic spatial excavation of other areas.

The 2019 excavation campaign saw the start of the investigations in one of these trenches, Trench 36, located in the eastern part of Shahr-i Sokhta, immediately to the east of the *Eastern Residential Area*. The trench was reopened in order to conduct microstratigraphic verification of the deposit's accumulation patterns. This entailed systematic vertical samplings (Fig. 3) aimed at the recovery of plant micro-remains (phytoliths) and macro-remains (charcoals, seeds and fruits). Further samplings of archaeobotanical remains were conducted for the purposes of C14 dating and analysis of stable isotopes (carbon and nitrogen). The sediment gathered for the analyses of plant macro-remains was wet sieved through 4 mm, 1 mm and 0.5 mm meshes. The plant material selected was partially analysed and determined and the results will be presented in another publication, together with those of the micro-remains.

Investigations in off-site and intermediate areas

Regarding the sampling strategies in the intermediate area, the investigation of the exploratory pit, about 200 cm deep, dug during the 2018 excavation campaign (Fig. 4), was extended.

Fig. 3: systematic vertical sampling in Trench 36.

Fig. 4: sampling in the pit of the depression inside the site.

In order to obtain as detailed a picture as possible of the dynamics of the depression, sampling was also performed along the walls of one of the dry tributaries that flowed into the depression both in the past and today (Fig. 5).

The analyses of pre-washed bulk samples are still in progress. The objective, as previously mentioned, is to identify any correlation between water levels in this depression lying within the site and the dynamics of occupation of the settlement, especially the adjacent 'Building 33', located next to the depression itself.
The off-site investigations entailed manually excavating a pit outside the site to a depth of 150 cm, in an area of relatively low dynamism along the course of the River Helmand (Fig. 6).

The analyses serve to reconstruct the dynamics of the river and its palaeohydrology, in parallel with the investigations already under way in the area (Hamzeh *et al.* 2016) but with greater chronological resolution, helping to determine any correlation with the settlement's various phases of life.

3. Materials and methods

The macroscopic plant component was directly selected and determined in the archaeobotanical laboratory in the MAIPS's storage facility in Shahr-i Sokhta with the aid of a stereomicroscope and a reflected-light metallographic microscope.

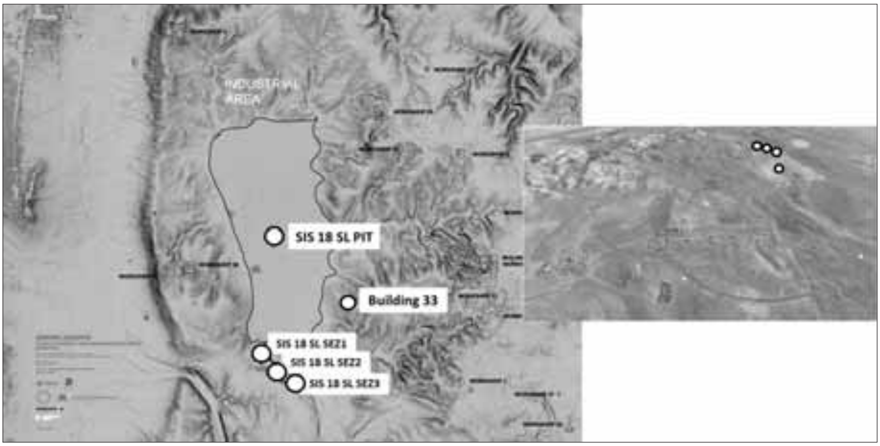


Fig. 5: distribution of the sampling inside the depression and on the walls of one of its tributaries.

Fig. 6: sampling in the off-site pit.

The anthracological remains (fragments of combusted woody tissue) were identified by reading the three fundamental cross-sections of the anatomy of wood (transversal, tangential, radial), observed at 100 to 400x magnification. Taxonomic determination was performed with reference to samples of current vegetation gathered in the area and dichotomous keys found in atlases of wood anatomy (Neumann *et al.* 2001; Schweingruber *et al.* 2011).

Analysis of the carpological component (seeds, fruits and other parts of the plant) entailed morphological and biometric recognition of the remains observed in various views, comparison with the collection of current samples gathered in the region and reference to specific carpological atlases, especially regarding the Poaceae family (Katz *et al.* 1965; Jacomet, 2006; Nesbit, 2006).

The sediment samples used for the analysis of the microscopic plant component were first tested to verify the presence of phytoliths and then prepared for transport and subsequent processing in the laboratory of the CaSEs Research Group of the Universitat Pompeu Fabra in Barcelona, where the analyses are currently in progress.

4. Results

Here we present the results of the anthracological and carpological analyses performed on plant macro-remains recovered during the 2017 and 2018 excavation campaigns in ʽBuilding 33ʼ.

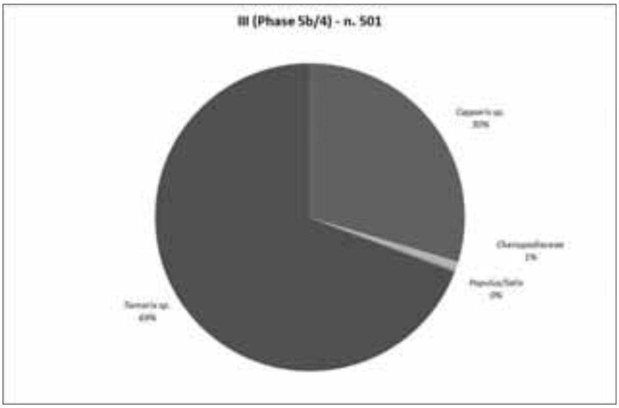
Anthracological analyses

In total, 1250 charcoal fragments were analysed (Tab. 1). Of these, 749 were classed as pertaining to phase 4-3 and 501 to phase 5b-4. On the whole, the taxonomic variability is very low (only four taxa are attested: *Capparis* sp., Chenopodiaceae, *Populus*/*Salix*, *Tamarix* sp.), as is typical for such contexts in arid areas in which the arboreal and shrub vegetation is characterised by low variability.

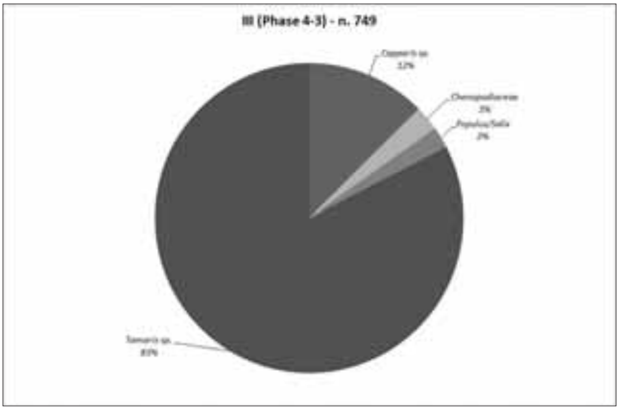
There are no variations between the two phases other than differences in the percentages accounted for by each taxon (Graphs 1-2). Specifically, in the more

Taxon	III (Phase 4-3)	III (Phase 5b/4)
Capparis sp	73	131
Chenopodiaceae	15	4
Populus/Salix	13	1
Tamarix sp.	480	306
Indeterminate	168	59
Total	749	501

Tab. 1: numbers of recovered charcoals by taxon and by phase.



Graph 1: taxonomic composition phase 5b-4.



Graph 2: Taxonomic composition phase 4-3.

recent phase 4-3, there seem to be more plants associated with an environment with greater humidity and increased salinity of the nearby depression (a greater presence of *Tamarix*).

The spatial analysis of the samples reveals taxonomic variability, although the most frequent taxon is always *Tamarix* sp. (Tab. 2).

The taxonomic differences between the loci sampled in the three functional areas previously described indicate lower variability in the area of the kitchens, probably related to the lower number of fragments recovered and analysed: 520 in the staterooms, 516 in the residential area, 122 in the area of the kitchens (Graph 3).

The greatest variability is seen in the staterooms, where there are also open spaces, such as L.19, in which the large number of fragments is probably due to the emptying of numerous combustion structures over time.

Carpological analyses

In total, 231 carpological remains belonging to various categories of seed/fruit and to parts of ears of cereals were analysed (Tab. 3). Most of the remains are from Locus 19, excavated in 2017, and Locus 185, excavated and systematically sampled in 2019, while the other loci yielded very few remains. The taxonomic richness is high, with 21 taxa at varying levels of resolution, from the family (Cyperaceae, Chenopodiaceae, Leguminosae, Poaceae, Polygonaceae) to the

taxa	**Staterooms sector**		**Residential sector**				**Kitchens sector**			
	locus 19	locus 21	locus 4	locus 6	locus 15	locus 16	locus 33	locus 34	locus 36	locus 37
Capparis sp.	29	22	17	1	102	29	2			2
Chenopodiaceae	3			1		4	11			
Populus/Salix	7	1	1		1		4			
Tamarix sp.	145	61	116	10	246	60	56	15	5	83
Indeterminate	68	16	34	3	51	8	31	2		15
Tot	252	100	168	15	400	101	104	17	5	100

Tab. 2: Numbers of recovered charcoals by locus and functional area.

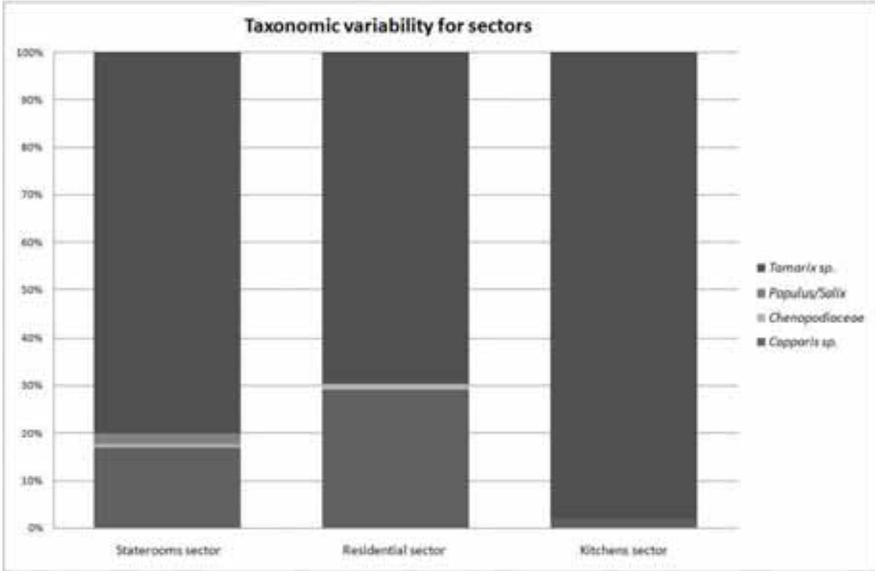
genus (*Avena, Bromus, Carex, Cucumis, Galium, Hordeum, Ranunculus, Rubus, Salsola, Triticum, Viburnum*) and – for some remains – the species (*Hordeum vulgare, Triticum aestivum/durum, Triticum monococcum, Vitis vinifera*) (Graph 4).

On the whole, most of the remains are of herbaceous plants, both wild vegetation and weeds typical of fields, especially the Poaceae identified. The plants most directly linked to diet and to cultivation are cereals, which include *Hordeum vulgare* and wheats both naked (*Triticum aestivum/durum*) and hulled (*Triticum monococcum*). The presence of remains of ears of wheat in the assemblage of Locus 19 also marks the area as a space used for processing cereals, probably in the open air. Legumes are not present in large quantities, but there are seeds of *Vitis vinifera* and vegetable crops such as *Cucumis*.

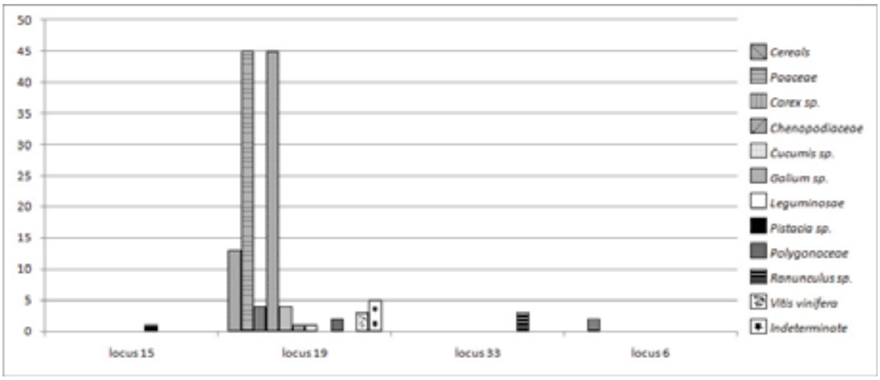
The carpological data seem to indicate a fairly sophisticated management of the plant resources, probably characterised by the cultivation of cereals in open spaces outside the site, while inside the settlement itself, where there was greater availability of water, there were probably allotments and gardens for the cultivation of vegetables and vines.

5. Discussion

The archaeobotanical analyses performed to date have focused on ˈBuilding 33ˈ, in which the extensive stratigraphic excavations have enabled more accurate sampling strategies and the systematic recovery of plant macro-remains. Despite being generally characterised by low taxonomic variability, the two phases considered were found to differ in terms of the anthracological remains, probably the result of micro-variations in the palaeohydrology of the nearby depression in the site and in the wider Hirmand river basin. The intensity of these variations is still difficult to measure, although the results of the analyses of the samples taken in the intermediate and off-site areas will no doubt shed some light on this. The carpological data seem to indicate for phase 4-3 a cultivated area next to the site, which clearly benefited from a water supply sufficient for growing cereals, including the more demanding species such as the naked wheats. A



Graph 3: Taxonomic composition by functional area.



Graph 4: taxonomic distribution of carpological remains by locus.

	Cereals	***Poaceae***	***Carex* sp.**	***Chenopodiaceae***	***Cucumis* sp.**	***Galium* sp.**	***Leguminosae***	***Pistacia* sp.**	***Polygonaceae***	***Ranunculus* sp.**	***Vitis vinifera***	**Indeterminate**
locus 15								1				
locus 19	13	45	4	45	4	1	1		2		3	5
locus 33										3		
locus 6		2										

Tab. 3: numbers of carpological remains by taxon and by locus.

further indicator of good management of water resources on the site, or indeed of higher rainfall, is the cultivation of vines and vegetable crops including cucurbits.

The continuation of the archaeobotanical investigations of micro- and macro-remains on the site and the processing of the data from the samplings conducted to date outside it will make it possible to correlate more accurately the internal dynamics of the site during its various phases with variations in the palaeoenvironment and palaeoclimate of the Hirmand river basin as a whole. Indeed, given its geographical location, the area of the site of Shahr-i Sokhta can provide important information for the reconstruction of the complex palaeoclimatic dynamics that affected this part of Sistan in the course of the Bronze Age, as part of the large climate systems characterising the Indian subcontinent and the Mediterranean basin.

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