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"ESTRUCTURES SOCIO-ECONÒMIQUES A LA PREHISTÒRIA I MÓN ANTIC"

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STUDY OF ASH LAYERS THROUGH PHYTOLITH ANALYSES FROM THE MIDDLE PALEOLITHIC LEVELS OF KEBARA AND TABUN CAVES.

TESI PER OPTAR AL TÍTOL DE DOCTOR EN GEOGRAFIA I HISTÒRIA (PREHISTÒRIA, HISTÒRIA ANTIGA I ARQUEOLOGIA)

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6 - CONCLUSIONS

The main results obtained through the study of phytoliths from the reference collection of plants from the Mount Carmel area (Israel) and the archaeological samples from the Middle Paleolithic levels of Kebara and Tabun cave, are summarized below:

Reference collection

Phytoliths are not abundant in the **wood** and **bark** of both woody dicotyledons and gymnosperms compared to monocotyledons. 2) The wood and bark of dicotyledons and gymnosperms contain a large proportion of phytoliths with variable, irregular morphologies compared to phytoliths with consistent or characteristic morphologies. 3) Among the phytoliths with consistent morphology, there is a low variation of forms among the different species. These forms tend to repeat themselves in most of the plants analyzed. The most common forms encountered are the spheroids and ellipsoids with surfaces that have psilate or scabrate textures. Also parallelepipeds are common, especially in the bark. 4) The redundancy of phytoliths with similar morphology in all the species analyzed, together with the fact that the amount of phytoliths varies

considerably depending on each species, indicates that different plants will contribute differentially in the amounts of phytoliths to the archaeological record. This in turn implies that taxonomical identification of phytoliths derived from wood and bark is difficult.

5) Phytoliths from **leaves** of woody dicotyledons show distinctive morphologies that indicate that they are produced in leaves, and not in wood or bark. Leaves of the gymnosperm groups, have phytoliths which cannot be differentiated from wood and bark.

Archaeological samples

Tabun cave

1) Levels B and C of **Tabun** cave are composed mainly of terra rossa soil and ash from wood/bark mixed in varying proportions. 2) The results of the phytoliths analyses show that fires were lit during Level B period. The phytoliths identified in this Level correspond mainly to wood and bark. 3) The relatively small proportion of ash in these

sediments does not imply that the intensity of occupation was low, as the ash was diluted by a high rate of sedimentation that increased dramatically during this period, due to the enlarging of the chimney. 4) In Level C, there are highly variable proportions of ash and terra rossa, that usually correspond to the white layers being rich in ash, ant the other rich in terra rossa. 5) The observations of the sediments in the field, the micromorphological analyses and the mineralogical and phytolith results are all consistent with a major ash component in many layers that is derived from the burning of wood. 6) Results from Levels B and C of Tabun cave support better the idea of a domestic occupation of the site with fires lit in both levels.

Kebara cave

1) In **Kebara** cave, wood and bark are the main components used as fuel in the hearths analyzed. These results are consistent with the analyses that indicated the presence of a large amount of siliceous aggregates from trees. 2) Phytoliths from leaves and other herbaceous dicotyledons were also observed, although in smaller amounts. 2) The amounts of grass phytoliths identified in the samples, were consistent with them having been brought into the cave together with the bark of the trees. 3) Wood ash is

also an important component of sediments that are not part of hearths. Thus, ash from the hearths was spread around the sediment, maybe for specific purposes. 4) The analyses of the hearths in the northeast section of the cave (RKE37) that are still composed of primary ash-derived calcite, indicated that phytoliths do not preserve well under these alkaline conditions. In other parts of the cave, the phytoliths are relatively well preserved. Studies of the mineralogy of the soil are thus necessary for a reliable interpretation of the phytolith record. 5) There is a variation in the results of the analyses of the consistent morphology phytolith analyses. Two samples of sediments between hearths contain phytoliths derived from plants that were probably not used for fuel.

General conclusions

Phytoliths analyses indicated therefore, that the ashy features from Tabun and Kebara cave are of anthropological origin. The material used for these fires was mainly wood and bark. In Kebara other plant remains were noted, indicating other possible uses of plants in this cave.

The results obtained from the phytolith analyses of Kebara and Tabun caves represent a new approach to studying important aspects of prehistory, and in particular the investigation of the use of fire and its social, economical and technological implications. The approach used integrates observations from the field, the mineralogy of the sediments, as well as quantitative analyses of the phytolith components. This broad approach used together with the phytolith plant reference collection of the local area provides a more comprehensive understanding of the prehistory of these two caves. This approach may well be applicable to the study of other prehistoric caves in other areas and from different periods.

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APPENDIX: Instructions for the use of the Image and Data catalogue.

The image and data catalogue is organized in the following way.

Organization of the catalogue

The image and data catalogue is divided in three different types of documents:

1) The **collection of photographs** of the phytolith morphotypes encountered during the microscope analysis of the reference collection and archaeological sediments from Tabun and Kebara caves. These collections of photographs are organized in an image and data catalogue.

The photographs in this catalogue are organized into a browseable on-line library. The software used for this catalogue is Extensis Fetch for Macintosh version 1.5. Files from Extensis Fetch 1.5 produced on Macintosh programs can be viewed and edited with Portfolio 3.0 on a PC computer. For more information on the

software and their use, please refer to:

info@extensis.com or http://www.extensis.com

2) **The instructions for the use of the image catalogue** with an explanation of the keywords and descriptions used in the pictorial catalogue. The software used for this guide is Microsoft Word 98 for Macintosh.

3) A **table with the results** of the morphological analyses of the phytoliths extracted from the modern plant taxa reference collection. This table includes the numbers and percentages of the different morphotypes identified. It also includes the ratio between the two groups in which this classification was divided, namely **consistent** and **variable** morphologies. This table provides information on the relative abundance of a specific phytolith in a plant or part of a plant.

Note that some of the photographs were taken when analyzing modern plant taxa from the Hayonim area. These data are not included in the tables of the morphological results, since quantification analyses were not carried out for these plants.

This quantitative data can be most helpful for identifying the presence of different plant taxa when analyzing archaeological sediments. The catalogue can be used as a basis for adding additional information and will hopefully be expanded with time to a broader geographical region.

The software utilized for this document is Microsoft Excel 1998 for Macintosh.

The **image and data catalogue** with the photographs of the phytoliths is organized according to the following criteria:

This catalogue has two main windows from which information can be obtained. These two windows are called **Keywords** and **Description**. The **Keyword** window is divided into different sections, each one with a different number and specific information. Through the **Search** command these sections can be used simultaneously. The **Description** section cannot be used through the **Search**

command, but it can be reached through the **Get Information** key.

The **Keyword** window contains information on the characteristics of the photographs and about the plants or the archaeological samples analyzed. This information can be obtained, by means of the **Search** command, either by using the number given for each type of information, or by typing in the information itself. The photographs of the phytoliths included in this catalogue have been classified according to their origin in the plant or their morphological characteristics (see **Keyword n 6**, for more information about the classification of phytoliths, and their terminology). For a better understanding of this classification system and to obtain a visual overview of the phytolith types, use **Keyword n 9**. This will present a selection of the different morphotypes of the phytoliths characterized in this classification. This information can be obtained, through the **Search** command, either by the number n **9** or by writing "**Key type**".

1. - CODES FOR THE "KEYWORD" WINDOW

The **keyword window** is divided into several sections, each with a different

number (1 to 9). Each number provides specific information concerning the photograph and the characteristics of the phytolith represented in the photograph. The list of the numbers and their codes is as follows:

1: PICTURE NUMBER

The first keyword is the picture number. If the picture was taken from an archaeological sample, the number is preceded by the acronym of the site name.

The archaeological sites and their codes, from where the pictures of this CD were taken are:

Kebara Cave - KE

Tabun Cave - TB

2: PICTURE CODE

The first number indicates the name of the plant analyzed from the reference

collection. Each plant was given a different number. The letter that goes with the first number indicates the part of the plant analyzed. If there is no letter, it means that the whole plant was analyzed.

Example: 6b: photograph of phytolith from the bark of *Quercus ithaburensis*.

For the pictures from archaeological samples the code of the site is first followed by the number of the sample, then the number of the fraction (different fractions were separated by heavy liquids to concentrate the phytoliths). The letter and number inside the parentheses, indicate the extraction method and the number of the slide.

Example: KE43.4 (T1/1) Photograph taken from Kebara Cave, from sample n 43, fraction n. 4. Extraction method 1 and slide no. 1.

Samples numbers 1-29 refer to modern plant taxa (listed in table n 1)

3 - LATIN NAME OF THE PLANT

4 - FAMILY

5 -PART OF THE PLANT FROM WHICH THE PHYTOLITH WAS IDENTIFIED

The codes are as follows:

a) wood

b) bark

c) leaves/leaf sheaths (grasses)

d) fruits, cones or seeds

e) other parts of the fruits/seeds

f) other parts of the fruits/seeds

6: PHYTOLITH MORPHOTYPES

Phytoliths were divided in two major categories: **consistent morphologies**, and **variable morphologies.** For both categories a list with the description of the

phytoliths identified in both, the reference collection and the archaeological samples was organized. This description list followed, whenever possible, classification systems and terminology of phytoliths of common use.

The definition and description of the different phytoliths identified is explained in Materials and Methods, chapter 3.

To facilitate the search of a determined phytolith by its morphology, with the **Search** command, it has been assigned a code that describes the different phytoliths identified. This code is in parenthesis next to the main description of the phytolith.

7: THE DISTRIBUTION OF SPECIFIC PHYTOLITHS IN OTHER PLANTS IN THE REFERENCE COLLECTION

This keyword lists the plant, or parts of the plants in the reference collection, where the phytolith type shown in the photograph is also present. In order to limit the search to the more common types and to minimize possible contamination problems, only those phytoliths that constitute more than 5% of the total number present in a

given plant specimen, are included here. (For bark we used 10%). (Note that the above percentages refer to the proportion of either the **consistent** or the **variable** phytolith types). For more information about the phytolith proportions in number and percentage in each plant species, see the tables with the morphological results for the reference collection (Tables 5a-5f) and archaeological samples, Tabun (Tables 14a-c) and Kebara (Tables 18a-e) in this book. Note that in the CD only those tables with the morphological results from the reference collection are included.

Due to space problems in the catalogue program codes were used. The number next to each code indicates the number of plants for each group, in which the specific form appears.

Example: 2L; 3F; 2HD: indicates, that this specific phytolith was also identified in two different species from leaves of woody dicotyledons and gymnosperms, 3 different species of fruits of woody dicotyledons and gymnosperms and 2 different species of herbaceous dicotyledons.

The codes are as follows:

(W): wood

(B): bark

(L): leaves/leaves sheath

(F): fruits, seeds, etc.

(HD): herbaceous dicotyledons

(G): grasses

8: COMMON NAME OF THE PLANT (IN ENGLISH)

9: "KEY TYPE" PHOTOGRAPH

This keyword shows the pictures that have been selected as significant to illustrate the principal characteristics of the morphotype.

- (B) Bulliform
- (C p) Cylindroid psilate
- (C p Bu) Cylindroid psilate bulbous

- (C p DL) Cylindroid psilate diagonal line

- (C v) Cylindroid verrucate

- (D p) Discoid psilate

- (E p) Ellipsoid psilate

- (E s) Ellipsoid scabrate

- (E v) Ellipsoid verrucate

- (EA H) Epidermal appendage. Hair

- (EA H) Epidermal appendage. Hair, "Bozarth" type

- (EA H a) Epidermal appendage. Hair armed

- (EA H f) Epidermal appendage. Hair "Foeniculum" type

- (EA Hb) Epidermal appendage. Hair base

- (EA PA) Epidermal appendage. Papillae

- (EA PR) Epidermal appendage. Prickle

- (F l) Fiber "Linum" type

- (HA Sp) Honeycomb spheroid

- (I p) Irregular psilate

- (I p Pr) Irregular psilate with protuberances

- (I s) Irregular scabrate

- (I v) Irregular verrucate

- (I ge) Irregular with green elongates

- (LC d) Long cell dendritic

- (LC e) Long cell echinate

- (LC si) Long cell sinuous

- (LC w) Long cell wavy

- (LC PO) Long cell polylobate

- (P Bk p re) Parallelepiped blocky psilate rounded ends

- (P Bk p se) Parallelepiped blocky psilate square ends

- (P Bk s se) Parallelepiped blocky scabrate square ends

- (P El p) Parallelepiped elongate psilate

- (P El s) Parallelepiped elongate scabrate

- (P El v) Parallelepiped elongate verrucate

- (P t p re) Parallelepiped thin psilate rounded ends

- (P t p se) Parallelepiped thin psilate square ends

- (P t s se) Parallelepiped thin scabrate square ends

- (PL) Platelet

- (S) Stomata

- (Sc) Sclereid cell

- (ShC) Short cell

- (ShC Bi) Short cell. Bilobate

- (Sp p) Spheroid psilate

- (Sp s) Spheroid scabrate

- (Sp si) Spheroid sinuous

- (Sp v) Spheroid verrucate

- (SS LC p) Silica skeleton long cells psilate

- (SS LC si) Silica skeleton long cells sinuous

- (SS LC w) Silica skeleton long cells wavy

- (SS C si) Silica skeleton cylindroid sinuous

- (SS JS) Silica skeleton jigsaw puzzle

- (SS Ph) Silica skeleton polyhedral

- (SS Ph w) Silica skeleton polyhedral with wavy edges

- (SS Sp/E) Silica skeleton spheroid/ellipsoid

- (SS Sp/R) Silica skeleton polyhedral with rings

- (SS sl) Silica skeleton sensu lato

- (SS ni) Silica skeleton no identified

- (T) Tracheary

- (WM) Weathered morphotype

- Diatom

ADDITIONAL INFORMATION ON PLANTS

The **Description key**, includes information that cannot be found in the window opened by the **Search** command. This contains more general information about the plant and the picture.

For the reference collection pictures, the following additional information is provided:

a) The area were the plant was collected

b) The date when the plant was collected

c) The magnification of the picture

d) The date when the picture was taken

For the archaeological sample pictures, the additional information provided is:

a) The archaeological site

b) The date when the sample was collected

c) The magnification of the picture

d) The date when the picture was taken

Any other additional information that can be relevant to the identification of the morphotype.

SUGGESTED PROCEDURES FOR THE USE OF THE CATALOGUE PROGRAM

When trying to identify an unknown phytolith in the catalogue, several steps are suggested:

1) First use the **Search** command. Type, either n **9:** or "**Key type**". A

list of the characteristic phytoliths with their corresponding photographs and information will appear on the screen. Choose one or several that are most similar morphologically to the unknown.

2) To see the other phytoliths present in the catalogue with a similar morphology, use the **Search** command, and type the letter code of the phytolith. A list of all the phytoliths with the same code and their corresponding photographs and information will appear on the screen. Again choose those that are most similar to the unknown.

3) To know in which other plants the same phytolith is also present, look at Keyword n 7 (The codes are explained in the corresponding section).

4) To know the relative abundance of the phytolith/s chosen in the plant reference collection, as compared to the other morphological types also present in the same plant or part of the plant, go to the

corresponding tables with the morphological results, and search for the name or code of the phytolith form.

Identification should ideally not only be based on morphology, but whenever possible be consistent with known relative abundance of other phytoliths in a given plant.

- KEY TO IDENTIFY THE PHYTOLITHS BY THE CODES

(B)	**BULLIFORM CELLS**
(C)	**CYLINDROIDS**
(C p)	Cylindroid psilate
(C p Bu)	Cylindroid psilate bulbous
(C p DL)	Cylindroid psilate diagonal line
(C s)	Cylindroid scabrate
(C v)	Cylindroid verrucate
(C cl)	Cylindroid clavate
(D)	**DISCOID**

(D p)	Discoid psilate
(D s)	Discoid scabrate
(E)	**ELLIPSOID**
(E p)	Ellipsoid psilate
(E s)	Ellipsoid scabrate
(E v)	Ellipsoid verrucate
(E e)	Ellipsoid echinate
(E PO)	Ellipsoid polylobate
(EA)	**EPIDERMAL APPENDAGES**
(EA H)	Epidermal appendage Hair
(EA H a)	Epidermal appendage Hair armed
(EA H b)	Epidermal appendage Hair with base
(EA H f)	Epidermal appendage *"Foeniculum"* type
(EA Hb)	Epidermal appendage Hair base
(EA PA)	Epidermal appendage Papillae
(EA PR)	Epidermal appendage Prickles
(F)	**FIBERS**
(F)	Fibers type

(F l)	Fiber net "Linum" type
(HA)	**HONEYCOMB ASSEMBLAGES**
(HA El)	Honeycomb elongate
(HA Ph)	Honeycomb polyhedral
(HA Sp)	Honeycomb spheroid
(I)	**IRREGULAR**
(I p)	Irregular psilate
(I p Pr)	Irregular psilate with protuberances
(I s)	Irregular scabrate
(I s Pr)	Irregular scabrate with protuberances
(I v)	Irregular verrucate
(I e)	Irregular echinate
(I ge)	Irregular with green elongates
(IN)	**INDETERMINATE.**
(LC)	**LONG CELLS**
(LC p)	Long cell psilate
(LC si)	Long cell sinuous
(LC v)	Long cell verrucate

(LC e) Long cell echinate

(LC d) Long cell dendritic

(LC w) Long cell wavy

(LC PO) Long cell polylobate

(P) PARALLELEPIPEDS

(P Bk) Parallelepiped blocky

(P Bk p re) Parallelepiped blocky psilate rounded ends

(P Bk p se) Parallelepiped blocky psilate square ends

(P BK s re) Parallelepiped blocky scabrate rounded ends

(P Bk s se) Parallelepiped blocky scabrate square ends

(P t) Parallelepiped thin

(P t p re) Parallelepiped thin psilate rounded ends

(P t p se) Parallelepiped thin psilate square ends

(P t s se) Parallelepiped thin scabrate square ends

(P El) Parallelepiped elongate

(P El p) Parallelepiped elongate psilate

(P El p ch) with channel

(P El s) Parallelepiped elongate scabrate

(P El v)	Parallelepiped elongate verrucate
(P El in)	Parallelepiped elongate indeterminate
(PL)	**PLATELET**
(SC)	**SCLEREID**
(S)	**STOMATA**
(ShC)	**SHORT CELLS**
(ShC)	Short cells sensu lato
(ShC Bi)	Short cells bilobates
(Sp)	**SPHEROIDS**
(Sp p)	Spheroid psilate
(Sp s)	Spheroid scabrate
(Sp v)	Spheroid verrucate
(Sp e)	Spheroid echinate
(SS)	**SILICA SKELETONS**
(SS LC p)	Silica skeleton long cells psilate
(SS LC si)	Silica skeleton long cells sinuous
(SS LC v)	Silica skeleton long cells verrucate
(SS LC w)	Silica skeleton long cells wavy

(SS LC e) Silica skeleton long cells echinate

(SS C si) Silica skeleton cylindroid cells sinuous

(SS C v) Silica skeleton cylindroid cells verrucate

(SS JS) Silica skeleton jigsaw puzzle

(SS Ph) Silica skeleton polyhedral cells

(SS Sp/E) Silica skeleton spheroid/ellipsoid cells

(SS Sp/R) Silica skeleton spheroid w/rings

(SS sl) Silica skeleton *sensu lato*

(SS ni) Silica skeleton no identifiable

(T) **TRACHEARY ELEMENTS**

(WM) **WEATHERED MORPHOTYPES**

Key to the terms used for the description of the phytoliths

a: armed

B: Bulliform

b: base

BA: with base

Bi: bilobate

Bk: blocky

Bu: bulbous

C: Cylindroid

Ch: channel

cl: clavate

D: discoid

d: dendritic

DL: diagonal line

E: Ellipsoid

e: echinate

EA: Epidermal appendages

El: elongate

F: Fibers

f: foeniculum

ge: green elongates

H: Hair

HA: Honeycomb assemblage

I: Irregular

IN/in: indetermined

JS: Jigsaw

l: linum

LC: Long cell

ni: no identifiable

P: Parallelepiped

p: psilate

PA: papillae

Ph: polyhedral

PL: Platelet

PO: polylobate

PR: prickles

Pr: protuberances

R: rings

re: rounded ends

S: Stomata

s: scabrate

SC: Sclereid

se: square ends

ShC: short cells

si: sinuous

sl: sensu lato

Sp: Spheroid

SS: Silica skeleton

T: Tracheary

t: thin

v: verrucate

w: wavy

WM: weathered morphotypes

For a first approximation of the presence of a specific phytolith in the plant reference collection, use **Keyword n 7**. Here information is provided about the different taxa where a specific phytolith is found.

Appendix

In order to become familiar with this catalogue, it is suggested that the user starts with the collection of photographs using **Keyword n 9,** whenever necessary, the explanations of the text guide, and in particular **Keyword n 7** and then proceeds to the tables with the morphological results.