Per. Mineral. (2002), *71*, SPECIAL ISSUE: *Archaeometry and Cultural Heritage*, **227-234** http://go.to/permin

PERIODICO di MINERALOGIA
established in 1930

An International Journal of
MINERALOGY, CRYSTALLOGRAPHY, GEOCHEMISTRY, ORE DEPOSITS, PETROLOGY, VOLCANOLOGY
and applied topics on *Environment, Archaeometry* and *Cultural Heritage*

Characterisation of textile fibres from the Roman ships of Pisa San Rossore, Italy

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ABSTRACT. — An ancient port of Etruscan and Roman origin was discovered in December 1988, during excavation works near the railway station of Pisa San Rossore (Tuscany, Italy). This discovery was particularly important, both because of the great number of well-preserved open ships 16 in all and the quantity of objects found aboard them. These included amphorae of various shapes, sizes and types, ceramic and glass artefacts, objects made of bone and horn, balm and balsamic cosmetics, oil lamps, surgical instruments, fishing and shipboard equipment: hooks, nets, ropes and lines, basket. small covered cord baskets, articles for repairing fishing-nets and sailors' protective clothing in leather. The remarkably good state of preservation of all these objects is due to the fact that they were completely immersed in water, in an oxygen-free environment. The area of excavation from which analysed samples (textile fibres) shows a long narrows conformation morphological (Bruni S., 1999-2000). In this area the rest of the Hellenistic ship together the dock with of the ancient port found the piling breakwater. In these stratigraphic layers prior to and as *limitation* of imperial age (Castagnoli F., 1958), same structures of the harbour of an Etruscan city have been found.

RIASSUNTO. — Durante il mese di Dicembre 1988, nel corso dei lavori di scavo per l'ampliamento della stazione delle Ferrovie dello Stato di Pisa San Rossore, sono state scoperte alcune strutture relative al porto urbano delle città Etrusca e Romana. Questi ritrovamenti sono particolarmente significativi per il numero di navi scoperte (16) e per il loro eccezionale stato di conservazione, relativo anche ai vari carichi trasportati. La quantità di oggetti recuperati quali anfore di varie forme e tipologie, manufatti vitrei, manufatti in osso e corno, lucerne, balsamari, strumenti chirurgici e materiali relativi alle attrezzature di bordo quali ganci, reti, ceste, ami, nasse, cime, aghi da rete e oggetti in cuoio relativi all'abbigliamento dei marinai. L'eccezionale conservazione di tutti questi materiali è dovuta probabilmente all'ambiente umido privo di ossigeno.

L'area di scavo da cui provengono i campioni analizzati, presentava una conformazione morfologica stretta e allungata (Bruni S., 1999-2000). In questa area sono stati rinvenuti i resti della nave di tipo Ellenistico, il molo dell'antico porto con la relativa palizzata frangiflutti. In queste unità stratigrafiche al di sotto dei livelli relativi alla centuriazione di età Imperiale (Castagnoli F., 1958) sono state rinvenute alcune strutture del porto della città Etrusca.

KEY WORDS: *Technology, Textile, Vegetable Fibres, Shipboard equipment, Roman ships, Pisa, Italy.*

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MATERIALS AND METHODS

Microscopic analyses aimed at identifying the morphological characteristics and biometrics of the woven artefacts, in order to establish their origin and technologies used to make them. Image analysis was applied to various woven fibres, vegetable fibres, tree bark, and some seeds of the following species:

Calotropis sp., *Musa sp.*, *Asclepias sp.*, *Hyphaene thabaica* MART., *Spartium junceum* L., *Cannabis sativa* L., *Gossypium sp.*, *Lygeum spartium* L., *Gomphocarpus fruticosus* (L.) AITON, *Hybiscus sabdariffa* L. and *Vitis sp.*. Some of these species are native to the Mediterranean area, some are cultivated plants, and others come from the Near East. On some fabrics, it was possible to identify of loom and type of weaving. Some ropes are composed of mixed fibres, representing progress in workmanship from the viewpoint of technological evolution. Sample materials were treated with 1:1 solution of glycerine and bi-distilled water, and mounted on refractive microscope slides. Ropes which appeared particularly deteriorated were consolidated with a 5% vinyl acrylic nitrile copolymer emulsion (Skinkle J.H., 1949).

Morpho-biometric study of the fibres was carried out using an image analysis system (JVC C322 RGB microscope video camera, mounted on a optical microscope) and an optical stereo microscope connected to a computer with a video imaging board and high resolution monitor, in order to characterise the images obtained. A new software program (Image Analysis and Measurement; Findlay F., 1995) provided both black and white and colour pictures.

The image obtained through the optical video microscope were acquired in true colour, in order to avoid the false colours obtained with commercial software. Pictures were acquired as raster images (binary matrix with an x - y origin), with maximum dimensions of 512 pixels. A colour threshold common to all morphologies was established through operations in which particular areas of the images were highlighted. Fibre diameter, number, area, radius and orientation of warp and weave were extracted automatically. In addition, a series of mathematical equalizations, scaled enlargements and geometric reflections highlighted detailed structural features in both fibres and vegetal cells.

RESULT AND DISCUSSION

LAYER 50, ROPE 1

The rope is made up of two cords twisted into a **Z** form, single strands are twisted into a **S** form (Fig. 1). Fibres were identified as coming from *Hybiscus sp.* (Fig. 2) mixed with *Calotropis sp.* (Fig. 3). The former were obtained by retting *Hybiscus* bark and young twigs, and the latter by retting bark from various species of *Calotropis sp.*, including the ancient Italian strain *Gomphocarpus fruticosus*

Fig. 1 – Photo (5X - Diameter 2,5 cm) Single constituent strand is S twisted, whole string is Z twisted. Samples was consolidated with 5% emulsion copolymer vinyl-acrylonitrile. To replace water molecules and prevent pulverisation. Note structure of strands and twist strands. Two or more strands were twisted to make a rope.

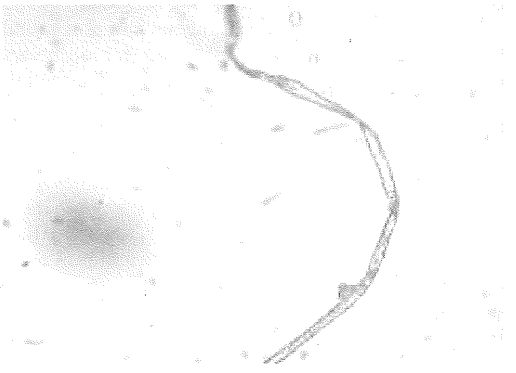

Fig. 2 – Photo (40X) *Hybiscus sp.* fiber.

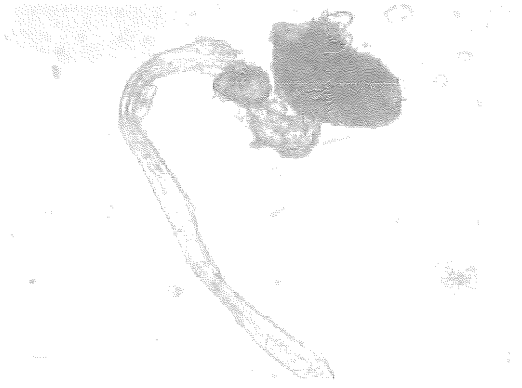

Fig. 3 – Photo (40X) *Calotropis sp.* fiber.

(L.) AITON. The name derives from the Greek τροπτσ, meaning hull, possibly from the custom of protecting ships hulls with these fibres when hauling inboard. The custom of mixing fibres from different species of plants to make ropes and lines was very common and, in this case, adding *Calotropis* fibres to *Hybiscus* ones conferred robustness, manageability and elasticity (Garner W., 1949).

TAXA and ELEMENT	AVERAGE WEIGHT
Hybiscus sp.	12.77
Calotropis sp.	13.96
Gomphocarpus fruticosus (L.) AITON	9.52
Gossipiyum sp.	10.26
Cannabis sativa	4.35
Hybiscus sabdariffa	5.44
Asclepia sp.	4.5
Hyphaene thebaica MART.	4.08
Musa sp.	6.44
Lygeum spartum L.	5.44
Halpha ghedima	6.72
Spartium junceum L.	4.13
Colorless wool	6.12
Dyed wool	4.76
Vitis sp. - seeds	1.51

Chart 1 percentage of fibers and seeds in SL 50

In the case examined here (SL 50 ST I°), torsion is slack. It should be noted that, until relatively recently, ropes were made on board and were either mooring-lines and cables, or ropes used for hoisting and strapping. The latter are considered «soft» and the former «hard» ropes, particularly those obtained from the stalks of *Musa sp.* leaves. In Area 4 in site SL 105, a very flat rope was discovered, evidently made in this fashion in order to reduce the tendency to lose torsion. This particular rope, made of *Musa sp.* mixed with *Asclepias sp.* fibres (Fig. 4), is considered to be a «hard» mooring-line, but one to which the more flexible *Asclepias* fibres were added elasticity and to lessen the tendency to lose torsion.

SL 50 AMPLIFIED SOUTHERN SECTION, LEVEL 1
ROPE

Shows a slack rope (Fig. 5), made with fibres from retted *Hyphaene thebaica* MART. leaves (Fig. 6), mixed *Calotropis sp.* fibres, probably from the Mediterranean area. The rope is composed of two Z twisted cords and single S twisted strands.

As regards technological evolution, mixture of fibres represent progress in the art of rope - making, the soft *Calotropis sp.* fibres giving the *Hyphaene thebaica* a degree of elasticity, making for higher torsion and greater strength.

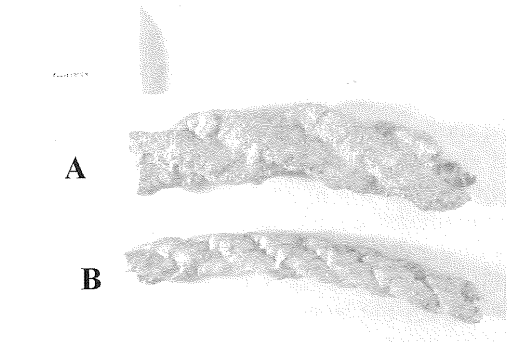

Fig. 4 – Photo (1X - A- Diameter 1,5 cm, B - Diameter 1 cm). Plain rope made of *Musa sp.* and *Asclepias sp.* fibers.

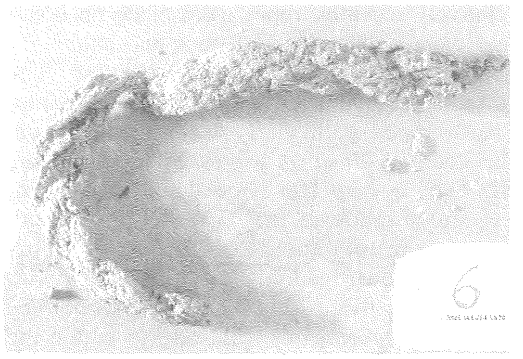

Fig. 5 – Photo (1X- Diameter 3 cm) Rope made of *Hyphaena thebaica* fibers.

Fig. 7 – Photo (40X) *Halpha ghedima* fiber.

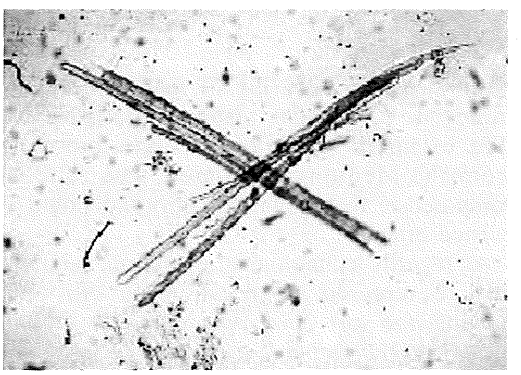

Fig. 6 – Photo (40X) *Hyphaena tebaica* fibers.

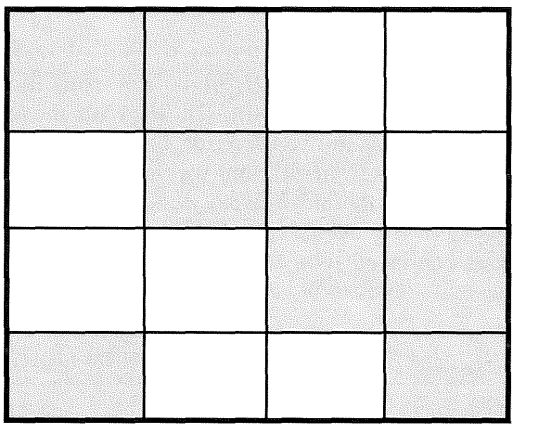

Fig. 8 – Hand-woven wool Batavian design.

BAG

This bag is woven from stalks of *Spartium junceum* L. and *Lygeum spartum* L., both typical weaving materials since ancient time. Today, together with *Halpha ghedima* L. (Fig. 7), they are marketed together under the name of «Esparto grass» (Villavecchia V., 1929).

The materials making up this bag identified by the fibres leaving the stalks. The handweave is of the close - knit diagonal «Batavian» type (Fig. 8), which is easy to do manually (Poma E., 1970) but more difficult to execute on a loom because of its derived and complex nature. *Vitis sp.* seeds were discovered and identified within weave (Fig. 9).

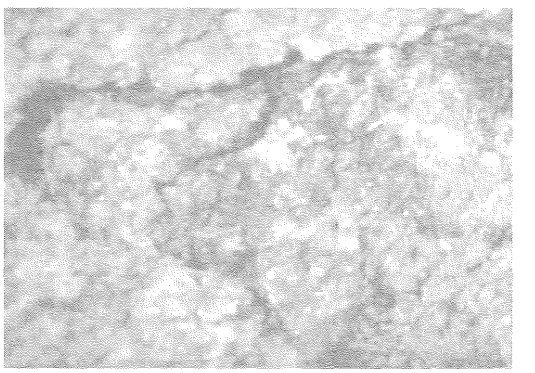

Fig. 9 – Photo (10X) Seed of *Vitis sp.* found in bag.

LEVEL 3
BASKET (fig. 10)

Identified in this basket were fibres of *Gossypium sp.* (Fig. 11), *Cannabis sativa* L. (Fig. 12) and *Hybiscus sabdariffa* L., cut into strips and woven according to a technique called «stepped making» (Fig. 13), identical to that found in SL 50, section 1 (basket). The cotton and hemp fibres probably belong to the selvage, applied to strengthen and decorate the basket.

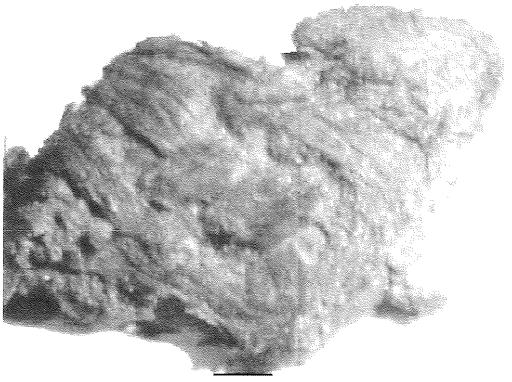

Fig. 10 – (Photo 1X) Basket woven in stepped matting from *Hybiscus sp.* fiber. The find appears more similar to a maintop or creel for the fishing to the rock-cliff.

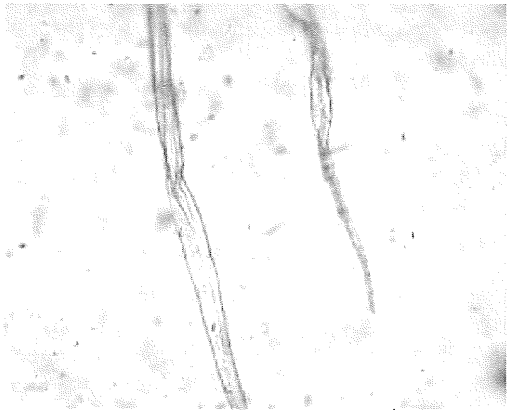

Fig. 11 – Photo (40X) *Gossipium sp.* fibers.

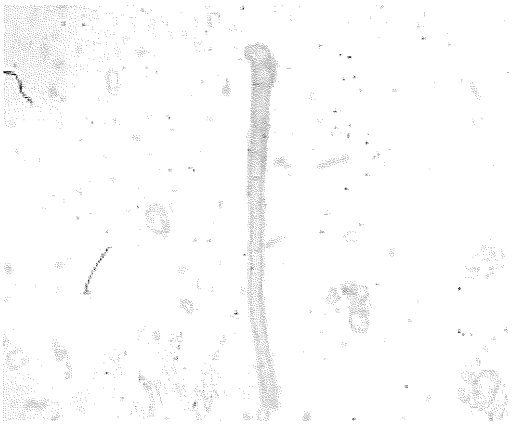

Fig. 12 – Photo (40X) *Cannabis sativa* L. fiber.

		X			
		X	0	0	X
X	X	0	0	X	X
X	0	0	X	X	0

Fig. 13 – Technical designed of the mat.

SL 50, SECTION 1
CLOTH

This fragment (Fig. 14) was characterised as medium - yarn, common wool (Fig. 15), twisted into a Z form (Fig. 16). It has no selvage but, as in most common examples, the selvage probably of the two bound strands themselves. Fragments of *Hybiscus sp.* stalks were found within the piece, and were probably added for their aromatic and anti-parasitic qualities (Paddok K., 1960).

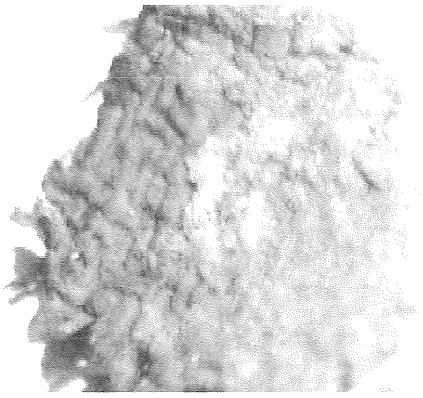

Fig. 14 – (Photo 1X) Fragment of cloth.

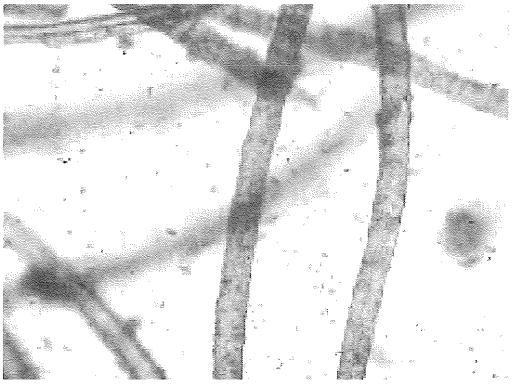

Fig. 15 – Photo (40X) Common wool fibers.

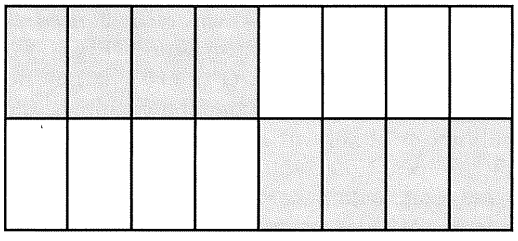

Fig. 16 – Technical design of the reps from four.

GEOGRAPHY AND VEGETATION

The results of analyses carried out on relative samples some brief information of Geobotanical nature, of the vegetated terrains and of the origin of various identified vegetated fibre species has been obtained.

Hybiscus sp. is found in low-lying marshy areas of Sicily, Sardinia, and southern Italy (Di Castri F. and Mooney H.A., 1973). Both cultived and wild species may grow together.

Calotropis sp. (Malveto - Hirschfeldietum; Eig A. 1931-32), of Mediterranean origin, is mainly found in Palestine and Syria, generally in sparsely vegetated terrains with little organic matter, near calcium deposits.

Musa sp., of a tropical origin, may either be a perennial weed or woody in consistency. Species imported into Italy have always been cultivated as ornamental plants (Zangheri P., 1976).

Asclepias sp. of Near East origin (Good R., 1954b), is cultivated throughout Italy as a Textile plant. Wild species may be found growing in rocky ground.

Hyphaene thebaica MART., originally from the Gulf of Aqaba near wadi Taba in Sinai (Zohary M., 1973), also occurs as a minor species in oases near the Dead Sea. During the Ptolemaic period (Lentini A., 1998), it spread extensively in Upper Egypt (Kosinovà J., 1972). It leaves were used to make woven goods and the horny endosperm for objects such as rings, pendants, bracelets, etc (Lucas A. and Harris J.R., 1962[4]).

Spartium junceum L. grows wild in the arid, rocky lowland regions of Sicily, Sardinia and Corsica (Di Castri F. and Mooney H.A., 1973). Morphologically, it present patent ramifications (rush-like).

Lygeum spartum L. grows wild in arid areas of southern Italy, Sicily, Sardinia, Zante, Crete and some Spanish coastal areas (Braun Blanquet J., 1937). Italian examples differ morphologically from other Mediterranean types in having only three stamens, whereas varieties growing on the Greek islands and in Spanish coastal areas have six.

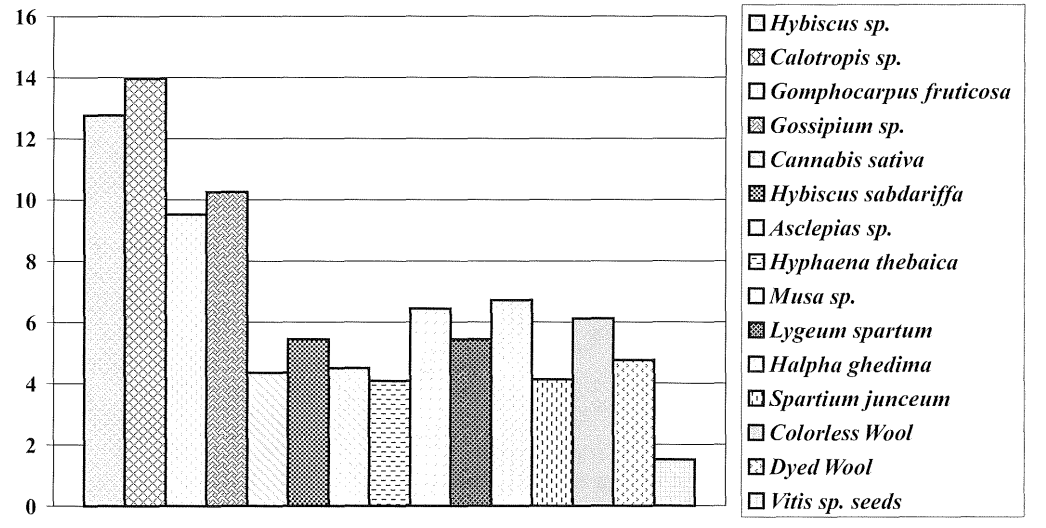

Fig. 17 – Average of the analysed elements.

Gossypium sp., the origin of the domesticated cotton plant has been identified in present-day Baluchistan (Pakistan) (Marshall J. 1990). The spread of this species to the Near East and the Mediterranean basin predates the Harappan period, and cultivation in southern Italy and Sicily goes back to ancient time. Recently, wild species have been observed, probably overlooked by farmers or seeding as a result of changes in agriculture in some regions.

Cannabis sativa L., according to the observation of late 19th century travellers, this domesticated variety of hemp originated near mountainous areas in the Indian subcontinent (Dastur J.F. 1963). Throughout Italy, it is grown as a textile plant, and its initial cultivation is mentioned in many diaries compiled by ancient Roman agronomists (Lachman K. and Rudorff A., 1848-1852). Many wild varieties grow spontaneously in Italy, in areas where hemp is no longer cultivated.

Conclusion

Diachronic examination of this SL studied here, generally indicate three phases in the history of textile fibres in the site. The first is characterised by the use of fibres obtained from suitable plants native to the Mediterranean, such as *Hybiscus sp.* and *Lygeum spartum* L., these plants were typical of the paleo - vegetation in the area. Cultivated textile plants, such as *Gossipium sp.* and *Cannabis sativa* L., are not only well documented by vegetal macro-remains in other sites (seeds and fibres) (Van Zeist W. and Caspaire W.A., 1984), but also provide information on an ancient agricultural economy in which the growing of fibre producing plants was important. Typical species indigenous to the Mediterranean, such as *Hyphaene thebaica* MART., *Musa sp.*, *Calotropis* sp. and *Asclepias sp.*, almost certainly originate from the Middle East (Davoli P. and Lentini A., 2000).

This study, although limited to a single excavation sector of archaeological interest, may constitute an approach to defining essential information on how textile plants were used in the ancient word

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