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Wood species and their uses in the Meroitic kingdom

(based on the collection of the Sudan National Museum, Khartoum)

Introduction

Throughout history, the unique characteristics and comparative abundance of wood have made it a natural material for homes and other structures, furniture, tools, vehicles, and decorative objects (Miller 1999). Wood is an organic material with a complex biological structure. It is made of cells of varying shapes and sizes (Panshin and de Zeeuw 1980). Variations in the characteristics of those cells make woods heavy or light, stiff or flexible, and hard or soft (Miller 1999). Trees are present in two biological groups, namely: gymnosperms and angiosperms. Gymnosperms include all trees that yield softwoods (pine, fir, etc.), while angiosperms are separated into the monocots (bamboo, palm, doum, etc.), and dicots (which include all trees that yield hardwood like mahogany, ebony, acacia, etc.).

The cells of softwood species differ in appearance from those of hardwood species. Softwoods retain a relatively primitive cell structure compared with the more specialized and complex anatomy of hardwoods. Hardwoods consist of four or five types of cells, while more than 95% of the softwood composition is only one type of cells called tracheids. Therefore, softwoods are very similar to each other and it is necessary to resort to very precise details to distinguish between them. The second type of softwood cell is called parenchyma. In hardwoods, the majority of cells (more than 50%) are long and narrow with closed and pointed ends. They have a general resemblance to softwood tracheids, but are much shorter. Most of wood properties (physical and mechanical) are depending upon this type of cells called fibers. In addition to fiber cells, hardwood consists also of vessels, ray and longitudinal parenchyma which vary in their characteristics from species to another. Like the other wood cells, fibers differ in their characteristics (e.g. length, diameter, shape, etc.) from one species to another and thus aid differentiating between different taxa. Previous studies have shown that fibers morphology is an important indicator for end-use. Furthermore, the suitability or quality of wood for a particular purpose is determined by the variability of one or more fibers characteristics, which affect its structure and hence its physical properties (Panshin and de Zeeuw 1980).

Sudan is endowed by a great diversity of tree species; it encompasses about 3156 species belonging to 1137 genera and 170 families (Broun and Massay 1929, Andrews, 1950, 1952, 1956, and El Amin 1990). Variation in annual rainfall and soil type has produced various vegetation types from desert in the northern zone to closed high forest in the most southern part of the country. The arid parts carry only scanty vegetation, and woody species are confined to few *Acacias* spp. in the seasonally flooded areas. The low rainfall savannah houses the main species currently utilized like *Senegalia senegal* (gum arabic tree, syn. *Acacia senegal*) and *Vachellia nilotica* (syn. *Acacia nilotica*), *Anogeissus leiocarpa*, *Terminalia* spp., *Combretum* spp., *Boswellia* spp., *Balanites aegyptiaca*, *Dalbergia melanoxylon* and some palms, mainly *Hyphaene* spp. and *Borassus* spp. The high rainfall savannah areas contain the most valuable forests of the country that have the largest potential of producing sawn timber. The main species of this zone are *Khaya senegalensis, Combretum hartmannianum, Parkia africana, Daniellia oliveri, Isoberbinia doka* and *Anogeissus leiocarpa* (Gorashi 2001).

No scientific studies achieved to determine species used in the different historical eras in ancient Sudan, with the exception of a few studies focused

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on charcoal and wood in both Kerma and New Kingdom period in Sudan. The charcoal remains which were investigated represented five identified taxa: *Ficus sycomorus* (sycamore) and *Tamarix* sp. (tamarisk) predominate, whereas *Acacia sp*. (acacia), *Hyphaene thebaica* (doum palm) and *Ziziphus spina christi* (christ's thorn) charcoals display relatively similar percentages of the remainder (Cartwright and Ryan 2017). Charcoal and wood samples from 40 graves from *Kerma ancien* showed that there are five indigenous species present: *Vachellia nilotica* (sunt, syn. *Acacia nilotica*), *Ficus sycomorus* (sycamore), *Phoenix dactylifera* (date palm), *Tamarix aphlla* (tamarisk) and *Ziziphus spina christi* (christ's thorn) (Cartwright 2018). Nevertheless, there is a lack of studies concerning wood as a material in the other periods. In order to close this research gap on wood use during the Meroitic Kingdom, it was decided to investigate the wooden objects present in the Sudan National Museum.[3]

Materials and Methods

Due to the few number of the available wooden pieces in the Sudan National Museum (SNM) store we decided to study all 51 of them, so it was not possible to rely on selecting some of them as a random sample[4]. They derive from different archaeological sites (see table 1).

Macroscopic and microscopic anatomical examinations have been conducted in order to identify the wood samples. The macroscopic anatomical structure examination has been conducted by using a hand lens of 10x magnification. The cross, radial and tangential sections have been tested whenever it is possible. A comparison of the study samples with reference species has been also conducted to confirm the results. In some cases the macroscopic anatomical structure examination was not possible due to the wood damage which may be attributed to some diseases. Also, at some samples, its small size made it impossible to test it by lens.

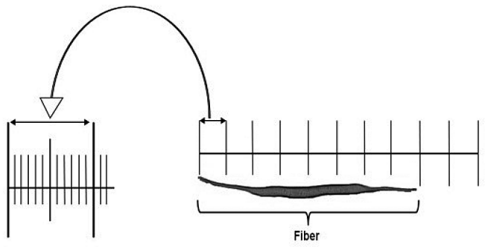


Fig. 1: Fiber length measurement using measuring scale provided in the microscope ocular lens.

A microscopic anatomical structure examination has been conducted whenever it was possible to confirm the results by taking small slivers of 0.5-0.7 cm in order to macerate the wood and investigate the wood fibers characteristics of the study samples. The maceration procedure developed by Shultze as cited in Jane (1970) was adopted to macerate the woody materials. Small slivers of wood were placed in test-tubes, to which 60% nitric acid was added and then warmed up in a water bath for about 3-7 minutes. The macerated materials were washed, stained, rewashed, fixed in slides and then left 24 hours to dry. A total of 5 slides were prepared from each sample. Both qualitative and quantitative examinations were carried out. The qualitative examination included observations of the presence of septate fibers, while quantitative examinations included the investigation of fibers characteristics (length, diameter and lumen diameter). The qualitative and quantitative examinations have been conducted using light microscope (model: Kruss - Optronic) with an 10x ocular lens provided with a measuring scale graduated into ten equal segments, each segment is graduated into ten sub-segments (fig. 1).

Fibers wall thickness was calculated using the following equation:

$$WT = \frac{D - LD}{2}$$

Where: WT is wall thickness; D is diameter and LD is lumen diameter

Results and discussion

The macroscopic and microscopic structure examinations revealed that the studied archaeological objects have been made mainly of three hardwood species and one monocot species grown natively in Sudan, as well as one imported soft wood species. The native four species are: *Dalbergia melanoxylon, Ficus sycomorus, Khaya senegalensis* as well as *Hyphaene thebaica* (table 1 & 2).

3 All the thank to the colleagues at the Sudan National Museum for their assistance in collecting specimens, special thanks to Dr. Shadia Abedu Rabbo and Dr. Ikhlas Abedel Latif Ahmed and Nusseibbeh Mahgoub Osman. Thanks also to the lab technician Gamil Allah Adam Guma, University of Khartoum, Faculty of Forestry, Department of Forest Products and Industies for his assistance in wood samples preparation.

4 With the exception of some wooden objects which were on display in the museum and stored in boxes by a committee of museum staff and members of UNESCO recently. It was not possible to include these items.

Table 1: Wood samples fibers characteristics[5]

SNM No	Type	Location	Measured fibers characteristics (mean ±STDEV)					The expected species according to macroscopic and microscopic examination
			Length (µm)	Diameter (µm)	Lumen diameter (µm)	Wall thickness (µm)	Septation[a]	
25196	Unidentified Pieces	Meroe	3310.20±710	36.52±11.06	29.42± 10.16	3.10±1.52	N	*Hyphaene thebaica* (doum)
38006	Board	Wad Ban Naga	592.28±75.76	13.11±3.82	4.78±2.91	4.16±1.22	N	*Dalbergia melanoxylon* (ebony)
20028	Part of Box	Attiri	1450.6±225	16.52±6.06	8.43±5.52	4.04±1.6	SN	*Cf. Ficus sycomorus* (gumeiz)?
20102	Part of Coffin	Dal?	1377.15±266	10.82±5.85	5.62±3.28	2.60±1.61	SN	*Cf. Ficus sycomorus* (gumeiz)*?*
31119	Disc	Sedeinga	1541.60±239.32	14.67±6.39	7.93±4.85	3.37±0.90	SN	*Cf. Ficus sycomorus* (gumeiz)?
7792(1-4)[6]	Fragment	Meroe	696.79±87.5	11.34±3.20	4.11±2.54	3.63±1.24	N	*Dalbergia melanoxylon* (ebony)
7792(5)	Fragment	Meroe	2702.20±726.10	40.50±7	18.30±4.20	10±3.25	--	Soft wood[b]
62-9-72 (1-2)	Leg of chair	Wad Ban Naga	717.09±76.40	16.58±4.16	8.98±2.77	7.59±2.39	N	*Dalbergia melanoxylon* (ebony)
62-10-170 (1-11)	Unidentified Pieces	Wad Ban Naga	610.50±63.07	12.71±2.74	4.94±2.69	7.78±2.66	N	*Dalbergia melanoxylon* (ebony)
18920	Kohl pot	Semna south	641.98±62.11	13.80±6.65	6.52±2.92	7.28±4.18	N	*Dalbergia melanoxylon* (ebony)
2364	Fragment of carved wood	Meroe	619.07±61.19	15.19±3.09	7.32±1.38	6.88±1.8	N	*Dalbergia melanoxylon* (ebony)
2462	Fragment of carved wood	Meroe	614.56±70.67	12.35±3.57	5.86±2.47	6.49±2.00	N	*Dalbergia melanoxylon* (ebony)
3303	Kohl stick	Sessebi	700.43±64.19	12.10±2.15	5.50±2.60	6.28±3.18	N	*Dalbergia melanoxylon* (ebony)
27868	Leg of chair	Atbara	987.46±253.51	16.25±5.53	8.52±2.97	3.86±1.34	SN	*Khaya senegalensis* (mahogany)
2373(1-9)	Bowls	Meroe	938.49±93.30	14.09±6.22	7.29±3.37	3.40±1.30	SN	*Khaya senegalensis* (mahogany)

a) Septation= the existence of thin transverse walls across the lumen. N: fibers are non septate; SN: both septate and non septate fiber are present. b) In this sample the provided cell dimension values are for tracheid cells and not fiber (soft wood have not fibers).

For softwoods, identifying the species through a hand lens is not easy due to the similarity of their anatomical structure. Furthermore, in the archaeological sample, the matter is more difficult because the wood surface is often being affected by time factors. Therefore, the detected softwood archaeological sample (no. 7792 (5)) was identified by the presence of tracheid cells in the macerated wood samples. However, it was not possible to identify the wood sample until the species level. As all the investigated objects are archeological, the taken sample were very small. This made it impossible to prepare cross and longitudinal sections for more detailed microscopic examination.

Dalbergia melanoxylon wood fibers characteristics values provided in table 1 are comparable with those of literature. For instance, Gamal (2007) reported short fiber length of 561 µm, fiber diameter of 17.2 µm with a range of 10.00 to 27.8 µm in a study of wood fibers characteristics of 32 hardwood species growing in Sudan. The author also reported lumen diameter range of 3.79 –15.15 µm with a mean of 7.06 µm. Gamal (2007) and Neumann *et al.* (2000) confirmed the existence of non septate fibers.

5 All species studied by Hanadi M. Shawgi.

6 Numbers inside brackets: numbers of samples with the same museum number.

Table 2: Wood samples identification according to macroscopic examination

SNM **No**	**Type**	**Location**	**The expected species according to macroscopic examination**
18585	Unidentified Objects	Sedeinga	Ebony
27870	Leg of bed	Atbara	Mahogany
27871	Leg of bed	Atbara	Mahogany
23052	Kohl stick (Hand)	Sedeinga	Ebony
22405	Spindle	Attiri	Ebony
22375	Spindle	Attiri	Ebony
2301	Toy in shape of Mouse	Meroe	Ebony
1824	Handle	Meroe	The hand is ebony, the upper part is not clear (maybe soft wood)
19595	Spindle	Attiri	Ebony

Gamal (2007) reported medium length of 1272 µm with a range of 377–1919 µm and medium wall thickness of 4.27 µm with a range of 1.39–11.10 µm for *Ficus sycomorus*, which is also comparable to our samples. In agreement with the current study result, the existence of both septate and non septate fiber were confirmed by Gamal (2007) as well as Neumann *et al.* (2000).

Khaya senegalensis wood fiber length mean values found in the current study are in similarity with those provided by Gamal (2007) of 1191 µm. Again septate and non-septae fiber were observed by Gamal (2007) and Neumann *et al.* (2000).

In addition to wood fibers characteristics provided in Table 1, macroscopic examination was conducted using hand lens of 10x magnification. The vessels, axial parenchyma and rays characteristics were observed in cross, radial and tangential sections in case of hardwood species. For soft wood species, the tracheid and ray cells were observed, while ground parenchyma and vascular bundles (consist of xylem, phloem and fiber cells) exist in case of the monocot species.

Fig. 2: Wooden handle (Meroe, North cemetery. Khartoum, SNM no.1824) (photo: Hadia M. Shawgi).

The observed characteristic were compared with reference species to confirm the results. Almost all the observed characteristics were comparable with those of the reference species.

As previously mentioned, it was not possible to take sample from all objects. So in some cases, just macroscopic examination has been conducted (table 2).

Wood species in the Meroitic Kingdom

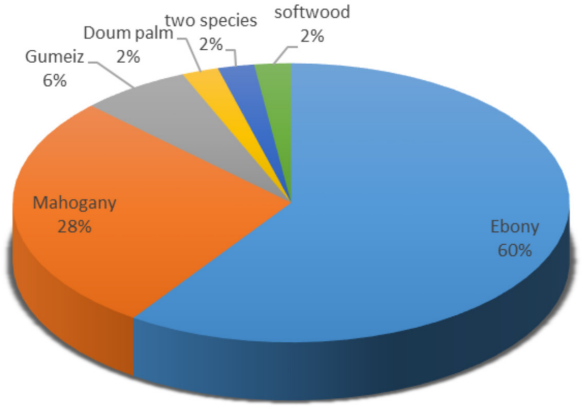
According to the results, most of the samples were ebony (60%) (total no. 28), followed by mahogany (28%) (total no. 13), with the existences of few pieces made by sycamore (6%) (total no. 3). Only one example of doum palm was found (2%), and another sample made of softwood (2%). One object was made of two species of wood (2%) (fig. 2): a handle of a mirror found at Meroe (North cemetery), where the hand is made of ebony, but the upper square part is made of softwood.

Unfortunately five samples were totally damaged (table 3), one of them (1828) lost all the properties of wood and became like cork, the rest is infected with cavities and their fibers melted when they were prepared several times (see diagram).

Table 3: Damaged samples

SNM No.	Type	Location	Notes
2363	Fragment of coffin	Meroe	Highly damaged, infected with cavities and their fibers melted when they were prepared
1828	Box	Meroe	Highly damaged and very weak, it seems that it lost all the characters of wood
27491	Cosmetic container	Sedeinga	Damaged, infected with cavities and their fibers melted when they were prepared
Without no	Not specified	Unknown	Two pieces, damaged, found at G IV 18 (place at SNM store)
Without no	Not specified	Unknown	Pieces damaged, found at G VIII 29 (place at SNM store)

Diagram: Wood species and their averages in the Meroitic objects of the SNM



Dalbergia melanoxylon Guill. & Perr. (babanus, african ebony)

Shrub or small tree, rarely over 10 m high. Distinct by its shape: it is multi-stemmed and multi branched, it is also distinct by its spines. Leaves slightly swollen at the base. Flowers white and sweetly scented. The papery seedpods are distinctive, being pointed at both ends (Vogt 1995). It is one of the *Papilionaceae* (Fabaceae) family trees. Sapwood white; heartwood brown-black, very hard, heavy, fine grain (Thirakul 1984). It is used as a good timber for caving, ornamental turnery, chessmen, and walking sticks (Thirakul 1984). Ebony is found in the dry savanna woodland of tropical Africa. The ancient Egyptians used it widely to make different artifacts. According to the Egyptian textual sources, ebony was imported from many regions like Kush and Punt (Gale *et al.* 2000).

Ebony was known in Sudan from early time on, it seems that ebony was one of the popular goods in ancient Nubia. It was the second important reason for the Egyptian army to intervene in Nubia to keep open the passage southwards to import ebony (Adams and Vercouter 2000). It was one of the main exports goods from Nubia during the Meroitic Period and seems to originate on Meroitic territory (Hakem *et al.* 2000). The result explains that ebony was widely used during the Meroitic period (60%). Because its high quality and beautiful shape and color it was used to make many cosmetic containers (fig. 3). Although ebony is very dark black and hard, thus difficult to work, it shines with a good polish and is highly decorative (Gale *et al.* 2000).

Fig. 3: Kohl stick, upper extremity in the shape of a closed right hand (ebony, from Sedeinga. Khartoum, SNM no. 23052. photo: Hadia M. Shawgi).

Fig. 4: Fragment of a flat piece of wood, carved, on one side as horse's head (ebony, from Meroe, North cemetery, Khartoum, SNM no. 2462. photo: Hadia M. Shawgi).

According to the literature, many non-manufactured pieces of different sizes were found at Wad Ban Naga. They were stored to be exported as pure wood, and we know that Wad Ban Naga was a center for trading goods. Ebony was found stock-piled in the store room of the palace (Welsby 1996). Because of its high quality and beauty, it was used also for carving of various objects (figs. 4, 5). A small chair made of ebony and the mouse toy may have belonged to important children. Two spindles are made by ebony, perhaps because of its hardness, which enables them to withstand repetitive uses.

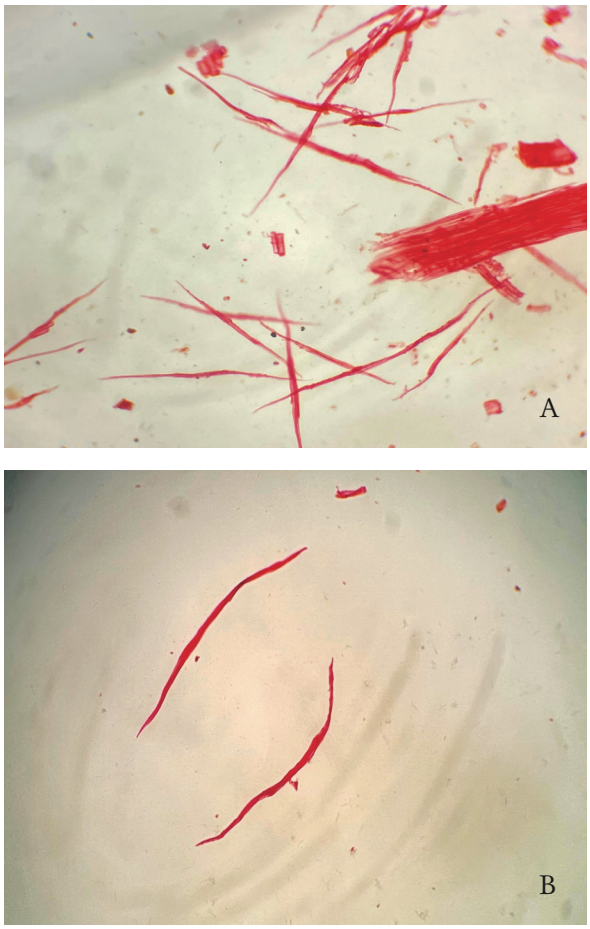


Fig. 5: Light microscopic photos show *Dalbergia melanoxylon* (ebony) fibers (100x magnification). A. sample No 38006 and B. sample No 18920. (photo: Hanadi M. Shawgi).

Khaya senegalensis A. Juss. (mahogany)

Tree up to 30 m high, belongs to the Meliacease family. It is recognized by its clean trunk and large rounded crown. Bark dark grey with small thin scales. Leaves pale green, paripinnate clustered at the ends of the twigs. Flowers are in axillary panicles up to 20 cm long, greenish white flowers. The fruits are distinctive, consisting of round capsules 5–10 cm in diameter, woody in texture; capsules break open into four segments. Wood reddish brown, heavy (Vogt 1995). It is distributed in the high rainfall savanna in Darfur, Bahr El Ghazal, Equatoria and grows in many parts along rivers (El Amin 1990). It is used in furniture, plywood, veneers and building construction (Vogt 1995).

No clear evidence is recorded for the use of this type of wood during the previous periods, but it was used during the Meroitic time (28%). According to the samples, it was mainly used to make bowls and furniture because it is easier to manufacture than ebony and nevertheless durable. Eight nice bowls found at Meroe (North cemetery), in a variety of shapes, and three leg beds were found at Atbara site (figs. 6, 7), in addition to use it to make a large board.

Fig. 6: Leg of bed (mahogany, from Atbara, Khartoum, SNM no 27870), (photo: Hadia M. Shawgi).

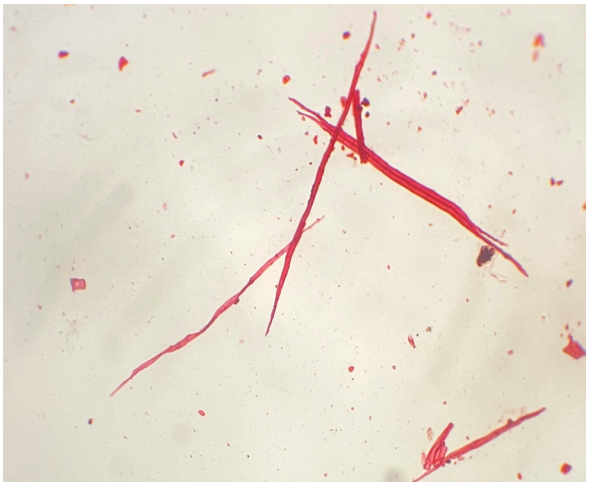


Fig. 7: Light microscopic photo shows the *Khaya senegalensis* (mahogany) fiber (100x magnification). Sample No 27868. (photo: Hanadi M.Shawgi).

Ficus sycomorus L. (sycamore, gumeiz)

Large tree of *Moraceae* family. It is up to 30 m high. Bole short and buttressed at the base. Bark yellow greenish, powdery flaking in minute papery scales.

Leaves simple, ovate orbicular alternate. Receptacles solitary and axillary or in axils of fallen leaves or on large branched leafless panicles on main branches or sometimes both axillary and paniculate; ostioles prominent with numerous exserted suberect bracts. Fruits figs subglobose about 3–5 cm in diameter, tomentose, with stout pubescent stalks, arranged singly in leaf-axils (El Amin 1990). It is found on river and stream banks and on alluvial soils in valleys all over the Sudan, especially along the Nile and its tributaries (El Amin 1990). The wood is creamy brown, has a fairly uniform structure, is very light, soft to moderately hard, tough, strong, easy to work, finishes smoothly and holds nails firmly. It is not very durable and is easily attacked by termites. Mainly used for making mortars and pestles, drums, stools, doors, beehives, dugout canoes, carvings, coffins, wagons and for house building (Lovett *et al*. 2005). It was used frequently in ancient Egypt (Gale *et al* 2000). *Sycamore* was used during both the Egyptian New Kingdom in Sudan and the Kerma period.

Only three samples were found in the SNM (part of coffin, part of box and disc). Although this species does not survive for a long time, it was used in the manufacture of large items, perhaps because of its ease of manufacture (figs. 8, 9).

Hyphaene thebaica (L.) Mart. (doum palm)

Hyphaene thebaica, belongs to Arecaceae family, is a deciduous palm 10–17 m high, with a girth of 90 cm. Trunk is Y-shaped, and the tree is easily recognizable by the dichotomy of its stem forming up to 16 crowns. Bole fairly smooth but clearly showing the scars of the fallen leaves. Bark dark grey. Doum wood can be cut using an axe, but is difficult to saw due to the many fibers that constitute the wood. Timber from the male palm is said to be better than that from the female, as it is borer and termite proof, decorative and durable, but in general it is of poor quality. It is often used for construction, providing supports and rafters for houses, water ducts and wheels, railway sleepers, planks, fence posts and raft construction (Orwa *et al*. 2009).

This type was available and has been used from early time on in Sudan. Many examples of Amara West date to the Egyptian New Kingdom. According to the study doum palm was found in one case but the type of the piece was not specified (figs. 10 ,11).

One sample refers to softwood, but it cannot be identified. It seems that it is not used frequently (fig. 12). The handle already discussed is made in its upper part of soft wood, its hand is from ebony.

Fig. 8: Part of box, decorated with ivory (sycamore, from Attiri, Khartoum, SNM no. 20028 (photo: Hadia M. Shawgi).

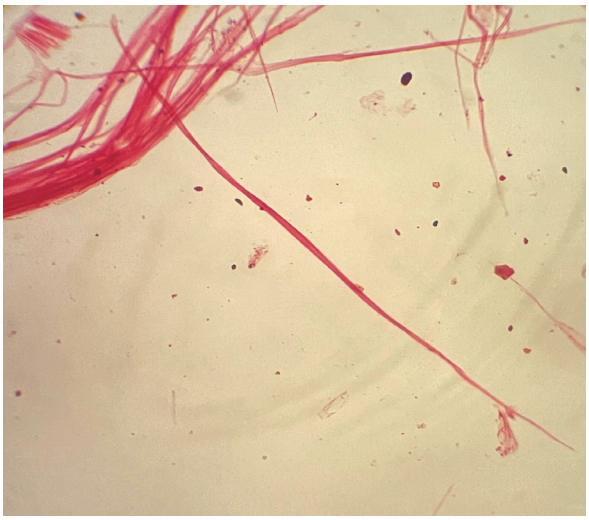


Fig. 9: Light microscopic photos show Ficus *sycomorus* (gumeiz) fibers (100x magnification). Sample number 31119 (photo: Hanadi M. Shawgi).

Fig.10: Unidentified pieces, of *Hyphaene thebaica* (L.) Mart. (doum palm) from Meroe, Khartoum, SNM, no. 25196 (photo: Hadia M.Shawgi).

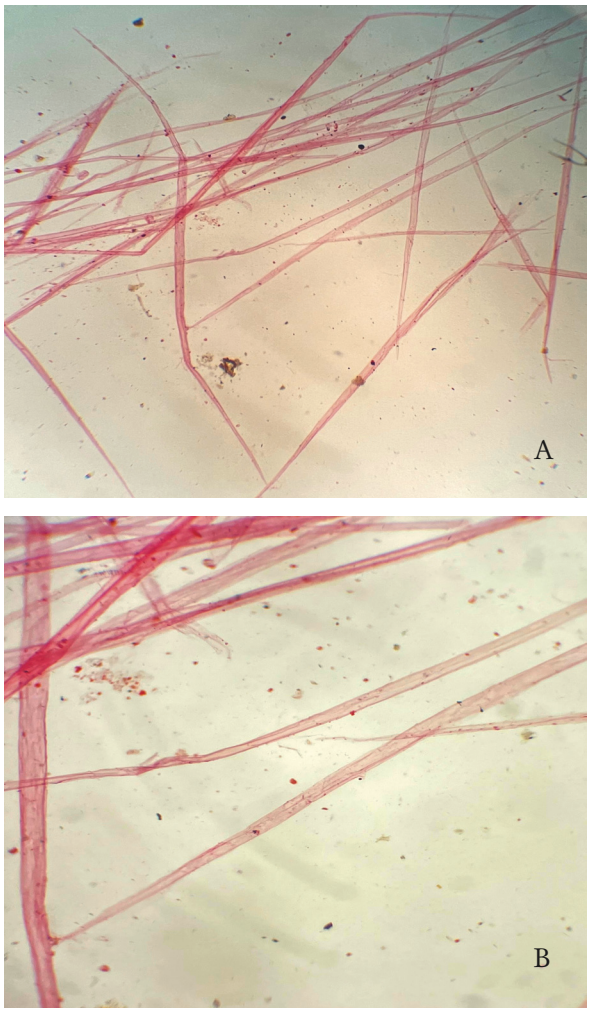


Fig. 11: Light microscopic photo shows Hyphaene thebaica (doum) fibers in sample No 25196. A. under 40x magnification and B. under 100x magnification (photo: Hanadi M. Shawgi).

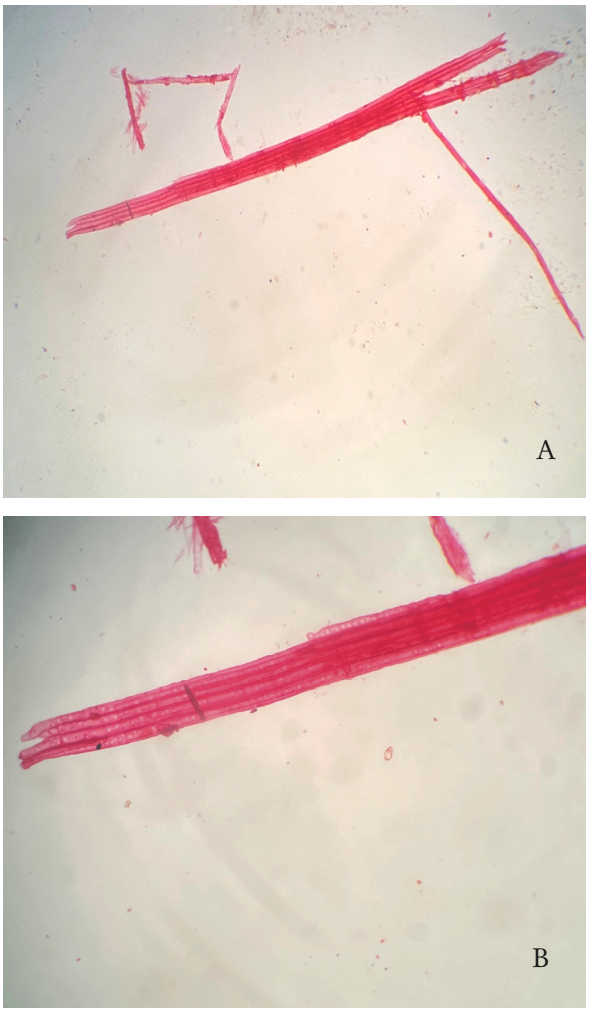


Fig. 12: Light microscopic photos show soft wood tracheid's cell in sample No 7792 (5). A. under 40x magnification and B. under 100x magnification (photo: Hanadi M. Shawgi).

Conclusion

It is evident that from very ancient times on wooden objects were made of native trees as well as imported timbers in Sudan. Ebony was widespread in the dataset, thus perhaps ebony was one of the reasons for the economic success of the Meroitic Kingdom. It has been used for commercial and luxury purposes. Most of the samples were found in Wad Ban Naga, a trade center (13 pieces), and at the Meroe royal cemeteries (7 pieces). The second important species was mahogany which clearly has been used for utensils and furniture because of its good quality. Many other species have been used but not intensively: sycamore, soft wood and doum palm. The softwood species does not grow naturally in Sudan today, so it may has been imported from abroad during the Meroitic time or it was growing in Sudan in the past.

Bibliography

Adams, W. and Vercouter, J. 2000. "The importance of Nubia: a link between central Africa and the Mediterranean". In: General History of Africa, Vol. 2, edited by Mokhtar, G., fourth edition, UNESCO publishing press, France, 226–244.

Andrews, F. W. 1950, 1952, 1956. The Flowering Plants of the (Anglo- Egyptian) Sudan. Vol. 1, 2, and 3. The Burncle of Co., Ltd, Arbroath.

Broun, A. F. and Massey. R. E. 1929. Flora of the Sudan. Wellington House, London.

Cartwright, C. 2018. "Charcoal and wood". In: Welsby, D.A. (ed.), Kerma Ancien cemetery in the Northern Dongola Reach: excavations at site H29, Sudan Archaeological Research Society Publication 22. London, 207–209.

Cartwright, C.R. and Ryan, P. 2017. "Archaeobotanical research at Amara West in New Kingdom Nubia". In:

Spencer, N., Stevens, A. and Binder, M. (eds.), Nubia in the New Kingdom. Lived experience, pharaonic control and indigenous traditions. British Museum Publications on Egypt and Sudan 3. Leuven, 271–286.

El Amin, H.M. 1990. Tree and shrubs of the Sudan. Ithaca press, Exeter, University of Khartoum.

Gale, R. et al., 2000. "Wood". In: Ancient Egyptian Materials and Technology, edited by Nicholson, P. T. and Shaw, I. Cambridge university press. The United Kingdom, 334–371.

Gamal, H. M. S. 2007. Variation in wood fiber characteristics among hardwood species growing in low-rainfall woodland savanna (Sudan). M.Sc. Thesis, Faculty of Forestry, University of Khartoum, Sudan.

Gorashi, A. 2001. State of Forest genetic Resources in Sudan. Sub-Regional Workshop FAO/IPGRI/ICRAF on the conservation, management, sustainable utilization and enhancement of forest genetic resources in Sahelian and North-Sudanian Africa (Ouagadougou, Burkina Faso, 22–24 September 1998). Forest Genetic Resources Working Papers, Working Paper FGR/20E. Forestry Department, FAO, Rome, Italy.

Hakem, A. A. et al, 2000, "The civilization of Napata and Meroe". In: General History of Africa,Vol. 2, edited by Mokhtar, G. Fourth edition. UNESCO publishing press, France, 298–325.

Hoadley, R. 1990. Identifying wood: Accurate results with simple tools. Thunton press, United States of America.

Jane, F.W. 1970. The Structure of Wood. 2nd ed. Completely revised by K. Wilson and D.J.B White. Published by London, Adam & Charles Black.

Lovett, J.C., Ruffo, C.K., Gereau, R.E. and Taplin, J.R.D. 2005. Field Guide to the Moist Forest Trees of Tanzania..The Society for Environmental Exploration, UK and the University of Dar es Salaam, Tanzania.

Miller, R. B. 1999. Characteristics and availability of commercially important woods. Wood handbook: wood as an engineering material. Madison, WI: USDA Forest Service, Forest Products Laboratory. General technical report FPL; GTR-113: Pages1.1–1.34.

Neumann, K., Schoch, W., Detienne, P., Schweingruber, F. H. 2000. Woods of Sahara and the Sahel, an anatomical atlas, Birmensdorf, Eidg. Forschungsanstalt WSL. Bern, Stuttgart, Wien.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Simons, A. 2009. Agroforestree Database: a tree reference and selection guide version 4.0. Accessed on January 2021, from http://www.worldagroforestry.org/.

Panshin, A. J., and de Zeeuw, C. 1980. Textbook of Wood Technology 4th ed. Mc Graw Hill Book Company. New York.

Richter, H.G. and M.J. Dallwitz. 2000. Commercial timbers: descriptions, illustrations, identification, and information retrieval. In English, French, German, Portuguese, and Spanish. Version: 16th April 2016. http://deltaintkey.com.

Thirakul, S. 1984. Manual of Dendrology, Bahr el Ghazal and Central Regions.Forest Inventory Project Areas. CIDA, Groupe Poulin, Theriault Ltee Consultants, Quebec, Canada.

Vogt, K. 1995. A Field Guide to the Identification, Propagation and Uses of the Common Trees and Shrubs of Dryland Sudan. SOS Sahel Interational (UK), London.

Welsby, D. 1996. The kingdom of Kush. The British Museum Press, London

Zusammenfassung

Schon in früheren Zeiten war Holz ein wichtiges Material für den Bau von Häusern und anderen Gebäuden. Im Sudan gibt es 3156 verschiedene bekannte Holzarten. Bisher liegen nur einige Studien zu Holzarten der Kerma-Zeit und des Neuen Reiches im Sudan vor, daher wurden nun an den meroitischen Objekte, die im Sudan National Museum (SNM) aufbewahrt werden, die Holzarten bestimmt.

Die makroskopischen und mikroskopischen Strukturuntersuchungen ergaben, dass die untersuchten archäologischen Objekte hauptsächlich aus drei Hartholzarten (*Dalbergia melanoxylon, Ficus sycomorus* und *Khaya senegalensis*) und einer einkeimblättrigen Art (*Hyphaene thebaica*), die im Sudan heimisch ist, sowie aus einer importierten Weichholzart hergestellt wurden.