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The First Record of Fossil Rubiaceae Wood from Egypt

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A FOSSIL dicot wood specimen is described from the lower Miocene of Gebel El-Khashab Formation in the west of Giza Pyramids, Egypt. Anatomical characters suggest affinities with Rubiaceae. Comment is given on the distribution of Rubiaceae fossil wood in the world particularly Africa.

Keywords: Africa, Miocene, Petrified Dicot Wood, Rubiaceous Wood, Xylotomy.

The fossiliferous, west of Giza Pyramids area, is located at latitude 30º 05` N and longitude 30º 37` E and lies in the northeast of the Western Desert of Egypt to the west of Cairo (Fig. 1). It belongs to Gebel El-Khashab Formation (Issawi *et al*. 1999) and is of early Miocene age (Said 1962, 1971).

The lithostratigraphic section exposed in the study area appears as vividly coloured sands and gravels. It underlies the Plio-Pleistocene gravel terraces of Sand-ford (Idfu gravels) and overlies the basalt flow. Fossil tree trunks are found in basal beds in places with *Scutella* remains (Said, 1971). Palaeobotanical works by Schenk (1883), Stenzel (1904), Schuster (1910), Kräusel and Stromer (1924), Kräusel (1939) and Youssef (1993) showed that these trunks belonged to 15 species (13 dicots and 2 monocots) in 8 families namely: Fabaceae (3 genera and 3 species), Combretaceae (one genus with 4 species), Moraceae and Arecaceae (one genus with 2 species each) and Anacardiaceae, Ebenaceae, Malvaceae and Sapindaceae (one species each).

The aim of this work, is to give the results of the study of fossil woods collected from the study area.

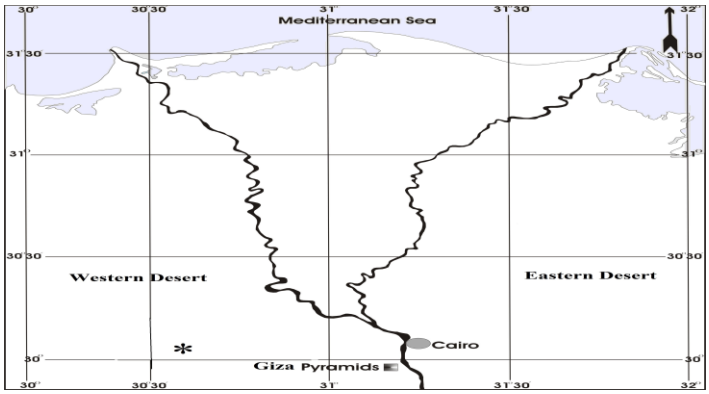

Fig. 1. Map of the northern part of Egypt showing location of the study area (asterisk).

Materials and Methods

Eighteen fossil wood specimens were collected by Dr. S. Youssef (one of the present authors) and Dr. R. Osman (Prof. of geology) who guided the excursion to the study area. The trunks or loose fragments from which the eighteen specimens were taken vary from 1-20 m in length and 20-50 cm in diameter. Section (cross, tangential and radial longitudinal) preparation was after Andrews (1961).

Results

Careful microscopic investigation using the format of the IAWA List of Features Suitable for Hardwood Identification (IAWA Committee 1989) and consulting references such as Metcalfe and Chalk (1950), Jansen *et al*. (2002), APG III (2009) and the database available at the web page: http://insidewood.lib.ncsu.edu/description for fossil and modern woods led us to find out that seventeen specimens belonged to three species namely: *Bombacoxylon owenii* (Malvaceae-Bombacoideae, seven specimens), *Terminalioxylon geinitzii* (Combretaceae, four specimens) and *Terminalioxylon intermedium* (Combretaceae, six specimens) that had already been recorded, described and commented upon from many sites in Egypt (Kräusel, 1939; Youssef, 1993; Kamal, El-Din, 2002; El-Saadawi & Kamal El-Din, 2004; El-Saadawi, *et al*. 2014 and Kamal El-Din, *et al*., 2015). It has to be mentioned, however, that *B. owenii*, *T. geinitzii* and *T. intermedium* are old records to the study area (Kräusel, 1939 and Youssef, 1993). The single remaining specimen no. 6 WGP (W = West, G = Giza, P = Pyramids) belonged to Rubiaceae. This is the first record of fossil wood belonging to this family from Egypt (Kräusel 1939; Dupéron-Laudoueneix & Dupéron 1995 and Gregory *et al*., 2009). However, a fossil Rubiaceae fruit had been reported earlier (Kräusel, 1939 and Chandler, 1954) from the Eocene of the country.

A description of this newly recorded fossil rubiaceous wood together with comments on affinities, distribution and palaeoclimate are given below.

Description, Comparisons and Affinities

Order: Gentianales
Family: Rubiaceae
Genus and species unnamed (Fig. 2)

Diagnosis: Vessels in radial multiples of 2–8 (mostly 3–4) and rarely solitary, perforation plates simple and scalariform, intervessel pits vestured; fibers septate; axial parenchyma apotracheal and paratracheal; rays 1-3 (rarely 4) seriate, with multiseriate portion(s) equal in width to uniseriate parts.

Growth rings indistinct. Wood diffuse-porous. Vessels in radial pattern, in radial multiples of 2–8 (mostly 3–4) and rarely solitary, angled in outline, tangential diameter 120–160 µm (mean 140 µm) and radial diameter 100–230 µm (mean 180 µm). Mean vessel element length 780 µm. Vessels / sq. mm 24–40. Perforation plates simple and scalariform with ≤ 10 bars, with very oblique end walls. Intervessel pits alternate, opposite and vestured. Tyloses absent. Fibers septate, very thin-walled. Axial parenchyma apotracheal diffuse, diffuse-in-aggregates and scanty paratracheal. Rays 1–3 (rarely 4) seriate, with multiseriate portion(s) equal in width to uniseriate parts, with 1 to over 4 marginal rows.

Note: Fungal hyphae are present in the vessel elements.

Similarities to extant woods

Families with some members that have radial multiples of 4 or more vessels, both simple and scalariform perforation plates, alternate intervessel pitting and septate fibers are Apocynaceae and Rubiaceae of the Gentianales. However, Rubiaceae is distinguished by vestured intervessel pits, 20–40 vessels/sq. mm, very long vessel elements, diffuse, diffuse-in-aggregates and scanty axial parenchyma, narrow rays, 1–3 rarely 4 seriate with 1 to over 4 uniseriate margins (Metcalfe & Chalk, 1950 and Jansen *et al*., 2002). We, therefore, consider this wood's affinities, even in the absence of the RLS, to be with Rubiaceae. In this family, there are two main types of secondary xylem (Koek-Noorman, 1977). Type I has fiber-tracheids, apotracheal diffuse, diffuse-in-aggregates or banded axial parenchyma, mainly solitary vessels and narrow rays with long uniseriate margins. In type II fibers are septate libriform, axial parenchyma scanty or absent, vessels in radial multiples (2–4 or more) and solitary, rays wider and with a few rows of upright/square ray cells (Jansen, *et al*., 2002). The west of Giza Pyramids wood specimen has combination of characters from type I as apotracheal diffuse and diffuse-in-aggregates axial

parenchyma, narrow rays with uniseriate margins and type II as septate fibers, vessels in radial multiples and scanty parenchyma. Family Rubiaceae has three subfamilies, of which subfamilies Cinchonoideae (mainly Tribe Guettardeae) and Rubioideae have wood type I and II in some genera and in species of some genera (Jansen, *et al*., 2002). The west of Giza Pyramids wood specimen has similarity to the genera of Tribe Guettardeae which have wood type I and II (mainly genus *Anthirhea*). But, the present fossil wood has septate fibers and these genera do not (Jansen, *et al*., 2002).

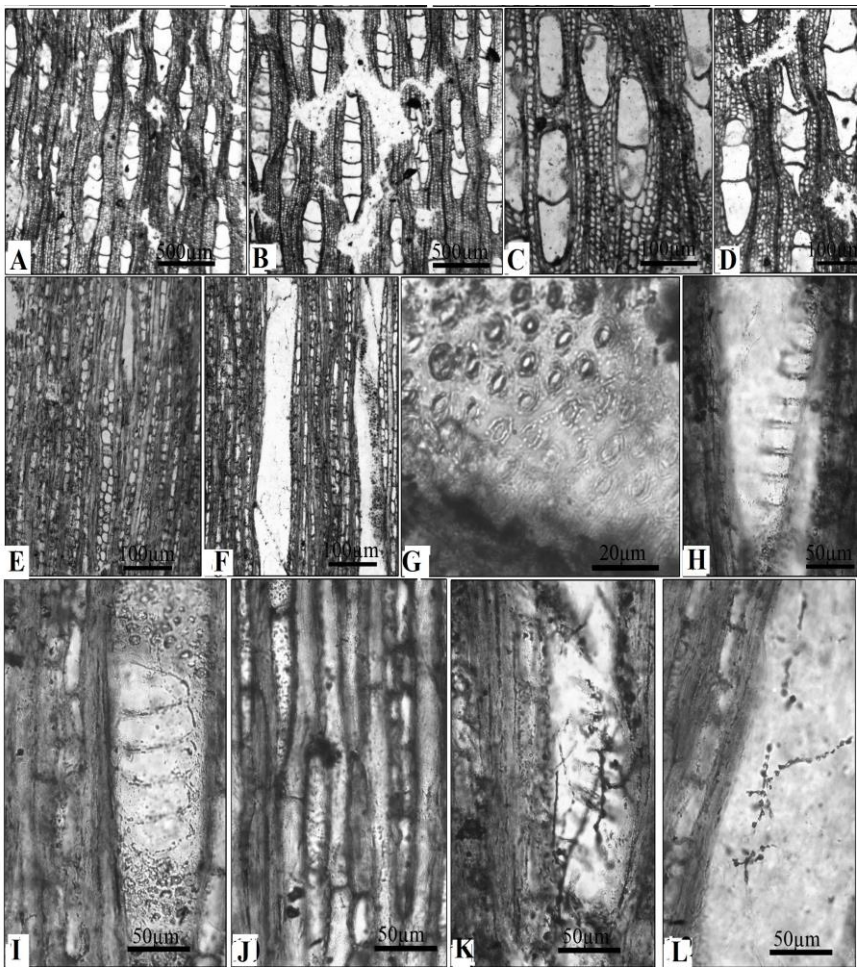

Fig. 2. Fossil rubiaceous wood 6 WGP– A, B: Indistinct growth rings, vessels in radial multiples, TS. – C, D: Diffuse and scanty parenchyma, TS. – E: Rays 1-3 seriate, TLS. – F: Oblique end walls and scalariform perforation plates, TLS. – G: Vestured pits, LS. – H, I: Scalariform perforation plates, LS. – J: Septate fibers, TLS. – K, L: Fungal hyphae in vessel element, LS. — Scale bars: A, B= 500 µm; C, D, E, F = 100 µm; G = 20 µm; H, I, J, K, L = 50 µm.

Comparisons with other fossil woods

There are over ten other fossil woods attributed to Rubiaceae worldwide as presented in Table (1) below.

TABLE 1. The distribution of fossil Rubiaceae woods in the world. based onDupéron-Laudoueneix & Dupéron (1995) Gregory *et al*. (2009) Insidewood (2016). (# = name seen in Koeniguer (1975) but reference not in his bibliography; perhaps error for *Mitragynoxylon gevini*? Gregory *et al*., 2009), ^ = reported by Dechamps (1976) however, without descriptions or illustrations (Gregory *et al*. 2009)). * = description available.

Fossil Rubiaceae wood taxa	**Continents**		
	Africa	**Asia**	**Europe**
Canthium omoensis *	Ethiopia (Pliocene)		
Canthiumoxylon neyveliensis		India (age unknown)	
Grangeonixylon apocynorubioides *			France (Eocene)
G. danguense *			France (Eocene)
Mitragynoxylon gevini *	Algeria (Oligocene and Miocene)		
Naucleoxylon gevini #	North Africa (Tertiary)		
N. spectabile		Java (Pliocene)	
Rothmannia aethiopica *	Ethiopia (Pliocene)		
R. omoensis *	Ethiopia (Pliocene)		
R. urcelliformis ^	Ethiopia (Pliocene)		
Rubioxylon naucleoides			Austria (Oligocene)
R. vincent *	Chad (Pliocene)		
cf. *R. vincenti* *	Ethiopia (Miocene)		

Out of the species listed, above, in Table 1 we have the descriptions of only the 8 asterisked species. Furthermore, *Grangeonixylon apocynorubioides* and *G. danguense* are not unequivocally assigned to Rubiaceae [probably Apocynaceae (Gregory, *et al*., 2009)]. Therefore, comparisons, between only 6 fossil woods of Rubiaceae (all African by chance), are made with the present fossil wood as comes in Table 2 below.

TABLE 2. Comparisons between the six African fossil wood species of Rubiaceae after Insidewood (2016) and the present Rubiaceae wood.

Characters	*Canthium omoensis*	*Mitragynoxylon gevini*	*Rothmannia aethiopica*	*R. omoensis*	*Rubioxylon vincenti*	cf. *R. vincenti*	The present wood
Growth rings	indistinct or absent	distinct	indistinct or absent	indistinct or absent	indistinct or absent	distinct	indistinct or absent
Wood	diffuse	semi-ring	diffuse	diffuse	semi-ring	semi-ring	diffuse
Vessels	-	in radial multiples of 4 or more	-	90% solitary	in radial multiples of 4 or more	-	in radial multiples of 4 or more
Perforation plates	simple	simple	simple and scalariform from 10–40 bars	simple and scalariform from 10–40 bars	simple	simple and scalariform from 10–40 bars	simple and scalariform less than 10 bars
Intervessel pits	scalariform, opposite and alternate	alternate	opposite and alternate	scalariform, opposite and alternate	alternate	scalariform, opposite and alternate	alternate, opposite and vestured
Vessels / mm^2	20–40	5-20, 20–40	5-20	40–100	≤ 5	≤ 5	24–40
parenchyma	diffuse, diffuse-in-aggregate and scanty	diffuse and diffuse-in-aggregate	diffuse, diffuse-in-aggregate and scanty	diffuse, diffuse-in-aggregate and rarely scanty	diffuse and diffuse-in-aggregate	diffuse, diffuse-in-aggregate and vasicentric	diffuse, diffuse-in-aggregate and scanty
Ray width	1–3	1–3	-	1–3, large rays 4–10 common	Exclusively uniseriate, presence of sheath cells	1–3	1–3, rarely 4
Rays body	procumbent, 2–4 rows of upright/ square marginal cells	with over 4 rows	with mostly 2–4 rows or over 4	with mostly 2–4 rows	with one or mostly 2–4 rows	with one row marginal	with one or over 4 rows marginal

From Table 2, the west of Giza Pyramids wood specimen is clearly different from these six African fossil species. It is also less likely that the present specimen, belongs to any of the remaining species (*Canthiumoxylon neyveliensis*, *Naucleoxylon spectabile* and *Rubioxylon naucleoides*) which exist in continents other than Africa and are or probably are of different ages (Table 1). The present specimen, therefore most probably represents a genus or at least a species that is new to science, however, in the absence of RLS it cannot be perfectly diagnosed or even named. It is hoped to come across this type of wood in a future excursion.

Discussion

The main wood features of the present Rubiaceae specimen are: indistinct growth rings, diffuse-porosity, often multiples of vessels, high vessel frequency, diffuse parenchyma and very thin-walled fibers, indicating non-seasonal cool temperate or more probably high montane tropical palaeoclimate because most of the other fossil wood species known from the study site [*Glutoxylon symphonioides* (Anacardiaceae), *Terminalioxylon edwardsii*, *T. geinitzii*, *T. intermedium*, *T. primigenium* (Combretaceae), *Ebenoxylon aegyptiacum* (Ebenaceae), *Detarioxylon aegyptiacum* (Fabaceae-Caealpinioideae), *Dalbergioxylon dicorynioides* (Fabaceae-Faboideae), *Tetrapleuroxylon acacieae* (Fabaceae-Mimosoideae), *Bombacoxylon owenii*, (Malvaceae-Bombacoideae), *Ficoxylon blanckenhornii*, *F. cretaceum* (Moraceae) and *Sapindoxylon stromeri* (Sapindaceae) (Schenk, 1883; Stenzel, 1904; Schuster, 1910; Kräusel, 1939 and Youssef, 1993)] have indistinct growth rings diffuse-porous wood, solitary and in multiples vessels, medium to large vessels, simple perforation plates, 5-20 vessels / sq. mm, abundance of axial parenchyma and very thick-walled fibers (Kräusel, 1939; Youssef, 1993; Kamal El-Din, 2002; El-Saadawi & Kamal El-Din, 2004; El-Saadawi *et al*., 2011; Kamal El-Din *et al*. 2015); features that are common in tropical non-seasonal climates (Wheeler & Baas 1991, 1993; Alves & Angyalossy-Alfonso 2000, 2002). The presence, in the study area, of *Palmoxylon* [*P. aschersoni* and *P. libycum* (Arecaceae) (Kräusel & Stromer, 1924)] also supports the tropical or subtropical nature of the growth site (see El-Saadawi *et al*., 2004).

In addition to this, the extant relatives of the sixteen fossil species of the west of Giza Pyramids area *i.e. Gluta*, *Terminalia*, *Detarium*, *Dalbergia*, *Tetrapleura*, *Bombax*, *Ficus*, Ebenaceae, Rubiaceae, Sapindaceae and Arecaceae all have a large number (a few have a small number) of species living today mainly in the tropics (Mabberley, 1987). Furthermore, the families: Ebenaceae, Fabaceae-Caesalpinioideae, Malvaceae *sensu lato*, Rubiaceae, Sapindaceae and Arecaeae which are represented by fossil wood in the present study site, dominate with some other families today, in the African forest communities (Jacobs, 2004), thus indicating essentially forest biomes for the present study site or more precisely for the original site of growth of these trees and palms.

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اول تسجيل لخشب حفري من فصيلة Rubiaceae من مصر

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تم وصف عينة خشب ذات فلقتين من عصر الميوسين المبكر من تكوين جبل الخشب غرب اهرامات الجيزة بمصر .وتم دراسة الصفات التشريحية التي تدل علي انتمائها لفصيلة Rubiaceae مع التعليق علي توزيع هذه الفصيلة في العالم وخاصة افريقيا .