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Plant Fragments from Tufa Deposits (Quaternary), Kharga Oasis, Egypt

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Abstract: Impressions of fragments of dicotyledon (*Acer, Dicotylophyllum, Ficus, Salix*) and monocotyledon (*Cyperus*) leaves are described from Quaternary Tufa deposits in Kharga Oasis, Egypt. The present record of *Acer, Dicotylophyllum, Salix* and *Cyperus* is the first from Quaternary strata. All fossils have not been recorded from Kharga Oasis except *Ficus*. Fossil remains of *Salix* and probably also of *Acer* are recorded for the first time from Egypt.

Key words: Aceraceae, Cyperaceae, Egypt, Kharga Oasis, Moraceae, Quaternary, Saliaceae, Tufa deposits

Introduction

Tufa deposits are continental freshwater deposits that originate from the precipitation of calcium carbonates under a wide range of climatic regimes, from wet cool temperatures to semi-arid conditions. They are extremely local at such sites as waterfalls and springs and they are considered of great interest in the studies of palaeogeography, palaeoclimatology and palaeoecology especially from Quaternary period (2 millions ago). Pedley (1990) described tufa as cool-water deposits of highly porous or spongy fresh-water carbonates rich in micro-and macrophytic growths, leaves and woody tissues. The associated vegetation is normally preserved on the longer term as moulds and casts framed by concomitant precipitation of sparite and micrite on the outer surfaces of the living plants.

Several tufa deposits at different sites along the western Desert plateau scarps in Egypt were studied and described by several authors, e.g. Kharga Oasis (Caton-Thompson, 1952) Kurkur Oasis (Crombie *et al.*, 1997), Dungul Oasis (Issawi, 1969) and the Nile cliffs (Said, 1981).

The Quaternary flora of Egypt is little known and sparse (Said, 1990; Hermina, 1990). It is known from two localities namely, Fayum and Kharga Oasis. From the former locality fossil wood of *Bombacoxylon owenii*, silicified rhizomes of *Phragmites australis (communis)* Trin and silicified roots of *Tamarix* were reported by Kräusel (1939) and El-Saadawi *et al.* (1975, 1979) respectively. It is worth mentioning that *Phragmites australis* was reported earlier from El-Fayum but under *Cyperus papyrus* (Kräusel and Stromer, 1924) and under *Bambusa* sp. (Soliman, 1964). Plant remains more relevant to the present work are, however, those reported from the latter locality (Kharga Oasis). From this locality Kräusel (1939) reported *Ficus* cf. *ingens* Miq., *Ficus* cf. *salicifolia* Vahl and *Ficus sycomorus* L.

The aim of the present work was to make further studies on fossil remains collected from Quaternary tufa deposits of Kharga Oasis.

Materials and Methods

Nine slabs (130A, 130B, 133A-G) were collected from tufa; Naqb Assiut, Naqb Boulaq, Naqb El-Rufuf and Naqb Esna (Fig. 1 a-d, respectively). The slabs contain fragmentary remains of leaves of dicotyledons (Aceraceae, Juglandaceae, Salicaceae and Moraceae) and monocotyledons (Cyperaceae). All are preserved as impressions without any organic matter left. The plant remains have pale yellow and brown colour.

Study area

General geology of Kharga Oasis: Kharga Oasis is long north-south trench-like basin, about 200 km in length, carved down to the Nubian Sandstone. This basin is sheltered by the Eocene plateau on the east and north, where the high cliffs form a sharp boundary to the basin. The floor of the depression is partially covered by large, flattish and highly dissected silt and clay playa deposits and several belts of active dunes, moving toward the south.

The following rock units represent the bedrock stratigraphy exposed on the eastern scarp of the Kharga Oasis (Fig. 1), from bottom to top (Hermina, 1990):

- Nubia Formation (pre-Campanion); consists of sandstone with occasional interbeds of clay and shale. It attains a thickness of about 100 m at the scarp foothills.
- Quseir Formation (Campanion); consists of varicolored mottled, silty and sandy claystone with a thickness of about 60 m.
- Duwi Formation (Upper Campanion-Lower Maastrichtian); consists of a series of phosphatic beds.
- Dakhla Formation (Middle Maastrichtian-Middle Paleocene); consists of shale, marl and clay with intercalations of calcareous, sandy and silty beds. It attains about 80 m in thickness.
- Tarawan Formation (early Upper Paleocene); consists of fossiliferous marly to chalky limestone with reworked dwarfed fauna and solitary corals. It attains a thickness of about 25 m.
- Esna Formation (late Upper Paleocene-lowermost Eocene); consists of marl and green shale with some carbonate intercalations. Its thickness is about 140 m.
- Thebes Formation (Lower Eocene); consists of marl, marly limestone and thick bedded limestone with intercalations of brown chert bands.
- Quaternary; includes gravel terraceces, playas, sabkhas, wadi sediments and tufa deposits. These deposits are scattered through the low-lying basins, wadis and slopes of different scores bounding Kharga Oasis.

Field and petrographic description of tufa deposits: Tufa deposits are well developed along the eastern scarp of the Kharga Oasis at Naqb Assiut, Naqb Boulaq, Naqb El-Rufuf and Naqb Esna (Fig.1). The extensive remains of tufa deposits are exposed unconformably as fan-like masses widening out towards the scarp foot slopes at an elevation varies between 340 and 375 m (a.s.l.). However, large dislocated slumped blocks of tufa deposits exist at low levels on the wadi floors (Fig. 2). The thickness of the exposed tufa deposits is variable. The deposits are only 3 m thick on their lower reaches; meanwhile, it attains more than 20 m thick on the upper one. In spite of the drastic changes in thickness, the lithostratigraphic characteristics on both the lower and the upper reaches are nearly the same.

Caton-Thompson (1952) classified them according to their physiographic settings into; a) plateau tufa, which occurs typically in horizontal sheets on the Eocene limestone (Thebes Formation) just below the scarp edges and b) wadi tufa, which is a softer and more porous type that rests on Quaternary deposits at lower level than the plateau tufa.

The colour of tufa deposits varies between white, yellow, brown or even black. The black colouration of all the exposed surfaces may be due to oxidation of the small amount of iron contained, or may represent a desert varnish postulated to the result of bacterially induced precipitation (Chaftez *et al.*, 1998).

The tufa deposits are mostly fragile and cavernous (Fig. 3),

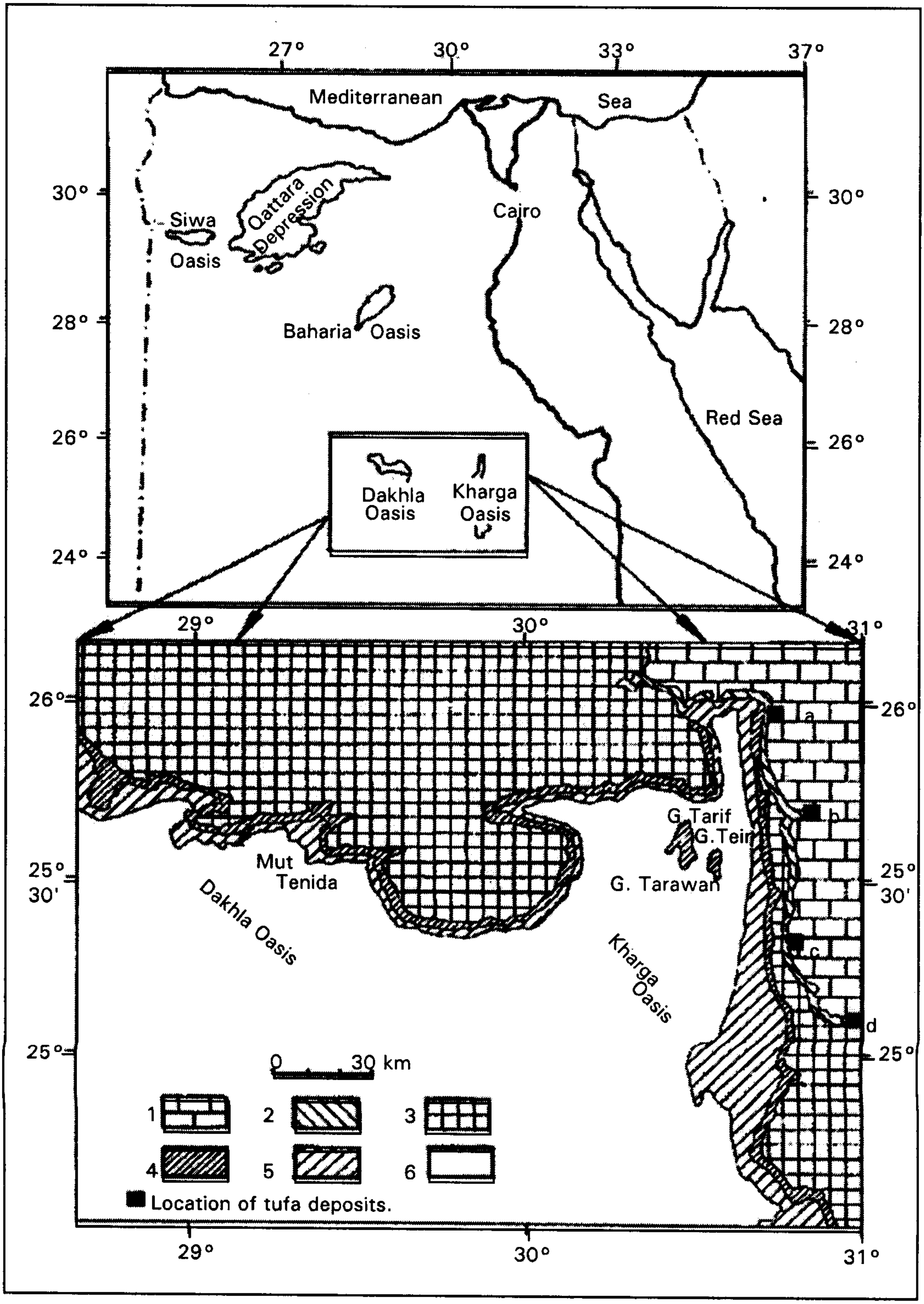

Fig.1: Location and geological map of Kharga and Dakhla Oases. 1. Thebes Formation; 2. Esna Formation; 3. Chalk; 4. Dakhla and Duwi Formation; 5. Quseir Formation; 6. Nubia Formation. a-d Naqb Assiut, Naqb Boulaq, Naqb El-Rufuf and Naqb Esna respectively

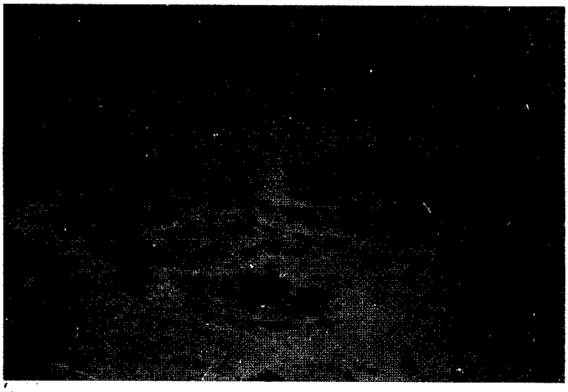

Fig. 2: Dislocated blocks and masses of tufa deposits on the scrap foot of Naqb Assuit, Kharga oasis.

Fig. 5. Photomicrograph of tufa deposits showing void fillings with drusy calcite (XPL x10).

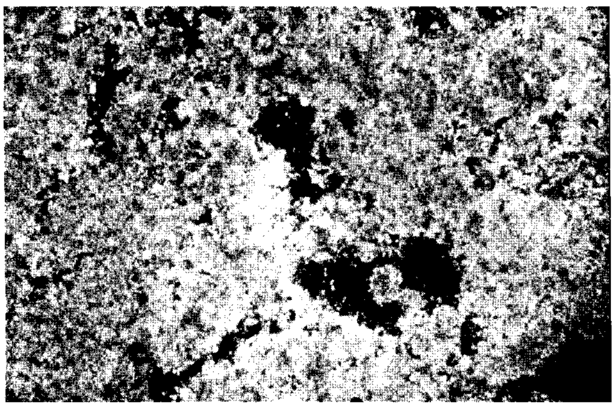

Fig. 3: Close-up view showing cavernous texture of tufa deposits.

Fig. 6: *Acer tricuspidatum* Al. Braun and Agassiz. Impression of a leaf fragment. x 0.7ca.

Fig. 4: Photomicrograph of tufa deposits showing clotted micritic texture with abundant voids (XPL x5).

Fig. 7: *Acer* cf. *tricuspidatum* Al. Braun and Agassiz. Impression of a leaf fragment. x 0.8 ca.

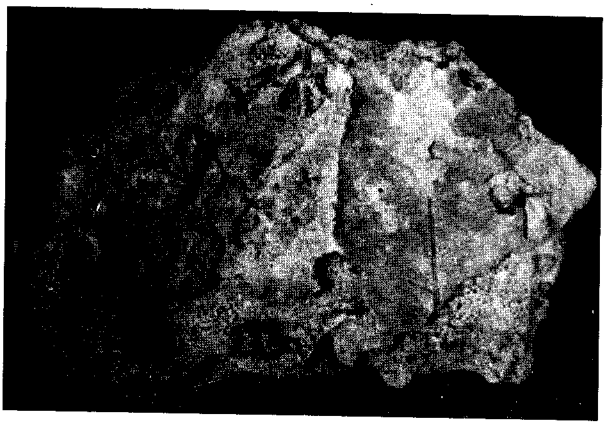

Fig. 8: *Dicotylophyllum* sp. leaf impression of a leaf fragment. natural size.

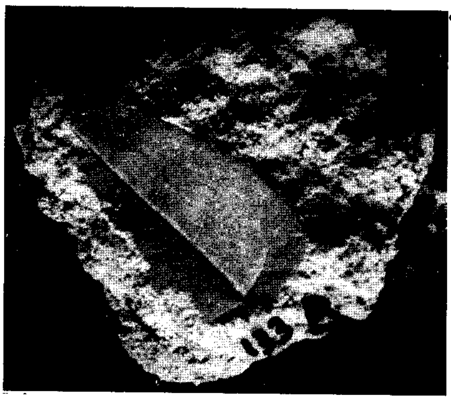

Fig. 9: *Dicotylophyllum* sp. leaf impression of a leaf fragment x ca 0.8.

Fig. 10: *Salix* sp. (133 D) leaf impression x ca 0.8.

Fig. 11: *Ficus salicifolia* Vahl (133 E) leaf impression of a leaf fragment x ca 1.5.

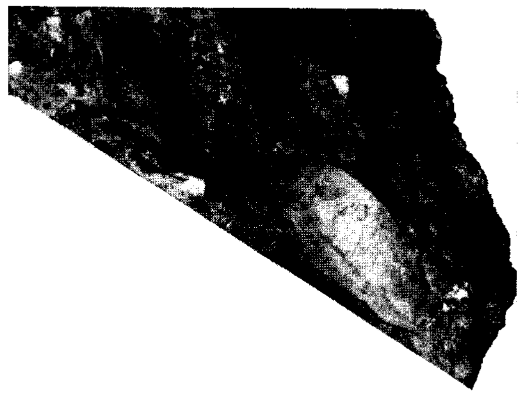

Fig. 12: *Ficus* sp. (133 F) leaf impression of a leaf fragment x ca1.

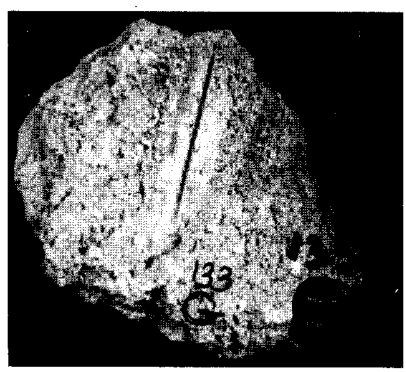

Fig. 13: *Cyperus* sp. (133 G) leaf impression x ca 0.7.

otherwise, void fillings by drusy calcite or amorphous silica increases its hardness. The dominant carbonate constituent is the clotted micrite (microcrystalline calcite) (Fig. 4) which includes several types of apparently reed stems and plant leaves (Figs. 6-13). Porous tufa is the predominant lithofacies in the studied tufa deposits. It consists of thin micritic calcite fringes surrounding circular to semicircular voids representing hollows after disintegrated plant stalks. Partial to complete void filling by equant drusy calcite spar mosaic is evident (Fig. 5).

Concerning the age dating of the studied tufa deposits, Sultan *et al.* (1996) defined four approximate age groups according to uranium-series disequilibrium analysis, which are 157-190, 255-286, 338 and>450 ka, (= 1000 y) BP (before present).

Results

Plant remains: All specimens were in a fragmentary condition, therefore, all specimens were incomplete. There were five types of leaves, met with several times in the slabs and they could be assigned to great extent to the following mentioned species of the genera *Acer, Dicotylophyllum, Salix, Ficus* and *Cyperus*.

Descriptions

Acer tricuspidatum **AL. Braun and Agassiz, Aceraceae. Specimen 130A (Fig. 6):** Leaf incomplete, about 4.5 cm long and about 6.5 cm wide. Lower end of midrib about 2 mm wide and decreases gradually in width towards leaf apex. Preservation of veins are good enough to show the midrib, secondary and tertiary veins. Venation actinodromous, 3 primary veins, first lateral primary vein arising at 40-45° from the mid veins, the others at 70-85°, 4 pairs of secondary veins bearing by the midveins ending in obtuse teeth or going superadjacent by loops; tertiary veins sinuous and reticulate. Margins rather irregularly crenulate-lobed.

***Acer* cf. *tricuspidatum* AL. Braun and Agassiz, Aceraceae. Specimen 130B (Fig. 7):** Leaf incomplete, may be broadly ovate-obovate. Leaf with clear venation. Midrib about 1-2 mm wide, lateral veins run parallel to one another at a distance of 0.8-1.7 cm. Tertiary veins given off from the secondaries, veinules clear. Margins not clear.

***Dicotylophyllum* sp., Juglandaceae. Specimens (133A-C) 133A (Fig.8):** Leaf incomplete but clearly ovate. Venation pinnate, midrib distinct. A deep groove represents midrib, 1 mm at the base and less than that upwards. Secondary veins alternate and clear, veinules very faint and forked as they approach the edge of the lamina. Margins entire.

133B (Fig. 9): Leaf incomplete but clearly ovate. Lamina of leaf probably more than 6 cm long and about 4.3 cm broad. Venation pinnate; midrib stout and distinct; lateral veins 4-5 pairs. Margins of leaf entire. Leaf base incurved.

133C: The width of right half of leaf is 4 cm (at the broader region), width of midrib about 1.5 mm. Secondary veins clear and opposite.

***Salix* sp., Salicaceae. Specimen 133 D (Fig. 10):** Leaf lanceolate, width about 10 mm. Midrib thin but clear. Veins very faint; the material has a brown yellowish colour.

***Ficus salicifolia* Vahl, Moraceae. Specimen 133 E (Fig. 11):** Leaf lanceolate with slightly rounded base, long-petioled, reticulate and quite glabrous, up to 1.5-2 cm broad and 5.5-6 cm long. Midrib and the secondaries clear, several short intermediate secondaries between the principals usually present. There are many hollows representing the positions of branches and globular hollow, probably resembling fig fruit.

***Ficus* sp. Specimen 133 F (Fig. 12):** Leaf elliptical to ovate in shape, length 4 cm, width in the middle 2 cm. Apex smoothly rounded, base rounded. Midrib thin, secondaries faint. Petiole short, margin entire.

***Cyperus*, Cyperaceae. Specimen 133 G (Fig. 13):** Leaf narrow, 6 mm broad, linear. Whole length of leaf unknown. Midrib clear, deep grooved. Longitudinal parallel veins clear. Leaf margins entire.

Discussion

This is the first record of fossil remains of *Salix* and probably also of *Acer* from Egypt, however, remains of *Dicotylophyllum, Ficus* and *Cyperus* were reported earlier from the country. It must be mentioned that fruits similar to those of Aceraceae are known from middle Cretaceous age in localities west of the bank of Nile in Egypt (Lejal-Nicol, 1990).

Acer remains are also known from other tertiary parts of the world as reported by Kvaèek *et al.* (1994), Knobloch and Kvaèek (1996), Saches and Mohr (1996), Leroy and Roiron (1996) and Saches *et al.* (1999), Hably and Kvaèek (1998), Fergusonand Knobloch (1998) and Titchaner (1999) from Spitsbergen, South Bohemian basins, southern Crete, France, western Hungary and Germany, respectively.

Acer tricuspidatum described here is almost identical with that recorded from Tertiary (Miocene) of South Bohemian basins by Knobloch and Kvaèek (1996). It resembles to some extant *Acer opulifolium* Villars described by Leroy and Roiron (1996) from Tertiary (latest Pliocene) of Bernasso Palaeolake (France) but the veinules of the latter are different in their arrangement on the midveins.

Acer cf. *tricuspidatum* recorded here is closely similar to that described from Tertiary (Miocene) of South Bohemian basins by Knobloch and Kvaèek (1996). It differs from *Acer arcticum* Heer described by Kvaèek *et al.* (1994) from Palaeogene of Spitsbergen in its basal venation.

There were three spp. of *Dicotylophyllum* reported from Egypt. Seward (1935) described *Dicotylophyllum balli* Seward and *D. egyptiacum* Seward from Cretaceous to Tertiary from Nubian Sandstone in Wadi Zeraib (a short distance south of Quseir). Lejal-Nicol (1990) recorded *Dicotylophyllum panandhroensis* among other Tertiary (Eocene) flora in the Gulf of Suez area. *Dicotylophyllum* sp. recorded here differs from *D. balli* in the angle of the secondary veins with the midrib, from *D. egyptiacum* in the shape of the leaf but venation is the same and from *D. panandhroensis* in leaf width. *Dicotylophyllum* spp. are also known from other Tertiary parts of the world (France, western Hungary and Crete) as reported by Leroy and Roiron (1996), Hably and Kvaèek (1998) and Saches *et al.* (1999).

Salix recorded here resembles *Saliciphyllum aswani* Lejal-Nicol described from Upper Cretaceous (Cenomanian) of Bahariya oasis (Egypt) by Lejal-Nicol (1987) but the leaf width of the latter is broader than our specimen. *Salix* was recorded previously from Tertiary of western Hungary and southern Crete (Greece) by Hably and Kvaèek (1998) and Saches *et al.* (1999) respectively.

Comparison of our *Ficus* specimens with the three different leaf types assigned to genus *Ficus* by Kräusel (1939) from Quaternary of Kharga Oasis is provisionally hardly possible because no illustrations or photographs were given by that author. However, from the little information given by Kräusel (1939) we can say that *Ficus salicifolia* recorded here resembles his *Ficus* cf. *salicifolia* Vahl but there is a slight difference in the leaf width. Our specimen greatly resembles the recent *Ficus salicifolia* described from Egypt (Täckholm, 1974).

Similarly *Ficus* sp. described here resembles Kräusel's (1939) *Ficus* cf. *ingens* Miq. but the latter leaf is very broad. The present specimen resembles also extant *Ficus thonningii* described from Eritrea by Bein *et al.* (1996). Both specimens of *Ficus* recorded here were quiet different from extant *Ficus sycomorus*.

The present *Cyperus* leaf was similar to the leaf impression described by Darwish *et al.* (2000) from Oligocene (?) of Farafra Oasis but here the midrib showed a deeper groove. Our specimen resembles the extant *Cyperus difformis* described earlier from Egypt (Täckholm, 1974).

It is clear from the studies of many authors that the Egyptian Tertiary–Quaternary paleoflora had been diversified (cf. Kräusel,1939; Chandler, 1954; El-Saadawi *et al.*, 1975, 1979; Gregor and Hang, 1982; Lejal–Nicol, 1990; Yousef, 1993; Kamal El-Din, 1996, 1999; Darwish *et al.*, 2000).

It is clear from the above paragraphs that all the fragments of fossil plants described here were angiospermous, that *Dicotylophyllum, Ficus* and *Cyperus* were recorded before from Cretaceous to Tertiary ages from other localities in Egypt and that all fossils have not been recorded before from Kharga Oasis except *Ficus*. The present record of *Acer, Dicotylophyllum, Salix* and *Cyperus* is the first from Quaternary strata; they were known earlier from older Cretaceous and Tertiary strata, so the present record may fill a gap because these plants are still represented in the present day flora.

However, it is not rather curious to find these leaves together at Kharga Oasis locality as Aceraceae live in normal temperate and tropical climate, Juglandaceae in warm and cool climate, Moraceae in warm, Saliaceae in normal temperate and Cyperaceae in tropical and warm temperate climates. The presence of spring–derived tufas, playas, remnant of fluvial drainage systems, fossil groundwater and Karst-related land forms indicate that the climate must have been more humid episodically in the past (Luo *et al.*, 1997; Issawi *et al.*, 1999).

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