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New palaeobotanical data from the Jarash Formation (Aptian–Albian, Kurnub Group) of NW Jordan

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ABSTRACT

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This contribution provides new palaeobotanical data from the Jarash Formation (Lower Cretaceous, Aptian–Albian) of NW Jordan. On the one hand it provides the first anatomical evidence for the occurrence of palaeo–wildfires in the Jarash Formation near the town of Jarash in NW Jordan, and, on the other hand, it provides a preliminary taxonomic assessment of the palaeoflora from a recently discovered locality nearby in the same formation. This flora consists of ferns assignable to *Weichselia reticulata* (Stokes et Webb) Fontaine in Ward and a so far unidentifiable taxon, conifer needles of *Agathis levantensis* Poinar & Milki and angiosperm leaves which can be attributed to the Platanaceae *Sapindopsis* cf. *lebanensis*. The latter taxon was so far only known from the Cenomanian of Lebanon.

Key–words—Lower Cretaceous, Jordan, Palaeo–wildfire, Palaeoflora, Angiosperm, *Sapindopsis*.

उत्तर पश्चिम जॉर्डन के जरश शैलसमूह (एप्टीयन–अल्बीय, कर्नब समूह) से प्राप्त नूतन पुरावानस्पतिक ऑकड़ा

अब्दुल्लाह एम.बी. आबू हमद, बिलाल अमीरह, एंड्रे जैस्पर एवं डीटर उह्ल

सारांश

यह योगदान उत्तर पश्चिम जॉर्डन के जरश शैलसमूह (अधो चाकमय, एप्टीयन–अल्बीयन) से नूतन पुरावानस्पतिक ऑकड़ा प्रदान करता है। जहां एक तरफ यह उत्तर पश्चिम जॉर्डन में जरश के नजदीक कस्बे में जरश शैलसमूह में पुरा–दावानल के प्रथम शारीरीय सबूत देता है वहीं दूसरी तरफ उसी शैलसमूह में हाल ही में खोजी गई नजदीकी बस्ती से पुरावनस्पति–जात का प्रारंभिक वर्गिकीय मूल्यांकन प्रदान करता है। वार्ड में *वीचसेलिया रेटिकुलेटा* (स्टोक्स एवं वेब) फॉटेन को निर्देश्य यह वनस्पतिजात पर्णांग तथा अब तक बेशिनाख्ती वर्गक, *अगतीस लेवनटेन्सिस* पोइनर एवं मिल्की के अनावश्यक शंकु और आवृतबीजी पत्तियॉं सन्निहित हैं जो कि प्लेटेनेसी *सेपिन्डोप्सिस तुल्य लेबान्सिस* को माना जा सकता है। बाद के वर्गाक अब तक लेबनान के सेनोमेनियन से ही ज्ञात हैं।

सूचक शब्द—अधो चाकमय, जार्डन, पुरा–दावानल, पुरावनस्पति–जात, आवृतबीजी, *सेपिन्डोप्सिस*।

INTRODUCTION

ALTHOUGH the occurrence of fossil plants in Cretaceous strata of Jordan has been known for nearly a century (e.g. Edwards, 1929) there were almost no detailed studies on macrofloras prior to the onset of the 21st century. Occasionally the occurrence of plant remains has been mentioned by a number of studies on amber from Jordan (e.g. Bandel & Haddadin, 1979; Amireh, 1997; Amireh & Abed, 1999; Poinar & Milki, 2001) but only a few studies dealt in more detail with plant macro remains: Bender & Mädler (1969) described an angiosperm dominated flora from the Late Cretaceous of Southern Jordan; Shinaq & Bandel (1998) dealt with a flora from a lignite lens from the Lower Cretaceous (Aptian–Albian) Ramel Formation near King Talal Dam in NW Jordan, and Poinar & Milki (2001) described a new species of the araucariacean conifer *Agathis* from the Lower Cretaceous Jarash Formation of Wadi Zarqa (see below for details). During the last 10 years interest in Cretaceous palaeofloras from Jordan increased, as witnessed by studies on microfloras from the Kurnub Group (e.g. Ahmad *et al.* 2012 and citations therein), as well as on a macroflora from the Mahis locality located about 10 km west of Amman (Hu *et al.*, 2008; Taylor *et al.*, 2008; Hu & Taylor, 2014). The latter locality is stratigraphically positioned in the upper part of the Jarash Formation and thus according to these authors of Albian age (e.g. Hu & Taylor, 2014).

The flora from Mahis is moderately diverse, with so far nine recognized taxa: six ferns *Marsileaceaephyllum mahisensis* Hu *et al.*, *Weichselia reticulata* (Stokes & Webb) Fontaine, *Phlebopteris hickeyi* Hu & Taylor, *Piazopteris branneri* (White) Lorch, *Aspidistes beckeri* Lorch and *Cladophlebis* sp., two gymnosperms *Zamites hoheneggeri* (Schenk) and *Brachyphyllum mamillare* Lindley & Hutton ex Brongniart as well as a single angiosperm, *Scutifolium jordanicum* Taylor *et al.*, a water lily.

To supplement the existing data from the Jarash Formation, new palaeobotanical data from two localities from the lower part of Jarash Formation are presented here, both located a few kilometers south of the city of Jarash in NW Jordan (Figs 1, 2).

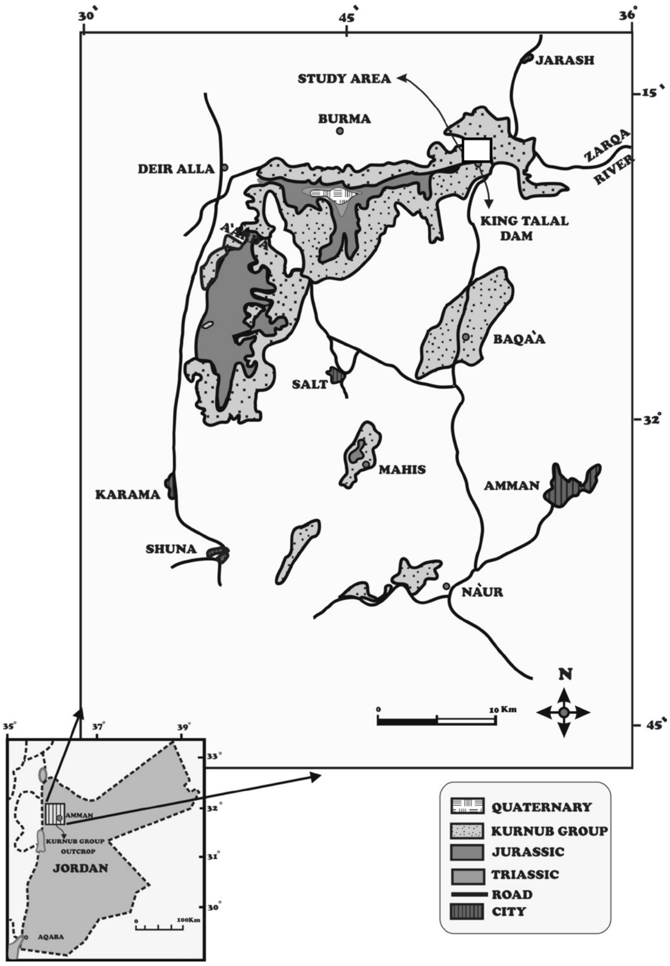

Fig. 1—Geological overview map showing the position of the area of investigation in NW Jordan.

GEOLOGICAL SETTING

The term Kurnub Group (KG) has recently been applied for Lower Cretaceous clastics and interbedded carbonates cropping out in Jordan (Amireh, 1997, 2000). The "Kurnub" term was originally introduced by Damesin (1948) in an unpublished report of the Iraq Petroleum Company to describe the clastic sediments exposed in Wadi Hathira which flows through the Kurnub breached anticline in the Naqab Desert southwest of the Dead Sea. Quennel (1951) subsequently applied the term to the correlative Lower Cretaceous clastic sequence of Jordan.

Amireh (1997) subdivided the KG into three formations in northern Jordan based on the change of lithology from clastics to carbonates or vice versa due to variation of the depositional environment from fluvial to marine or marginal marine or vice versa through the entire KG sequence. The three formations are the following in ascending stratigraphic order: Ramel, Jarash and Bir Fa'as. In contrast, Amireh (2000) subdivided the KG in central and southern Jordan that consists entirely of fluvial clastic rocks into three formations. These formations are the following in an ascending order: Karak, Hammamat and Bir Fa'as.

Amireh (1997, 2000) and Amireh & Abed (1999) recorded the presence of carbonaceous shale and lignite–coal deposits in the Ramel and Jarash formations of the KG that are rich with coalified plant fragments ranging in length from a few millimeters up to 15 cm. Moreover, these authors already reported that these deposits contain imprints and carbonaceous films of leaves, amber (plant resin), as well as charcoal debris. Amireh (1997) and Amireh & Abed (1999) interpreted the depositional environment of these carbonaceous shale and lignite deposits as a tidal marsh to a coastal swamp. Based on the presence of the amber deposits, Bandel & Haddadin (1979) have earlier recorded the depositional environment of these carbonaceous shale and lignite deposits as coastal swamp where an araucarian conifer (*Agathis*) lived in coastal forests.

An Early Cretaceous age was first assigned to the KG because it is enclosed by Middle to Late Jurassic carbonates and Cenomanian limestone and marl (Wetzel & Morton, 1959; Bender, 1968). The base of the KG rests on a regional angular unconformity extending across Jordan and the adjacent countries. This unconformity resulted from the deep erosion that accompanied and followed the uplifting and block faulting tectonic activity during the Late Jurassic (Cohen, 1976; Saint–Marc, 1978; Bandel, 1981; Garfunkle & Derin, 1988). In northern and northwestern Jordan, the KG rests unconformably on top of the Jurassic sediments in A'arda, Jarash and Mahis areas (Amireh, 1997; Fig. 1), whereas in central and southern Jordan it overlies other Mesozoic and Paleozoic sediments (Amireh, 2000).

The determination of the ages of the Early Cretaceous Epoch is still problematic in Jordan due to the scarcity of paleontological and radiometric age data. Most of these data come from the marine carbonate intercalations within the KG in northern Jordan. The uppermost part of the KG (Bir Fa'as Formation) consists of glauconitic facies that has recently been dated by the K/Ar radiometric method yielding an age of 95.7+–1.1 Ma which corresponds to an Albian Age (Amireh *et al.*, 1998).

Wetzel & Morton (1959) gave an Albian age to a glauconitic argillaceous dolomite layer located 125 m above the base of the KG in the A'arda section based on the occurrence of the ammonite *Knemiceras* sp. A Neocomian age was assigned to the group by Edwards (1929) due to the presence of the fern *Weichselia reticulata*. Basha (1985) determined the age of some of the marine intercalations as Albian, based on foraminifera and ostracods picked from subsurface samples. Based on the results of a palynomorphic study recently conducted by Al–Said & Mustafa (1994), a Neocomian age is given to the lower part of the KG in northwestern Jordan (Zarqa River area, Figs 1, 2), whereas the central and upper parts have been given a Late Aptian to Albian age.

Accordingly, only an Albian age has been assigned by most of the above–mentioned authors to the marine carbonate intercalations within the central and upper part of the KG. The underlying fluvial clastic sediments might be given a Neocomian age due to their lower stratigraphic position. Upon correlation with equivalent deposits in the west of study area, a Late Neocomian and particularly Barremian (Brenner & Bickoff, 1992) age can be assigned to this lower part of the KG. The rest of the KG has an Aptian to Albian age as recorded by the authors mentioned above.

In the study area, the KG attains a thickness of 225 m (Fig. 3). The lower thirty meters consist of conglomerate and sandstone facies association, of proximal to distal braidplain origin. About ten meters of tidal flat, mixed carbonate–siliciclastic facies overlie the conglomerate and sandstone. These deposits are in turn overlain by the carbonaceous shale and lignite–coal deposits of tidal marsh–coastal swamp origin, from which the charcoal samples described here originate. About 70 m of medial to distal braidplain sandstone overlie the carbonaceous shale and lignites. Around fifty meters of well bedded siliciclastic and mixed carbonate–siliciclastic facies of tidal flat origin with interbedded coastal swamp black shale and lignite overlie the sandstone. The remaining part of the KG consists of alternating sandstone from a meandering river of low sinuosity, with tidal flat siliciclastic and mixed carbonate–siliciclastic facies association. The KG is overlain conformably by Upper Cretaceous carbonates.

MATERIALS

The materials come from two localities from the lower part of the Jarash Formation located a few kilometers south of the city of Jarash directly at the road from Highway 35 (Jarash to Amman) to the King Talal Dam in NW Jordan (Figs 1, 2).

Locality 1—At this locality grey clays, containing amber (Bandel & Haddadin, 1979) crop out at the side of the road (Fig. 2; Fig. 4A, B). This locality yielded charcoals, which originate from a conspicuous, approx. 20 cm thick, dark grey band within the clays (Fig. 4B).

Locality 2—At this locality yellowish, brownish sandstones with overlying reddish claystones crop out at the side of the road (Fig. 2; Fig. 4B, C). A distinct bedding plane of one sandstone yields numerous, more or less fragmented leaves of the angiosperm *Sapindopsis* cf. *lebanensis* (Fig. 6; Pl. 1.9), together with fragments of unidentified ferns. The

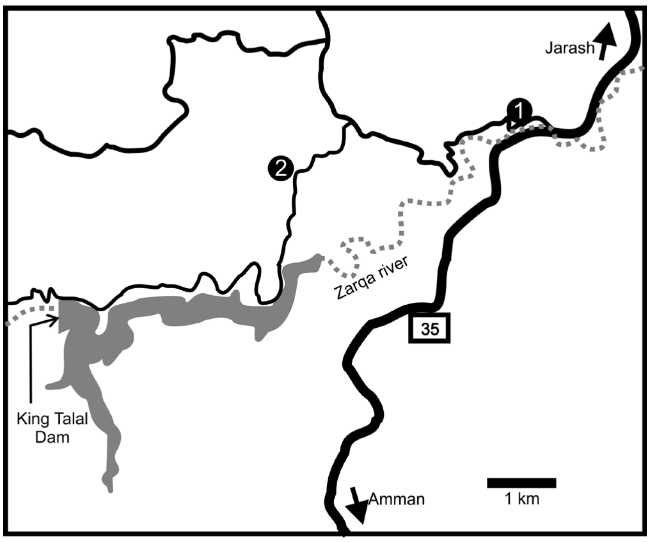

Fig. 2—Map showing the position of the sampling localities South of Jarash in NW Jordan. ❶ = locality 1 with charcoal; ❷ = locality 2 with macroflora.

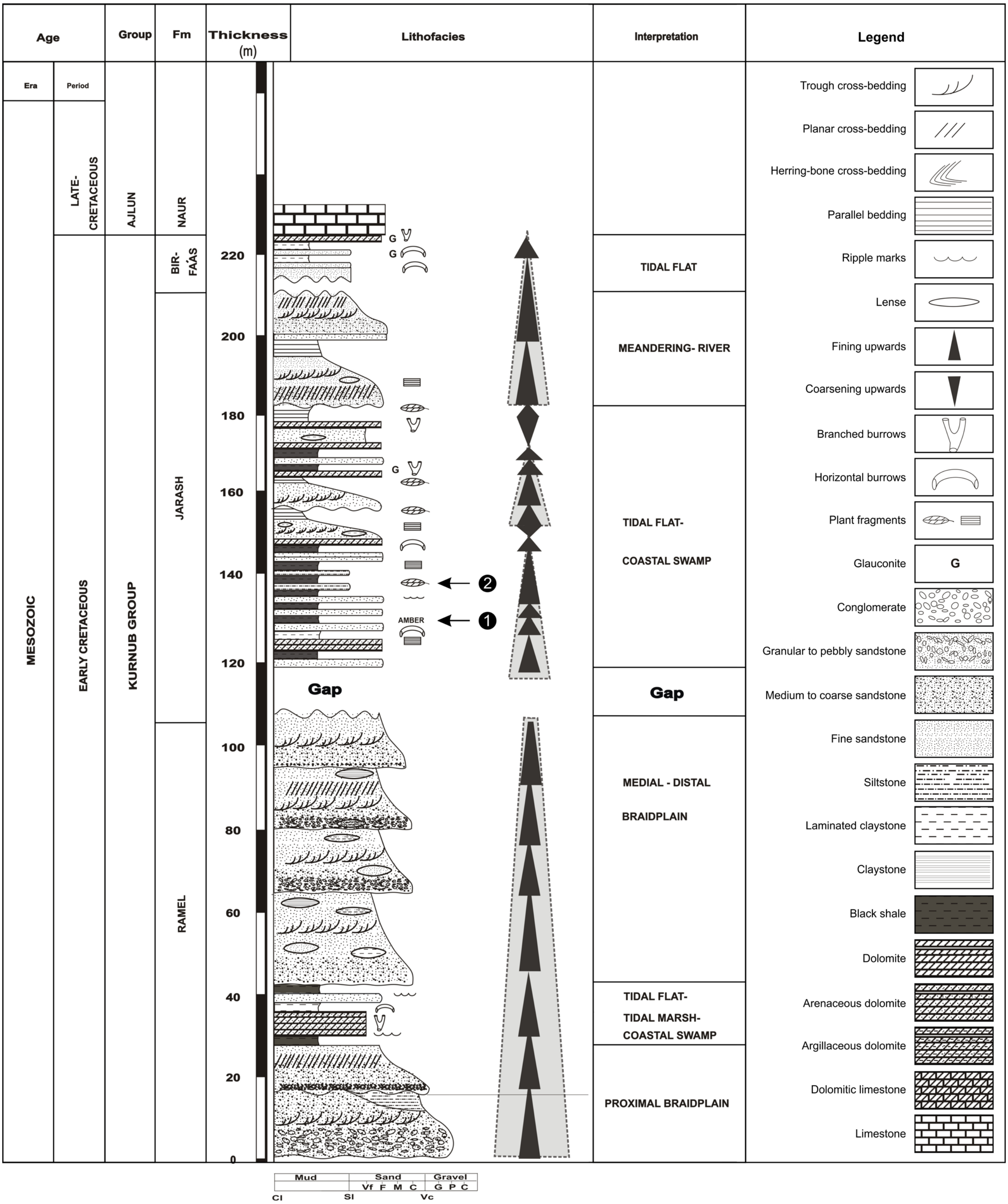

Fig. 3—Lithological profile of the Kurnub Group in Jordan. The position of both localities dealt with in this study is indicated by arrows. ❶ = locality 1 with charcoal; ❷ = locality 2 with macroflora.

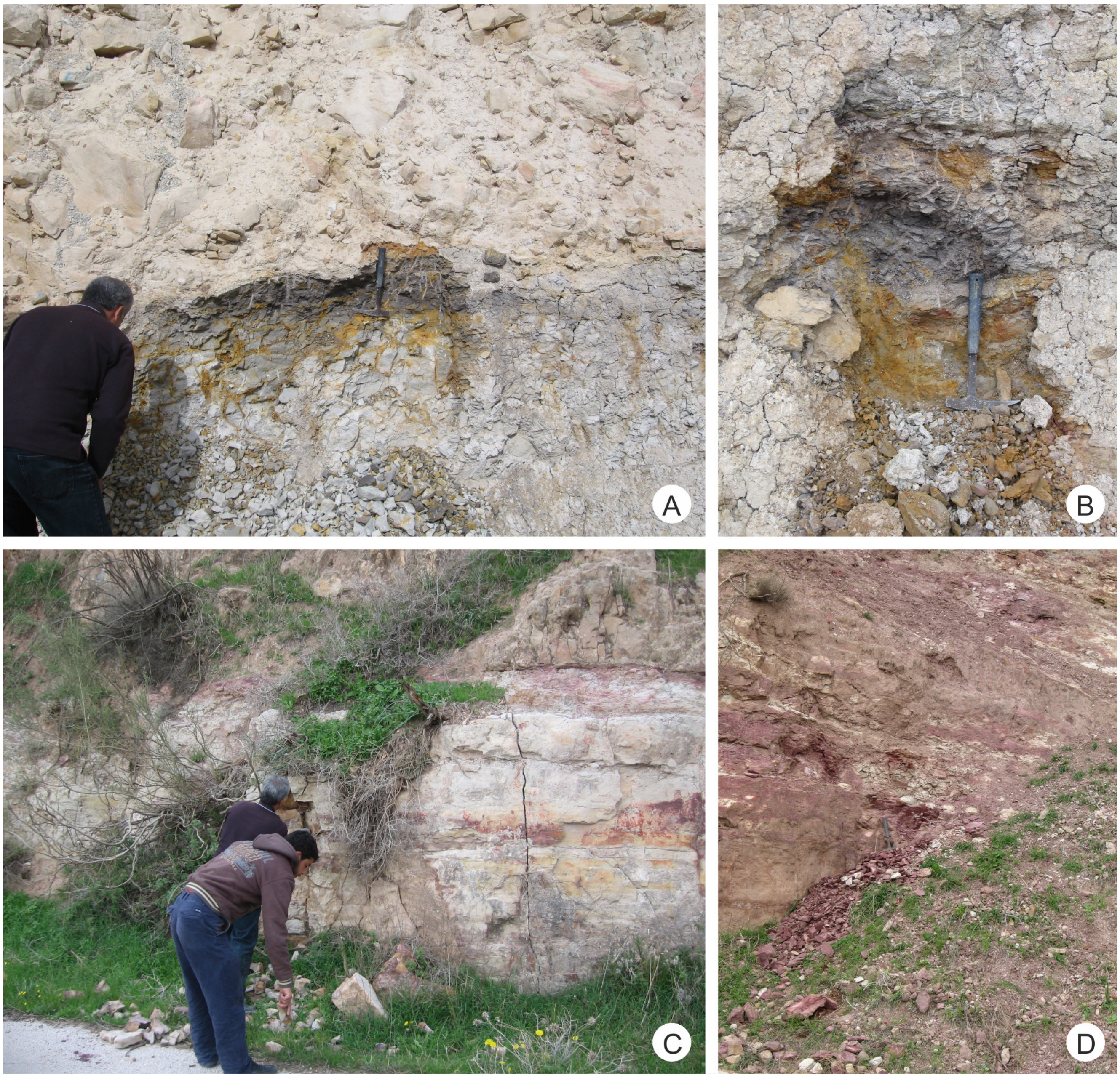

Fig. 4—Field photographs of sampling localities. (A) Dark grey charcoal bearing layer in the profile at locality 1; (B) detail of (A), hammer as scale bar; (C) thick sandstone containing ferns and leaves of *Sapindopsis* cf. *lebanensis* at locality 2; (D) reddish clays containing ferns and conifer needles on top of the sandstone.

reddish claystone yields numerous fragments of ferns, conifer needles and unidentifiable plant fragments.

METHODS

Samples of the clay from locality 1 were soaked in water for several days, which led to disintegration of the sedimentary matrix. The material was then washed through a sieve with 250 µm mesh width. Charcoal fragments, measuring 0.5–1 x 1–3 mm, were extracted from the sieve residues with the aid of preparation needles and tweezers under a Leica M 80 binocular microscope in the laboratory. Due to the very fragile nature of some specimens, these could not be cleaned with water or any acids to remove adhering mineral remains. The charcoal samples were mounted on standard stubs with LeitC (Plano), and subsequently examined with the aid of a JEOL JSM 6490 LV Scanning Electron Microscope (SEM) at the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt.

Leaves from locality 2 were investigated with aid of a Leica M 80 binocular microscope. Specimens are stored at the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (Germany) under accession numbers SM.B 21522–SM.B 21540. Photographs of leaves were taken with a Canon Powershot G11 camera. Contrast and brightness of the images were adjusted with Corel Photopaint X4.

RESULTS AND DISCUSSION

Charcoal from locality 1

Macroscopically this material exhibits a silky lustre and a black streak. Under the SEM three–dimensionally preserved tracheids can be observed (Fig. 5A, B) and cell walls of these tracheids are clearly homogenized (Fig. 5B). Together these observations are considered as typical for charcoal, as direct evidence for the occurrence of palaeo–wildfire (e.g. Scott, 2000, 2010).

The occurrence of charcoal in the Jarash Formation has previously been reported (e.g. Amireh 1997, 2000; Amireh & Abed 1999) but so far without detailed anatomical analysis, like SEM–images of homogenized cell walls, to provide unequivocal proof of these interpretations. Unfortunately these reports have not been included in global reviews of Cretaceous occurrences of evidence for palaeo–wildfires (e.g. Bond & Scott, 2010; Brown *et al.*, 2012). So far verified records of fossil charcoal from the entire Cretaceous of the former parts of the continent Gondwana are rather rare, and Brown *et al.* (2012), for example, listed only six records from the Lower Cretaceous in their comprehensive review on Cretaceous wildfires. None of these records comes from the Aptian–Albian of Africa (including the Arabian Plate), thus this report can be considered as the first record of Aptian–Albian wildfires from Africa (including the Arabian Plate) verified by anatomical investigation (i.e. the presence of diagnostic homogenized cell walls).

On some of the samples, remains of charred fungal hyphae of unknown taxonomic affinity are visible (Fig. 5A). The occurrence of charred fungal hyphae has repeatedly been reported from fossil charcoal (e.g. Scott, 2000; Uhl *et al.*, 2007; Kubik *et al.*, 2015) and usually it is not clear whether these fungi were growing before the wood died or not. However, it can be assumed that the occurrence of such fungi indicates that biological decay of the wood started prior to charring of the wood (e.g. Kubik *et al.*, 2015).

The occurrence of charcoal in the Jarash Formation shows that the source–vegetation must have experienced fire, though at the moment it is impossible to provide any assumption about the frequency or intensity of such a wildfire activity. In modern ecosystems fires occur more frequently in vegetation types with a well–marked dry season and there is a tendency to increasing fire frequencies parallel to increasing aridity (e.g. Martin, 1996; Brown, 2000; Paysen *et al.*, 2000). Apart from the higher probability of ignition and burning of dry biomass in such environments, such conditions lead also to an increasing accumulation of biomass, due to slow decomposition of leaf litter and wood (e.g. Harrington & Sackett, 1992). Occasional severe dry spells can also promote the spreading of wildfires in tropical rain forests over large areas (e.g. Johnson, 1984). Based on this, it can be assumed, that the Lower Cretaceous flora growing during the deposition of the Jarash Formation has experienced, at least seasonally, more or less relatively dry conditions. Evidence for relatively dry climatic conditions, at least in some habitats, comes also from palaeoecological interpretations of the plants discovered at the Mahis locality (Hu & Taylor, 2014).

Macroflora from locality 2

Incertae sedis

Unidentifiable, strap–like plant organs

(Pl. 1.2)

Materials—SM.B 21522, SM.B 21523, SM.B 21524.

Description—Fragments of strap–like plant organs. Fragments of up to 3 cm length and 5 cm width preserved, with numerous parallel lines (Pl. 1.2), probably representing veins or xylem strands.

Remarks—Such fragments occur on several hand–specimens from the claystone on top of the sandstone body. Due to their fragmentary nature and the absence of any diagnostic features they cannot be affiliated to any plant group. Affiliation to sphenophytes, which usually exhibit comparable

PLATE 1

Photographs of macrofossils from locality 2 →

1. Three pinnae of *Weichselia reticulata* attached to rhachis, Inv.–Nr. SM.B 21525; scale bar = 1 cm.
2. Unidentifiable strap–like leaf fragment, Inv.–Nr. SM.B 21522; scale bar = 1 cm.
3. Fragment of pinnae of *Weichselia reticulata*, Inv.–Nr. SM.B 21526; scale bar = 1 cm.
4. Fragment of pinnae of *Weichselia reticulata*, Inv.–Nr. SM.B 21527; scale bar = 1 cm.
5. fragment of pinnae of unidentified fern, Inv.–Nr. SM.B 21529; scale bar = 1 cm.
6. Fragment of pinnae of apical part of frond/pinnae of unidentified fern, Inv.–Nr. SM.B 21530; scale bar = 1 cm.
7. Isolated needle of *Agathis levantensis*, Inv.–Nr. SM.B 21534; scale bar = 1 cm.
8. Isolated needle of *Agathis levantensis*, Inv.–Nr. SM.B 21535; scale bar = 1 cm.
9. Almost complete leaf of *Sapindopsis* cf. *lebanensis*, Inv.–Nr. SM.B 21536; scale bar = 1 cm.

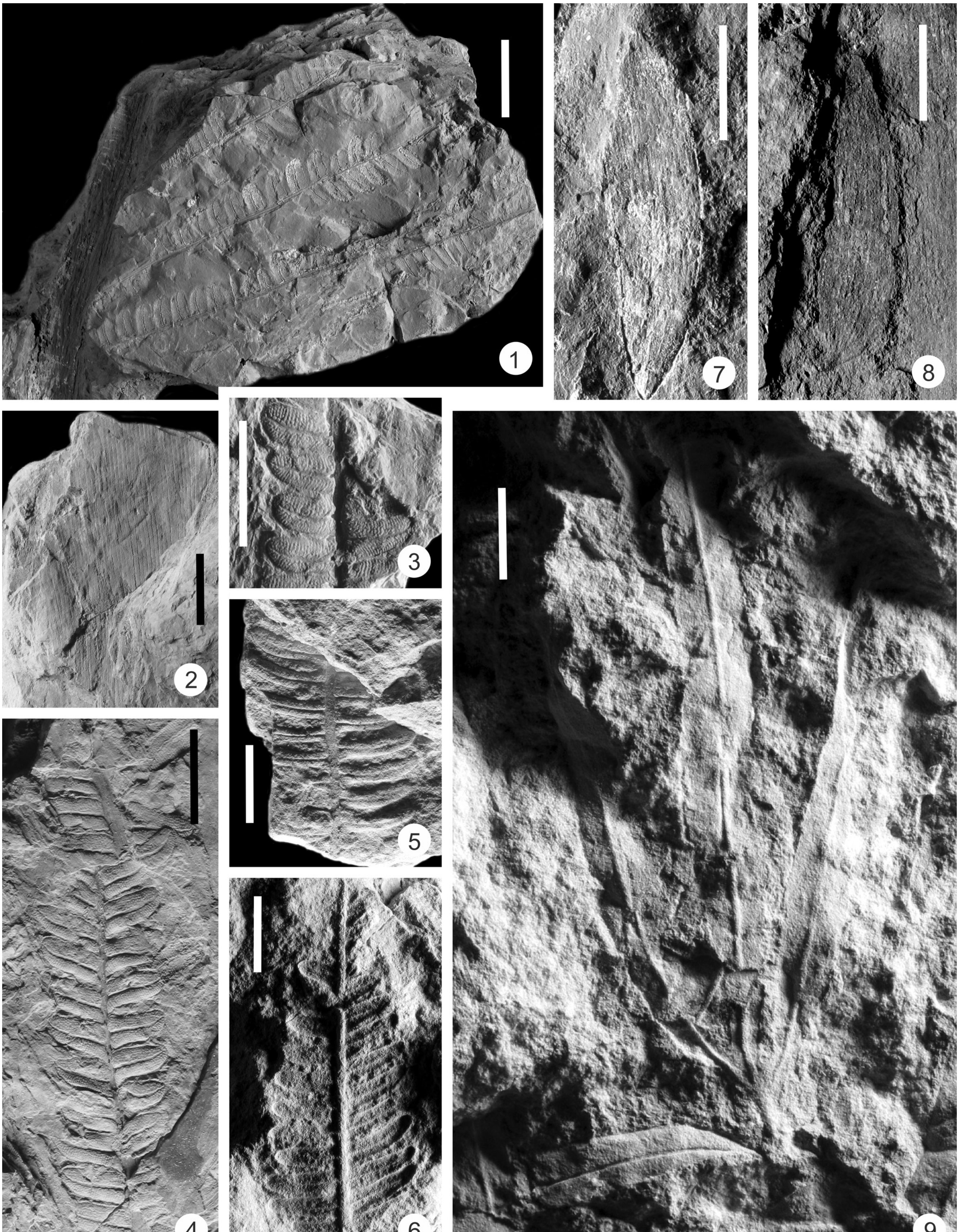

PLATE 1

patterns of xylem strands on their axes, is not possible due to the absence of the characteristic nodal areas.

PTERIDOPHYTES

Class—POLYPODIOPSIDA

Order—GLEICHENIALES

Family—MATONIACEAE

Genus—WEICHSELIA Stiehler, 1857

Weichselia reticulata (Stokes & Webb, 1824) Fontaine in Ward, 1899

(Pl. 1.1, 3, 4)

Materials—SM.B 21525, SM.B 21526, SM.B 21524, SM.B 21527, SM.B 21528.

Description—Isolated fragments of pinnae with suboppositely to alternatingly attached, sessile pinnules. In a single specimen three pinnae are still attached to the rachis (Pl. 1.1). Pinnules 4–7 mm long and 2–3 mm wide, with reticulate venation and apically slightly upwards curved apex (Pl. 1.1, 3, 4).

Remarks—Based on the characteristic morphology of the pinnules these remains from the claystone can be attributed to the mattoniaceous tree fern *Weichselia reticulata*, which has been widely distributed in the Northern Hemisphere and on the shores of the Tethys during the Early Cretaceous (e.g. Barale, 1979; Silantieva & Krassilov, 2006; Hu & Taylor, 2014). The taxon is reconstructed as a tree fern, growing in mangrove–like coastal marshes, but is also known to grow under relatively dry conditions (e.g. Alvin, 1971; Barale, 1979; Van Konijnenburg–van Cittert, 2002). Due to the fragmentary nature of the specimens it is difficult to draw any conclusions concerning the habitat of the source plant, but it is likely that the specimens experienced considerable transport prior to burial.

Class—INCERTAE SEDIS

Fern sp. A

(Pl. 1.5, 6)

Materials—SM.B 21529, SM.B 21530, SM.B 21531, SM.B 21532, SM.B 21533.

Description—Fragments of pinnae with straight to apically slightly upwards curved, sessile pinnules. Pinnules (5) 8–12 mm long and 3–4 mm wide, with a prominent midrib (Pl. 1.5, 6).

Remarks—From the somewhat younger Mahis locality six different fern taxa (including *Weichselia reticulata*) have recently been described (Hu & Taylor, 2014). Of these only *Phlebopteris hickeyi* Hu & Taylor has pinnules that reach approximately the same size as the material described here, but as no details of the venation are visible in the material, it is impossible to provide a meaningful taxonomic interpretation of these fragments beyond a very general affiliation to pteridophyta (i.e. ferns).

GYMNOSPERMS

Class—CONIFEROPSIDA

Order—CONIFERALES

Family—ARAUCARIACEAE

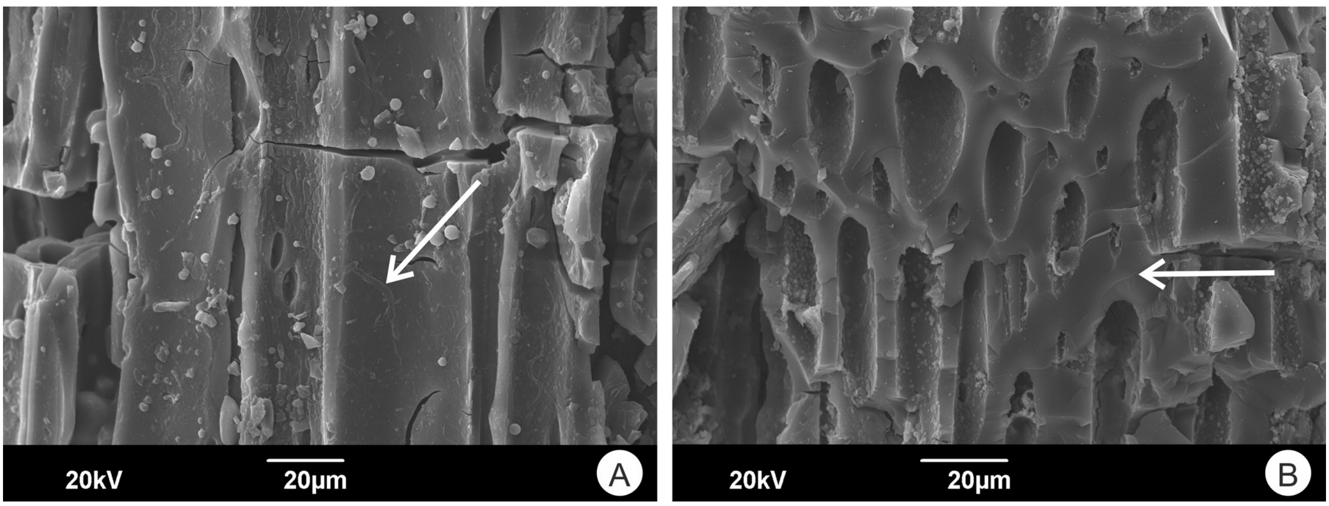

Fig. 5—SEM–photographs of charcoals from locality 1. (A) tracheids in longitudinal view with putative remains of burnt fungal hyphae (arrow); (B) tracheids in slightly oblique cross section, clearly exhibiting homogenized cell walls (arrow).

Fig. 6—Overview of bedding plane of the sandstone with numerous leaf fragments of *Sapindopsis* cf. *lebanensis*, Inv.–Nr. SM.B 21536; scale bar = 1 cm.

Genus—AGATHIS Salisbury, 1807

Agathis levantensis Poinar & Milki, 2001

(Pl. 1.7, 8)

Materials—SM.B 21534, SM.B 21535.

Description—Isolated, elliptic to ovate needles, narrow to wide lanceolate with a slightly rounded apex. Base with a 2.5–3.5 wide, slightly oblique attachment. Needles up to 3.8 cm long and 8.5 mm wide. Margin entire and flat. Venation consisting of numerous, faintly visible, parallel veins (Pl. 1.7, 8).

Remarks—In the reddish clay on top of the sandstones several isolated leaves have been found, which can be assigned to *Agathis levantensis* Poinar & Milki (Poinar & Milki, 2001). This species has been described from material collected in the amber bearing horizon of the Jarash Formation in the Wadi Zarqa, which is the same horizon as locality 1. The occurrence of *Agathis* leaves in this horizon has first been mentioned by Bandel & Haddadin (1979) and later on Bandel & Vávra (1981) could demonstrate, based on chemical analyses, that *Agathis* is probably the source of amber in these sediments. *Agathis* is also regarded as the source of Lower Cretaceous ambers of Lebanon and many other countries (e.g. Lambert *et al.*, 1996). Poinar *et al.* (2004) found no chemical differences between Lower Cretaceous ambers of Jordan, Lebanon and the Persian Gulf area and these authors concluded that a forest with *A. levantensis*, as the potential source of the amber in the Middle East, spread from the Levant to Kuwait and Saudi Arabia during the Early Cretaceous.

For a discussion concerning the potential relationship between *Podozamites* leaves reported by Edwards (1929) from the Lower Cretaceous of Wadi Zarqa with *Agathis* needles see Poinar & Milki (2001).

ANGIOSPERMS

Class—MAGNOLIOPSIDA

Order—PROTEALES

Family—PLATANACEAE Lestib.

Genus—SAPINDOPSIS (Fontaine, 1889) emend. Dilcher & Basson, 1990

Sapindopsis cf. *lebanensis* Krassilov & Maslova in Krassilov & Bacchia, 2000

(Fig. 6, Pl. 1.9)

Materials—SM.B 21536, SM.B 21537, SM.B 21538, SM.B 21539, SM.B 21540.

Description—On a single bedding plane in the thick yellowish–brownish sandstone, directly at the road level, abundant impressions of angiosperm leaves occur (Fig. 6) together with so far unidentified fern fragments. The angiosperms are characterized by a three–(to five–) lobed, palmate lamina, with linear–lanceolate, acutely pointed leaflets, exhibiting a prominent mid–rib (Pl. 1.9). Individual leaflets are narrow, 6–12 (15) mm wide and up to 10 cm long. Higher order venation is not visible.

Remarks—Morphologically these leaves resemble those of *Sapindopsis*, especially *S. lebanensis* Krassilov & Maslova, a taxon that has been described by Krassilov & Maslova in Krassilov & Bacchia (2000) from the Cennomanian of Nammoura in Lebanon. Due to the poor preservation in the sandstones, which shows only gross–morphological features and no fine details of venation, these leaves are determined here for the time being as *Sapindopsis* cf. *lebanensis*. This represents the first (although tentative) record of this taxon in the Kurnub Group of Jordan and also the first evidence of this taxon in the Early Cretaceous.

S. lebanensis exhibits several characters, like narrow leaflets, a thick and probably coriaceous lamina, inconspicuous venation, as well as sunken stomata on an amphistomatic cuticle and that point to a potential xeromorphic adaptation of this taxon (Krassilov & Bacchia, 2000; Carpenter *et al.*, 2014). The mass occurrence of leaves of this taxon on a single bedding plane of a fluvial sandstone probably indicates a deciduous habit of the source plant, which was may be growing on well drained, sun–exposed habitats near the river.

CONCLUSIONS

Based on the new data the following conclusions can be drawn:

1. Wildfires occurred in the coastal areas of Jordan on the southern shore of the Tethys during deposition of the middle Jarash Formation of the Kurnub Group.
2. The angiosperm component of the palaeoflora of the Kurnub Group was more diverse than previously considered based on macrofloral remains.
3. Based on inferences about the autecology of *Weichselia reticulata* and *Sapindopsis* cf. *lebanenis*, as well as the occurrence of palaeo–wildfires, an at least seasonally dry climate can be assumed, which is in accordance with earlier assumptions based on palaeobotanical data (e.g. Hu & Taylor, 2014).

The new findings, together with previously published studies on the macroflora of the Kurnub Group in Jordan (e.g. Edwards, 1929; Shinaq & Bandel, 1998; Poinar & Milki, 2001; Hu *et al.*, 2008; Taylor *et al.*, 2008; Hu & Taylor, 2014), suggest that there is still a large, so far unrecognized potential for additional palaeobotanical discoveries in the Cretaceous of Jordan.

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