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PENNSYLVANIAN-PERMIAN FOSSIL FLORAS FROM THE CUTLER GROUP, CAÑON DEL COBRE AND ARROYO DEL AGUA AREAS, IN NORTHERN NEW MEXICO

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FLORAS OF CAÑON DEL COBRE

Fossil plants occur in the Cañon del Cobre (El Cobre Canyon) in the El Cobre Canyon Formation of the Cutler Group. The first fossil plants reported from Cañon del Cobre were published in a comment by C. B. Read in Smith et al. (1961). Subsequently, Fracasso (1980) and Hunt and Lucas (1992) documented some fossil plants from a locality near the main arroyo.

We have collected fossil plants from eight sites in Cañon del Cobre, representing seven separate beds. One bed was collected at two sites some distance apart and is not considered a replicate sample. There are 12 separate collections; the discrepancy between the number of beds and the number of collections is caused by collection of replicate samples from the same sites. Although there are compositional and dominance-diversity differences among the sites (see Table 1), the overall flora appears to be drawn from the same basic species pool. This species pool is typical of wetland floodplains of the Late Pennsylvanian, particularly the Stephanian C/Virgilian. Selected elements of the Cañon del Cobre floras can be seen in Figures 1-3.

A few taxa are notably more common, based on presence-absence, than others in the flora, based on the number of collecting sites at which they are found. These include *Alethopteris* aff. *A. bohemica*, *Macroneuropteris scheuchzeri*, *Sphenophyllum verticillatum*, *Calamites* stems (one stem measured 25 cm in diameter), and pecopterid foliage of several types. Other species occurring commonly include *Alethopteris* cf. *A. zeilleri*, *Sphenophyllum oblongifolium*, *Annularia carinata*, and various organs attributable to the *Sigillaria brardii* plant. Rare but significant elements include *Neurodontopteris auriculata*, *Annularia spicata*, *Asterophyllities equisetiformis*, *Sphenophyllum angustifolium*, *Pseudomariopteris cordato-ovata*, *Nemejcopteris feminaeformis*, *Oligocarpia* cf. *leptophylla*, *Sphenopteris* cf. *S. biturica*, and *Pecopteris unita*.

Occuring at two sites were foliage fragments with pinnules similar in shape to *Odontopteris reichiana*. However, these pinnules had a distinct midvein and, to the extent that it could be seen, concavely arched lateral veins. In overall aspect, they are similar to a specimen described by Wagner from the Puertollana Basin in Spain as *Callipteridium zeilleri*.

Walchia pinniformis occurred at two sites, one of which was a single specimen (42128). The presence of conifers is well documented in deposits older than those of Cañon del Cobre and, so, does not have particular significance with regard to the age of the deposit. These occurrences do indicate, however, that conifers, and the presumably well drained to seasonally dry deposits that supported them, were proximate to the wetter areas within which the prevailing flora was preserved.

Within these collections several abundance patterns are noteworthy. *Alethopteris* of one or the other of the two identified species was generally the most abundant (> 50% of hand specimens) species at those sites where it occurred. *Macroneuropteris scheuchzeri*, although not as widely occurring as *Alethopteris*, was generally common (10-50% of hand specimens) when present. Sphenophylls, particularly *Sphenophyllum verticillatum*, where present were common. *Pecopteris* of several forms was common at a number of sites, and *P. unita* was the dominant element at the only site (replicate samples 41875 & 41876) at which it occurred. *Sigillaria* occurred at only two sites and *Sigillariostrobus* at three (two overlapping with stem remains), however stigmarian rootlets were present at five sites, three of which had no other evidence of lycopsids, suggesting that this plant was more widespread than aerial remains suggest. This is a caution for all taxa occurring in these relatively small samples – they are likely more common and widely distributed than detected by our sampling.

FLORAS OF THE ARROYO DEL AGUA AREA

Fossil plants occur in the Arroyo del Agua area in the El Cobre Canyon Formation of the Cutler Group. The first and here-to-fore only reference to floras from the Arroyo del Agua area were plants identified by W. C. Darrah from the VanderHoof Quarry in Langston (1953). Floras were collected from five sites in Arroyo del Agua, representing three fossiliferous beds. The largest collection was made from Quarry Butte, a site that produced vertebrate remains but was reported by Langston (1953) to lack fossil plant remains. As with Cañon del Cobre, the floras found at each site are substantially the same in occurrence patterns and appear to be drawn from a common species pool. The plants are typical of floras found in the earliest Wolfcampian of the better documented Late Pennsylvanian- Early Permian section of north-central Texas, although a correlation is difficult because the plant biostratigraphy of North America is imprecisely established in this part of the geological record . One collection (USNM locality 38336) is from a red mudstone above the vertebrate-producing level in the Welles Quarry that may have been pedogenically overprinted, but is dominated by a pteridospermous plant of uncertain affinity, possibly a mariopterid. Diversity in these collections is about two-thirds that of the Cañon del Cobre collections, consistent with a general diversity decline in the paleotropics of western North America from the Late Pennsylvanian wetlands into drier environments of the Early Permian. Selected elements of the Arroyo del Agua floras can be seen in Figures 4-5.

The conifer, either *Walchia pinniformis* or a form similar to *Culmitzschia*, in addition to *Taeniopteris*, *Calamites* stems, and generally rare (< 10% of hand samples) pinnules of an indeterminate pteridosperm of *Odontopteris* form are present at every collecting site. Other diagnostic elements include callipterids similar to *Autunia conferta*, *Neurodontopteris auriculata, Pseudomariopteris cordato-ovata*, indeterminate forms of *Pecopteris*, and *Asterophyllites equisetiformis*.

There are several odd elements of this flora. These include small fragments of foliage that have pinnule shape and venation similar to that found in peltaspermous plants from various Permian localities in Texas, Oklahoma, Kansas, and New Mexico. These are too incompletely preserved to make a confident identification to the generic level, however. Also present are medium-sized pinnules with straight sides and pecopteroid attachments but considerably larger than pecopterids. Venation is somewhat intermediate between alethopteroid and neuropteroid. We have called these "*Callipteridium*"-like in form, but at present do not have a definitive identification. Finally, the red mudstone site is dominated by foliage of mariopteroid aspect, not unlike *Mariopteris muricata*, but scaled down in size. It may be a *Pseudomariopteris* of some type, but not *P. cordato-ovata*, which occurs in this flora at other sites. *Calamites* stems are noteworthy for their very straight, simple nodes and their association at one site with *Asterophyllites equisetiformis*, in which the leaves are somewhat more succulent or fleshy looking than is typical for this species.

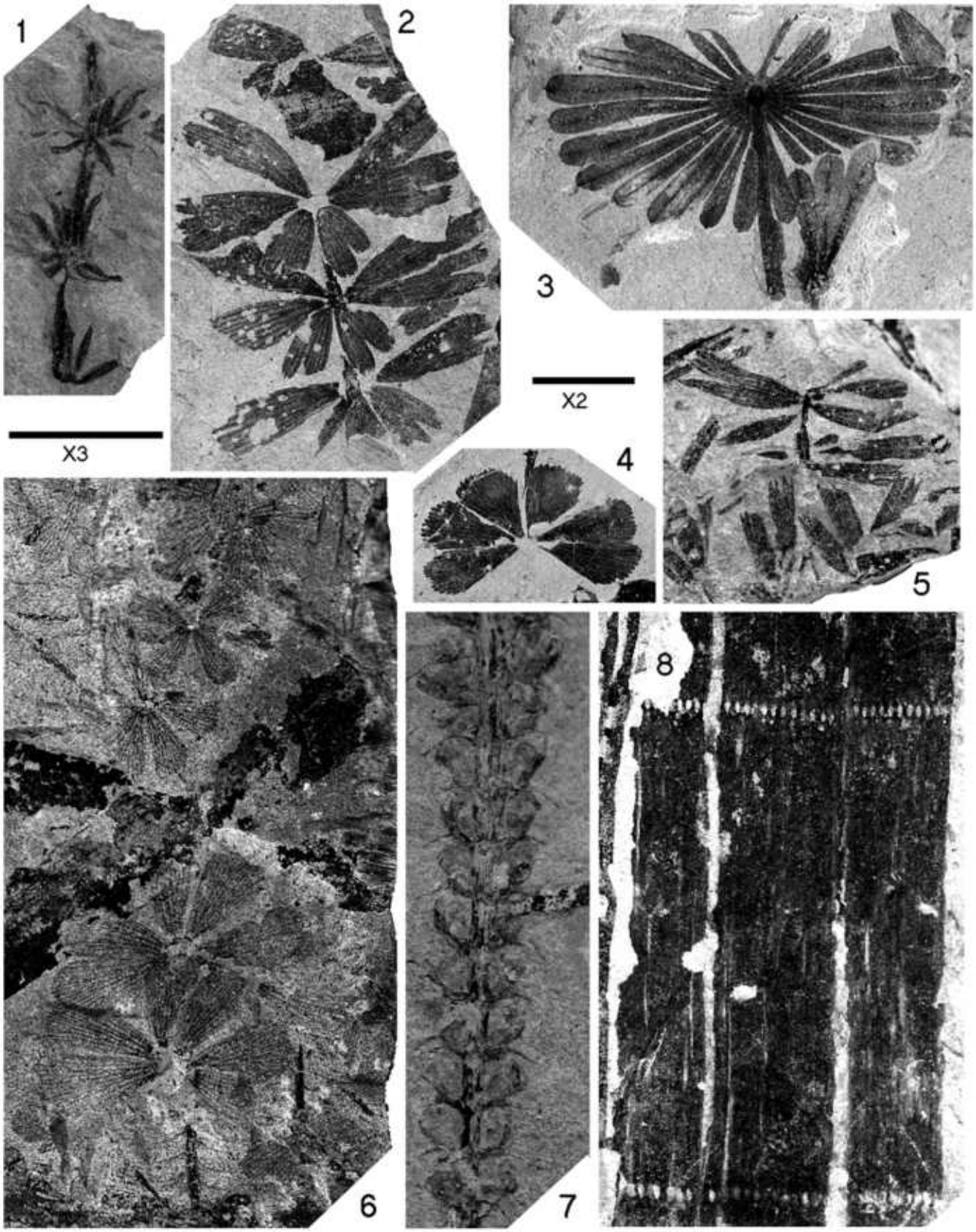

FIGURE 1. Selected plants fossils from Cañon del Cobre. **1**, *Annularia spicata* USNM 528479 Copper Mine (loc. 42128) X3. **2**, *Sphenophyllum oblongifolium* USNM 528636 Cañon del Cobre #1 (loc. 41876) X2. **3**, *Annularia carinata* USNM 528642 Cañon del Cobre #1 (loc. 41878) X2. **4**, *Sphenophyllum emarginatum* USNM 528654 Cañon del Cobre #1 (loc. 42121) X2 **5**, *Sphenophyllum angustifolium* USNM 528658 Cañon del Cobre #1 (loc. 42120) X2. **6**, *Sphenophyllum verticillatum* USNM 528640 Cañon del Cobre #1 (loc. 41875) X2. **7**, *Calamostachys* sp. USNM 528460 Copper Mine (loc. 42128) X3. **8**, *Calamites* sp. USNM 528486 Copper Mine (loc. 42128) X1.

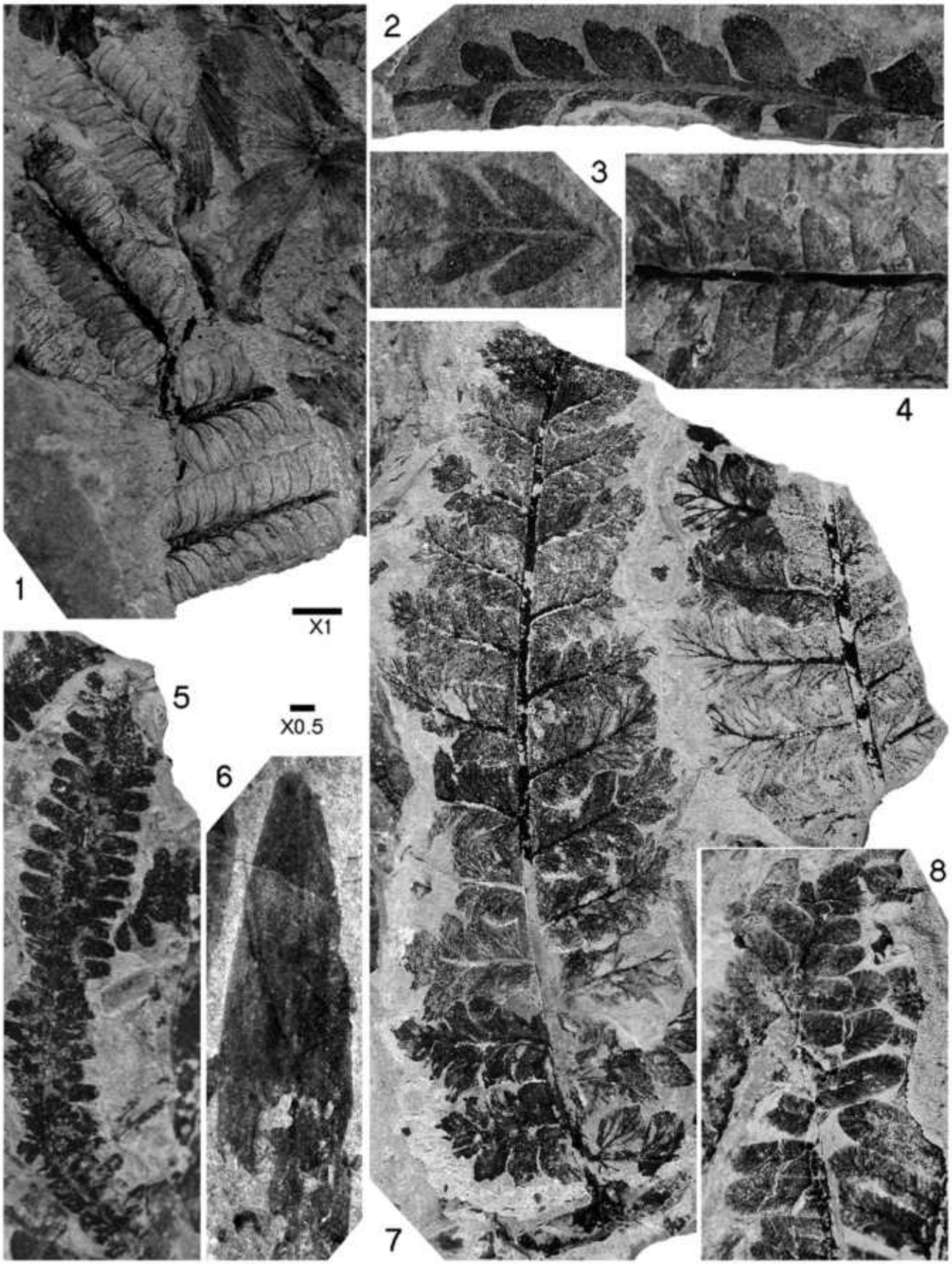

FIGURE 2. Selected plants fossils from Cañon del Cobre. **1**, *Pecopteris unita* USNM 528637 Cañon del Cobre #1 (loc. 41875) X1. **2**, *Pseudomariopteris cordato-ovata* USNM 528638 Cañon del Cobre #1 (loc. 41878) X1. **3**, *Odontopteris* cf. *O. brardii* USNM 528477 Copper Mine (loc. 42128) X1. **4**, Unidentifed foliage USNM 528639 Cañon del Cobre #1 (loc. 41878) X1. **5**, *Pecopteris* sp. USNM 528653 Cañon del Cobre #1 (loc. 42120) X1. **6**, *Cordaites* sp. USNM 528481 Copper Mine (loc. 42128) X1. **7**, *Pseudomariopteris* sp. USNM 528656 Cañon del Cobre #1 (loc. 42120) X1. **8**, *Pecopteris* sp. USNM 528649 Cañon del Cobre #1 (loc. 41877) X1.

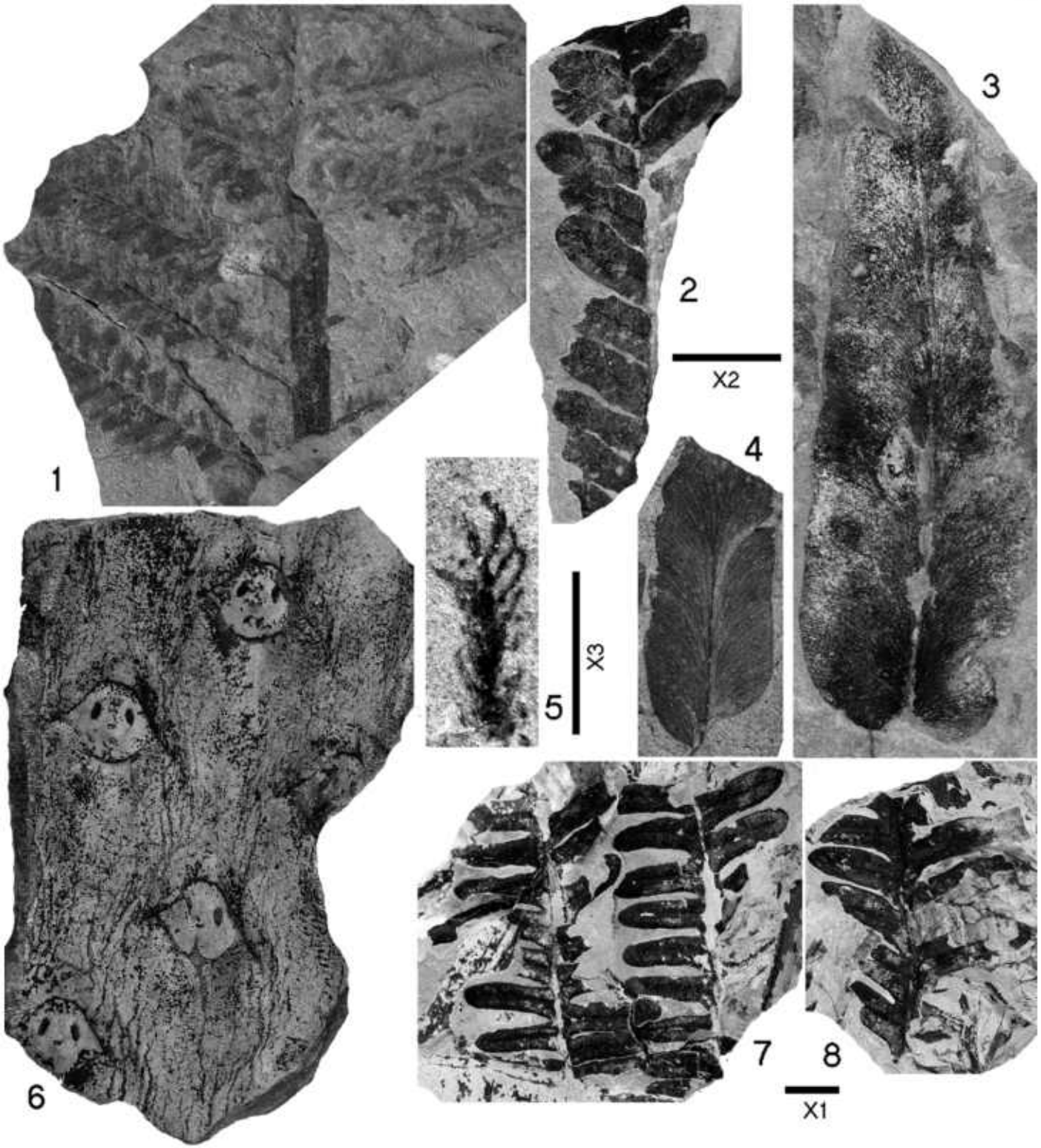

FIGURE 3. Selected plants fossils from Cañon del Cobre. **1**, *Polymorphopteris polymorpha* USNM 528469 Copper Mine (loc. 42128) X1. **2**, *Neuropteris* sp. USNM 528468 Copper Mine (loc. 42128) X2. **3**, *Macroneuropteris scheuchzeri* USNM 528641 Cañon del Cobre #1 (loc. 41878) X2. **4**, *Neuropteris* sp. or *Odontopteris* cf. *O. lingulata* USNM 528466 Copper Mine (loc. 42128) X2. **5**, *Walchia pinniformis* USNM 528482 Copper Mine (loc. 42128) X3. **6**, *Sigillaria brardii* USNM 528655 Cañon del Cobre #1 (loc. 42122) X2. **7**, *Alethopteris bohemica* USNM 528657 Cañon del Cobre #1 (loc. 42120) X1. **8**, *Alethopteris zeilleri* USNM 528644 Cañon del Cobre #1 (loc. 41877) X1.

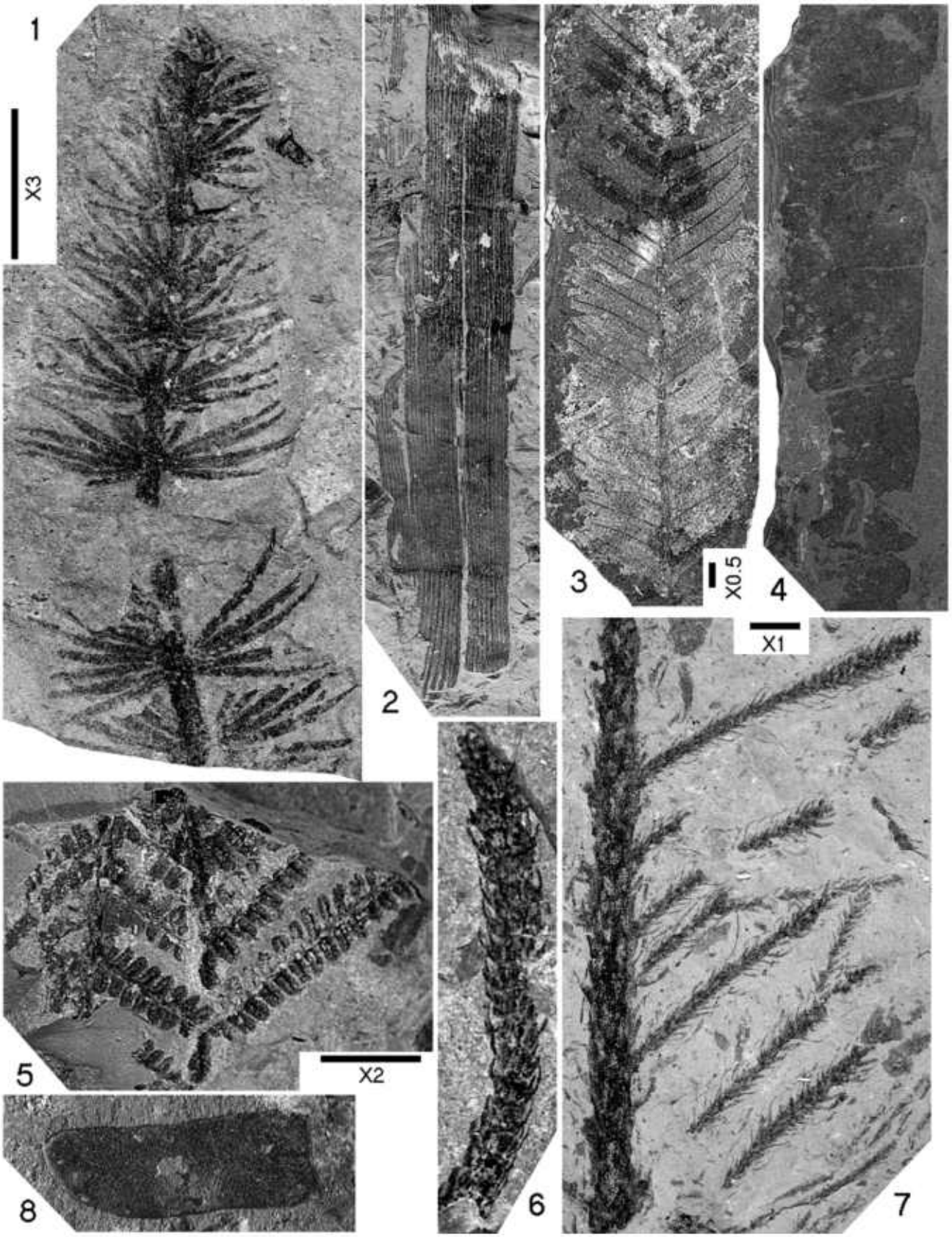

FIGURE 4. Selected plant fossils from Arroyo del Agua. **1**, *Asterophyllites equisetiformis* 528617 Quarry Butte (loc. 41918) X3. **2**, *Calamites* sp. USNM 528620 Quarry Butte (loc. 41918) X1. **3**, *Pecopteris* sp. USNM 528631 Quarry Butte (loc. 41918) X0.5. **4**, *Taeniopteris* sp. USNM 528623 Quarry Butte (loc. 41918) X1. **5**, *Pecopteris* sp. USNM 528632 Quarry Butte (loc. 41918) X2. **6**, *Palaeostachya* sp. USNM 528633 Quarry Butte (loc. 41918) X3. **7**, *Walchia/Culmitzschia* sp.USNM 528619 Quarry Butte (loc. 41918) X1. **8**, cf. *Callipteridium* sp. USNM 528613 Quarry Butte (loc. 41918) X3.

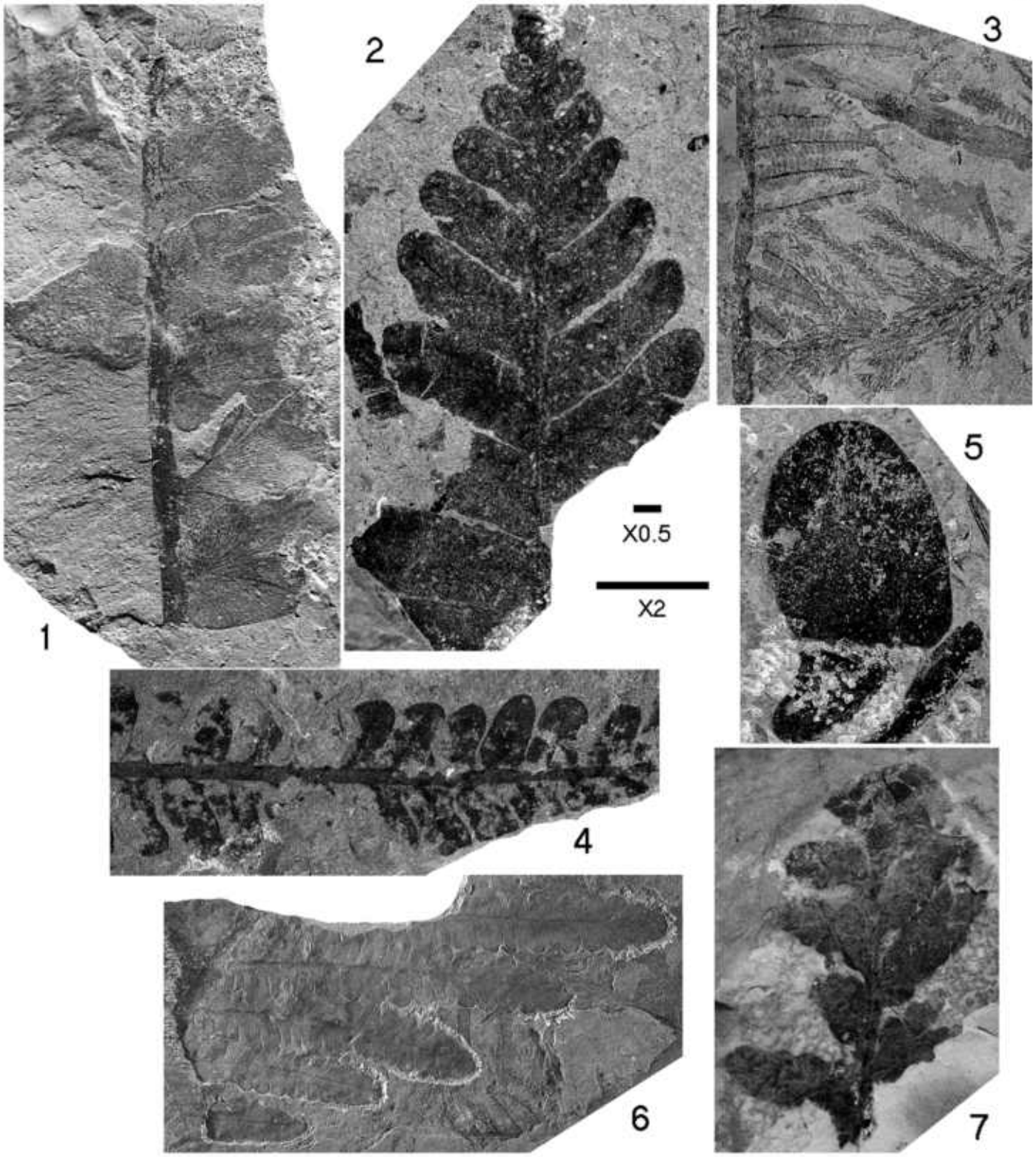

FIGURE 5. Selected plant fossils from Arroyo del Agua. **1**, *Neurodontopteris auriculata* USNM 528615 VanderHoof Quarry B (loc.41880) X2. **2**, peltasperm indeterminate USNM 528620 Quarry Butte (loc. 41918) X2. **3**, *Pecopteris* sp. and walchian conifer USNM 528621 Quarry Butte (loc. 41918) X0.5. **4**, *Pseudomariopteris* sp. USNM 528630 Quarry Butte (loc. 41918) X2. **5**, *Odontopteris* indeterminate USNM 528625 Quarry Butte (loc. 41918) X2. **6**, *Callipteris* sp. (?*Autunia)*USNM 528622 Quarry Butte (loc. 41918) X0.5. **7**, cf. *Mariopteris* sp. USNM 528650 Welles Quarry (loc. 38336) X2.

TABLE 1. Taxon abundances at fossil plant localities in Canñon del Cobre and Arroyo del Agua. CC##### indicates a USNM collecting locality in Cañon del Cobre. QB41918 = Quarry Butte locality in the Arroyo del Agua area. AA##### indicates a USNM collecting locality in the Arroyo del Agua area.

	CC 42120	**CC 42121**	**CC 42122**	**CC 42123**	**CC 42125**	**CC 42126**	**CC 42127**	**CC 42128**	**CC 41875**	**CC 41876**	**CC 41877**	**CC 41878**	
Walchia pinniformis	0	0	0	0	0	0	1	1	0	0	0	0	2—12
Culmitzchia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Autunia/Callipteris	0	0	0	0	0	0	0	0	0	0	0	0	0—12
?Sphenopcallipteris	0	0	0	0	0	0	0	0	0	0	0	0	0—12
?Callipteridum	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Taeniopteris spp.	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Peltasperm-Supaioid	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Cordaites/Artisia	0	0	0	0	0	0	1	1	0	0	0	0	2—12
Neurodontopteris auriculata	0	0	0	0	0	0	1	0	0	0	0	0	1—12
Macroneuropteris scheuchzeri	1	0	1	0	1	1	0	0	0	0	0	1	5—12
Neuropteris spp.	0	0	0	0	0	0	1	1	0	0	0	0	2—12
Alethopteris zeilleri	0	0	0	0	1	0	0	0	0	1	1	1	4—12
Alethopteris bohemica	1	1	1	1	1	0	0	0	1	1	0	1	8—12
Odontopteris reichiana-form	0	0	0	0	0	0	0	1	0	0	0	1	2—12
Odontopteris lingulata-form	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Trigonocarpus big seeds	0	0	0	1	0	0	0	0	0	0	0	0	1—12
Medium ribbed seeds	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Small ovoid seeds	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Pteridosperm axes	1	0	0	1	1	1	1	0	1	1	1	1	9—12
Calamites	1	0	0	0	0	0	1	1	0	0	1	1	5—12
Asterophyllites equisetiformis	0	0	0	0	0	0	0	0	0	0	0	1	1—12
Annularia stellata/carinata	0	0	0	0	0	1	0	1	0	0	0	1	3—12
Annularia spicata	0	0	0	0	0	0	0	1	0	0	0	0	1—12
Calamostachys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Palaeostachya sp.	0	0	0	0	0	0	1	0	0	0	0	0	1—12
Sphenophyllum oblongifolium	0	0	0	1	0	0	0	0	1	1	0	0	3—12
Sphenophyllum verticillatum	1	1	0	0	0	0	0	0	1	1	1	1	6—12
Sphenophyllum angustifolium	1	0	0	0	0	0	0	0	0	0	0	0	1—12
Sphenophyllum emarginatum	0	0	0	0	0	0	0	0	1	0	0	1	2—12
Sphenophyllum sp.	0	0	0	1	1	1	0	0	0	0	0	0	3—12
Pecopteris sp.	1	0	0	0	0	0	1	1	0	1	0	0	4—12
Lobatopteris sp.	0	0	0	0	0	0	0	1	1	0	1	0	3—12
Polymorphopteris sp.	0	0	0	0	0	0	0	1	0	0	0	0	1—12
Pecopteris unita	0	0	0	0	0	0	0	0	1	1	0	0	2—12
Danaeites ?	0	0	1	0	0	0	0	0	0	0	0	0	1—12
Oligocarpia leptophylla	0	0	0	0	0	0	0	1	0	0	0	0	1—12
Sphenopteris biturica	1	0	0	0	0	0	0	0	0	0	0	0	1—12
Nemejcopteris feminaeformis	1	0	0	0	0	0	0	0	0	0	0	0	1—12
Pseudomariopteris cordato-ovata	0	0	0	0	0	0	0	0	1	0	1	0	2—12
?Mariopteris sp.	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Sphenopteris spp.	0	0	0	0	0	0	0	0	0	0	0	0	0—12
Sigillaria brardii	0	0	1	0	0	0	0	0	0	0	1	0	2—12
Sigillariostrobus sp.	0	1	0	0	0	0	0	0	0	1	1	0	3—2
Stigmarian rootlets	0	0	0	1	0	0	0	1	1	1	1	0	5—12
Fine roots	0	0	1	0	0	1	0	0	0	0	1	1	4—12
Charcoal	0	1	0	0	0	0	1	0	0	0	0	0	2—12
bivalves	0	0	0	0	0	0	0	0	0	0	0	0	0—12
conchostrachans	0	0	0	0	0	0	0	0	0	0	0	0	0-12
insects	0	0	0	0	0	0	0	0	0	0	0	0	0—12
coprolites	0	0	0	0	0	0	0	0	0	0	0	0	0—12
													32 plant spp.

TABLE 1 cntd.

	QB 41918	AA 41880 4B	AA 41673	AA 41880 2B	AA 38336	
Walchia pinniformis	0	0	1	1	0	2—5
Culmitzchia sp.	1	1	0	1	1	4—5
Autunia/Callipteris	1	1	0	0	0	2—5
?Sphenopcallipteris	1	0	0	0	0	1—5
?Callipteridum	1	1	0	1	0	3—5
Taeniopteris spp.	1	1	1	1	1	5—5
Peltasperm-Supaioid	1	0	0	0	0	1—5
Cordaites/Artisia	0	1	0	0	0	1—5
Neurodontopteris auriculata	1	1	0	0	0	2—5
Macroneuropteris scheuchzeri	0	0	0	0	0	0—5
Neuropteris spp.	0	0	0	0	0	0—5
Alethopteris zeilleri	0	0	0	0	0	0—5
Alethopteris bohemica	0	0	0	0	0	0—5
Odontopteris reichiana-form	0	0	0	0	0	0—5
Odontopteris lingulata-form	1	1	1	1	1	5—5
Trigonocarpus big seeds	0	0	0	0	0	0—5
Medium ribbed seeds	1	1	0	0	0	2—5
Small ovoid seeds	1	0	0	0	0	1—5
Pteridosperm axes	0	0	1	1	1	3—5
Calamites	1	1	1	1	1	5—5
Asterophyllites equisetiformis	1	0	0	0	0	1—5
Annularia stellata/carinata	0	0	0	0	0	0—5
Annularia spicata	0	0	0	0	0	0—5
Calamostachys sp.	1	0	0	0	0	1—5
Palaeostachya sp.	1	0	0	0	0	1—5
Sphenophyllum oblongifolium	0	0	0	0	0	0—5
Sphenophyllum verticillatum	0	0	0	0	0	0—5
Sphenophyllum angustifolium	0	0	0	0	0	0—5
Sphenophyllum emarginatum	0	0	0	0	0	0—5
Sphenophyllum sp.	0	0	1	0	0	1—5
Pecopteris sp.	0	1	1	1	0	3—5
Lobatopteris sp.	0	0	0	0	0	0—5
Polymorphopteris sp.	0	0	0	0	0	0—5
Pecopteris unita	0	0	0	0	0	0—5
Danaeites ?	0	0	0	0	0	0—5
Oligocarpia leptophylla	0	0	0	0	0	0—5
Sphenopteris biturica	0	0	0	0	0	0—5
Nemejcopteris feminaeformis	0	0	0	0	0	0—5
Pseudomariopteris cordato-ovata	1	1	0	0	0	2—5
?Mariopteris sp.	0	0	0	0	1	1—5
Sphenopteris spp.	1	0	0	0	0	1—5
Sigillaria brardii	0	0	0	0	0	0—5
Sigillariostrobus sp.	0	0	0	0	0	0—5
Stigmarian rootlets	0	0	0	0	0	0—5
Fine roots	0	0	0	0	0	0—5
Charcoal	0	0	0	0	1	1—5
bivalves	1	1	1	1	0	4—5
conchostrachans	0	0	0	0	1	1—5
insects	1	0	0	0	0	1—5
coprolites	1	0	1	0	0	2—5
					22 plant spp.	

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