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BRIEF COMMUNICATION

IN SITU FOSSIL SEEDLINGS OF A *METASEQUOIA*-LIKE TAXODIACEOUS CONIFER FROM PALEOCENE RIVER FLOODPLAIN DEPOSITS OF CENTRAL ALBERTA, CANADA[1]

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Fossil seeds and seedlings of a *Metasequoia*-like taxodiaceous conifer occur in Paleocene deposits at the Munce's Hill and Gao Mine localities of central Alberta, Canada. Compression/impression specimens are preserved in upright growth positions among seedlings of the cercidiphyllaceous dicot *Joffrea speirsii* Crane & Stockey. There are a large number of seeds, a few of which were buried while germinating and show a radicle or short primary root. More than 500 *Metasequoia*-like seedlings have been identified that have two linear cotyledons with parallel margins and rounded tips. Three specimens have been found that display three cotyledons. Slightly older seedlings show decussate pairs of leaves attached to the stem distal to the cotyledons. Still older seedlings have axillary branches that show varying sizes and numbers of opposite leaves arranged in a single plane distal to the opposite pairs. These specimens reveal that both *Joffrea* and this extinct taxodiaceous conifer were early colonizers of North American floodplain communities at the beginning of the Tertiary.

Key words: *Metasequoia*; Paleocene; seedlings; Taxodiaceae.

Large collections of in situ plant remains from a single locality allow for the thorough characterization of whole plants, for studies of plant community associations, and for the interpretation of ecological settings for extinct vegetation. In recent years collections from several Paleocene and Eocene localities have provided such data for the taxonomic and ecological characterization of extinct floras from Alberta and British Columbia, Canada (Stockey and Crane, 1983, 1985; Cevallos-Ferriz, Stockey, and Pigg, 1991; Rothwell and Stockey, 1991; Pigg and Stockey, 1991, Sun and Stockey, 1992; 1996; Hoffman and Stockey, 1994, 1997; Hoffman, 1995; Stockey, Hoffman, and Rothwell, 1997). The coniferous component of two such floras in central Alberta consists almost entirely of a single taxodiaceous conifer species with a distinctly opposite arrangement of leaves and branches. Vegetative shoots, pollen cones, and dispersed seeds are intriguingly similar to those of *Metasequoia* Miki, but the helical arrangement of ovuliferous scales in some cones, an absence of shoot dimorphism, and unusually large leaves at the Munce's Hill and Gao Mine localities suggest that the material may represent a currently unrecognized taxon. Recent collections at these localities demonstrate that the seedlings typically occur in narrow intervals overlying layers rich in mature organs of the *Metasequoia*-like plant.

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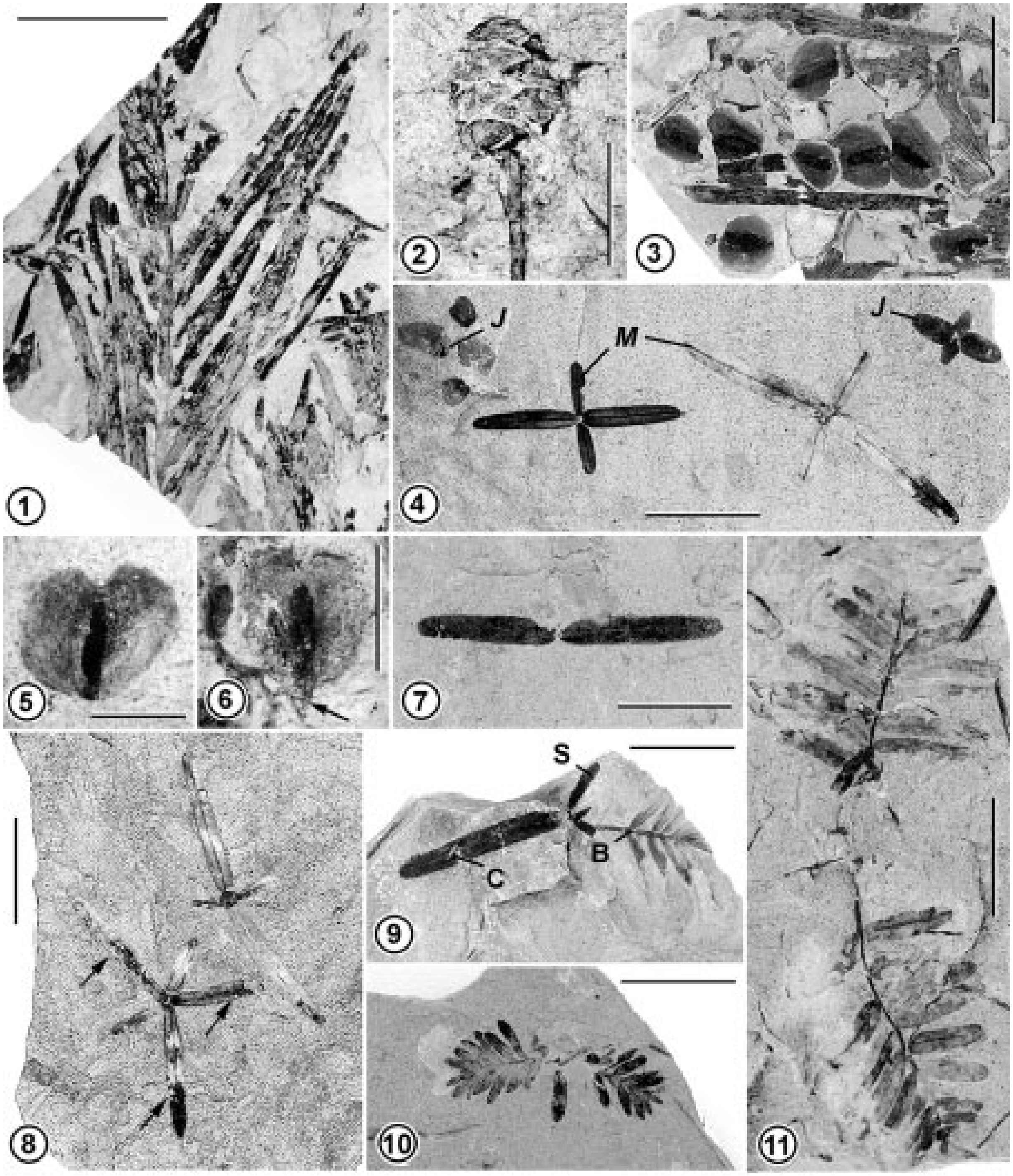
Among the 4000 taxodiaceous specimens that have been collected to date is a large number of seedlings and germinating seeds that have been preserved along with in situ angiospermous seedlings of the genus *Joffrea* (Stockey and Crane, 1983; Crane and Stockey, 1985), all of which are in growth position. The purpose of this paper is to describe the first seedlings of taxodiaceous conifers to be discovered in the fossil record and to elucidate the direct evidence that they provide for the habitat of growth for this *Metasequoia*-like plant in the early Tertiary of North America. A detailed plant reconstruction and formal taxonomic description of the new species will be presented elsewhere.

The fossil seedlings were collected from the Munce's Hill locality (a roadcut 3 km northeast of Canyon Ski Quarry; NW 1/4 Sec. 34, T 38, R 26, W 4) and the Gao Mine locality (a roadcut on the north bank of Highway 593, 14 km east of Red Deer; Sec. 3, T 38, R 26, W 4), both of which are large roadcuts in nonmarine fluvial deposits of the Paskapoo Formation near Red Deer, Alberta (Fox, 1990; Rothwell and Stockey, 1991). Sediments at these localities consist of buff to light-gray medium-grain sandstones interbedded with highly fractured, finer sandstones and mudstones that are more or less flat lying, and are late Tiffanian (Ti_4) age (Fox, 1990, and personal communication, 1996). Images of the fossils were captured with a MicroLumina scanning camera (Leaf Systems, Inc., Bedford, MA; http://www.scitex.com) and processed using Adobe Photoshop 4.0. All specimens are housed in the University of Alberta Paleobotanical Collection (UAPC-ALTA).

Mature organs of the *Metasequoia*-like plant include articulated branch systems with oppositely arranged, linear leaves with rounded tips (Fig. 1), shoots bearing small pollen cones in the axils of vegetative leaves, and ellipsoidal ovulate cones with decussately arranged cone–



Figs. 1–11. *Metasequoia*-like fossils. **1.** Mature shoot showing large, oppositely arranged vegetative leaves. S52290. X1.2. Scale = 2 cm. **2**. Longitudinal section of ovulate cone with decussately arranged bract-scale complexes and naked stalk. S52291. X1. Scale = 2 cm. **3.** Several seeds among other plant debris on bedding plane slightly above the level that yielded the specimen in Fig. 1. S46729. X1.7. Scale = 1 cm. **4.** Two in situ *Metasequoia*-like seedlings (at M) showing cotyledons and first pair of vegetative leaves of the stem, and two in situ seedlings of the cercidiphyllaceous dicot *Joffrea speirsii* at a similar stage of development. S51651b. X1.8. Scale = 1 cm. **5.** Winged seed showing seed body, symmetrical lateral wings, and chalazal notch that represents the point of attachment. S36431. X3. Scale = 5 mm. **6.** Germinating *Metasequoia*-like seed showing emergence of the radicle from the micropylar end (at arrow). S51553. X4. Scale = 5 mm. **7.** In situ seedling showing fully expanded cotyledons, but no stem leaves. S51476b. X1.8. Scale = 1 cm. **8.** Two seedlings showing fully expanded cotyledons and one pair of stem leaves. Note that the seedling at the bottom has three cotyledons, arrows. S51468b. X1.7. Scale = 1 cm. **9.** Seedling showing one of the pair of cotyledons (C), stem leaves (S), and a small lateral branch (B). S46729d. X1.75. Scale = 1 cm. **10.** Specimen showing two small lateral branches. S28143. X1.8. Scale = 1 cm. **11.** Specimen showing two larger lateral branches. S33343. X1.9. Scale = 1 cm.

scale complexes that terminate naked stalks (Fig. 2). The virtual absence of any other conifer remains from these localities and the opposite arrangement of the leaves on the seedlings provide convincing evidence that the seeds and seedlings were produced by this plant.

Seeds are 5–6 mm long and 6–7 mm wide, with a narrow body and two symmetrical wings (Figs. 3, 5, 6). As in living *Metasequoia*, the fossil seeds are cordate with a rounded apex and a chalazal notch that represents the point of attachment (Figs. 5, 6). Germinating seeds display the emergence of a radicle from the micropylar end (Fig. 6, at arrow). Virtually all of the seedlings are preserved in growth position, with the cotyledons, leaves of the stem, and branches oriented parallel to the bedding plane (Figs. 4, 7–11). The stem and root extend vertically through the sediment. When split at close intervals, some specimens display two, three, or even four levels of the same plant on adjacent planes of fracture.

Approximately 7% of the seedlings are preserved at a stage of growth where there is an apical bud between the cotyledons (Fig. 7). Nearly all seedlings have two cotyledons (Figs. 4, 7, 8), but three specimens display three (Fig. 8). This is consistent with cotyledon numbers produced by living *M. glyptostroboides* Chaney plants (Sterling, 1949). Cotyledons are 8–21 mm long, 1.2–3.0 mm wide with parallel margins, a rounded tip, and a single midvein. All of the other seedlings display decussately arranged pairs of leaves on the stem distal to the cotyledons (Figs. 4, 8). Leaves on the stem are 3–14 mm long, and can be distinguished from the cotyledons by their consistently smaller size (Figs. 4, 8, 9). Nearly 20% of the specimens show lateral branches (Figs. 9–11). Some show two nearly opposite branches (Figs. 10, 11), but in others only one is preserved on the bedding plane (Fig. 9). This variation is consistent with branch arrangement on living *M. glyptostroboides* seedlings that we are currently growing for comparison to the fossil specimens. Branches are from 9 to 22 mm long, and have 2–12 pairs of leaves arranged in a single plane. This is also characteristic of living *M. glyptostroboides* branches, where the leaves diverge in a decussate arrangement and then bend into a single plane (Sterling, 1949). Branch leaves are linear with a rounded tip, single midvein, and range from 3 to 10 mm long.

Habitats of growth for extinct species usually must be inferred from a combination of indirect evidence. Sediments in which disarticulated organs are found reflect environments of deposition, and depositional associations of species more-or-less reflect community associations in which the plants grew. However, geological mechanisms of transport and deposition alter such relationships. Only when plant remains are buried in situ are growth and depositional environments the same. As a result, in situ associations are more likely to accurately reflect plant community structure. The in situ occurrence of these seedlings with rooted *Equisetum* and *Onoclea sensibilis* plants (Rothwell and Stockey, 1991) demonstrates that they germinated and grew in marshy habitats near the margins of oxbow lakes in floodplain environments. Their co-occurrence with seedlings of the cercidiphyllaceous dicot *Joffrea speirsii* (Crane and Stockey, 1985) demonstrates that these species all occupied the same lowland habitats at the beginning of the Tertiary.

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