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The Bolca *Fossil-Lagerstätten*:
A window into the Eocene World
(*editors* C.A. Papazzoni, L. Giusberti, G. Carnevale, G. Roghi, D. Bassi & R. Zorzin)

6. The Pesciara-Monte Postale *Fossil-Lagerstätte:* 3. Flora

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One of the most important Ypresian plant localities in northern Italy is the worldwide famous Pesciara-Monte Postale *Lagerstätte*, located NE of the Bolca village (Verona and Vicenza Province). But, as seen in this guide (Carnevale et al., 2014, this volume), the fishes found in the respective sites are so beautifully preserved that they initially received all attention and plant fossils (Figs 1-3) have been almost neglected up to the second half of the 19th century (see also Roghi, 2014 and Giusberti et al., 2014).

Abramo Bartolomeo Massalongo was the first providing systematic descriptions of the Bolca macroflora. He recognized 105 genera and 277 species, but with sparse descriptions and illustrations (Massalongo, 1850, 1851, 1852, 1853a, b, 1855-1856, 1857, 1858, 1859). Massalongo's determinations were partly revised by Meschinelli & Squinabol (1892) and Gola (1941). Successively, partial studies were also published by De Visiani (1864), Beggiato (1865), Fiore (1932, 1936a-d), Schmid & Schmid (1973, 1974) and, more recently, Caccin & Pallozzi (2001). Maria Fiore recognized the presence of *Delesserites pinnatus* Unger in the Pesciara site (Fiore, 1936d) and re-determined the fern *Thecophyllum flabellatum* Massalongo as an aquatic monocotyledon (*Eichorniopsis*; Fiore, 1936a). From the same locality, Fiore (1936b) also reported *Podogonium knorii* Heer and *Banksia dillenioides* Ettinghausen. Forti (1926) emended *Zoophycos caputmedusae* (Massalongo, 1850) Massalongo 1851 (previously named *Zonarites*? *caputmedusae*), recognizing its affinity with brown algae of the family Laminariaceae. Based on its similarity with the living genus *Postelsia*, he erected the new genus *Postelsiopsis*. The name *Zoophycos* Massalongo also included four species of true trace fossils, among which Olivero (2007) designed the lectotype of this well-known ichnogenus (*Zoophycos brianteus* Massalongo, 1855).

Following the older literature, the main group of the Bolca macroflora is represented by dicotyledonous angiosperms which have been assigned to different genera of Gramineae, Cyperaceae, Najadaceae, Liliaceae, Bromeliaceae, Myricaceae, Urticaceae, Nymphaeaceae, Cabombaceae, Caryophyllaceae, Sterculiaceae (big fruits of *Fracastoria*), Byttneriaceae, Aurantiaceae, Xanthoxylaceae, Zygophyllaceae, Sapindaceae, Araliaceae, Saxifragaceae, Podostemaceae, Haloragidaceae, Myrtaceae, Papilionaceae, Caesalpiniaceae, Santalaceae, Ericaceae, Sapotaceae, Gentianaceae, and Bignoniaceae (Massalongo, 1859; Meschinelli & Squinabol, 1892; Fiore, 1936e; and Gola, 1941). Large

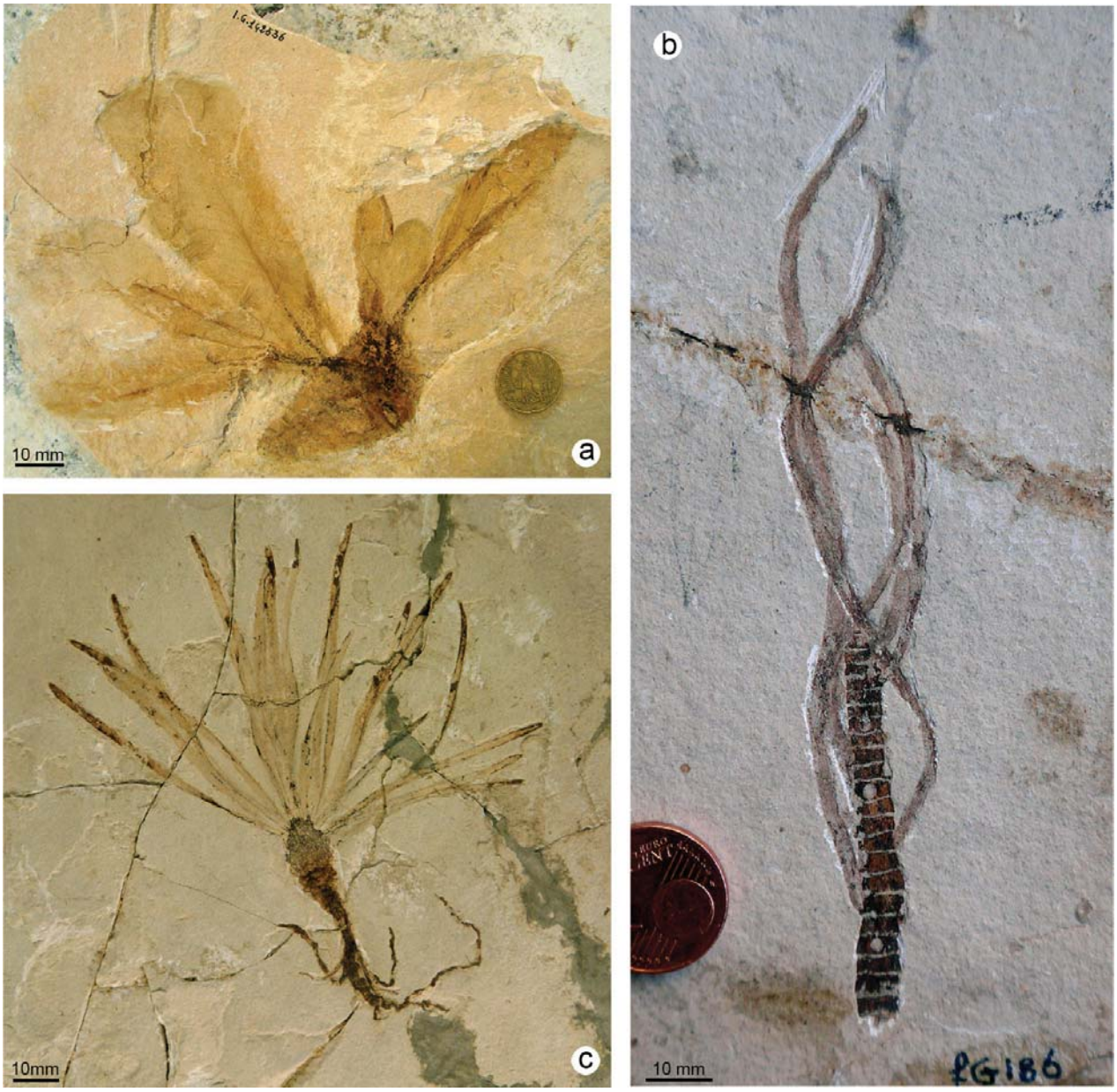

Fig. 1 - a) Leaf-like thalli of *Delesserites* (red algae) still attached to a common holdfast, MCSNV IG. 142536. b) Seagrass of potential affinity to extant *Thalassodendron*, MCSNV fG186. c) Seagrass of potential affinity to extant *Phyllospadix* or *Posidonia*, MCSNV fB47.

palm fruits such as *Castellinia* Massalongo, *Geonomites* De Visiani, and *Palaeospathe* Unger, have also been noted. The conifers are represented by *Podocarpus* and *Taxodium* (Massalongo, 1859; Fiore, 1936e).

Regrettably, Massalongo's determinations are hardly accompanied by appropriate descriptions and comparatively few illustrations. As seen above, his determinations have partly been revised and some new information has been added. However, the taphocoenosis is in urgent need of revision, which is hampered by the common mode of preservation as pure imprints without remaining organic material. As a first step, and for preparation of the fieldtrip guide, the authors have re-visited the material as preserved in the rich historical collections at Padova and Verona and the more recently collected material at Bolca and Verona. Independent of a planned systematic revision this resulted in some interesting observations helping for an interpretation of the plant taphocoenosis. This is only part of the so-called "Florenkomplex Montebolca" of Mai (1995) which is in fact a composite from several more or less coeval localities between Sardinia and Croatia.

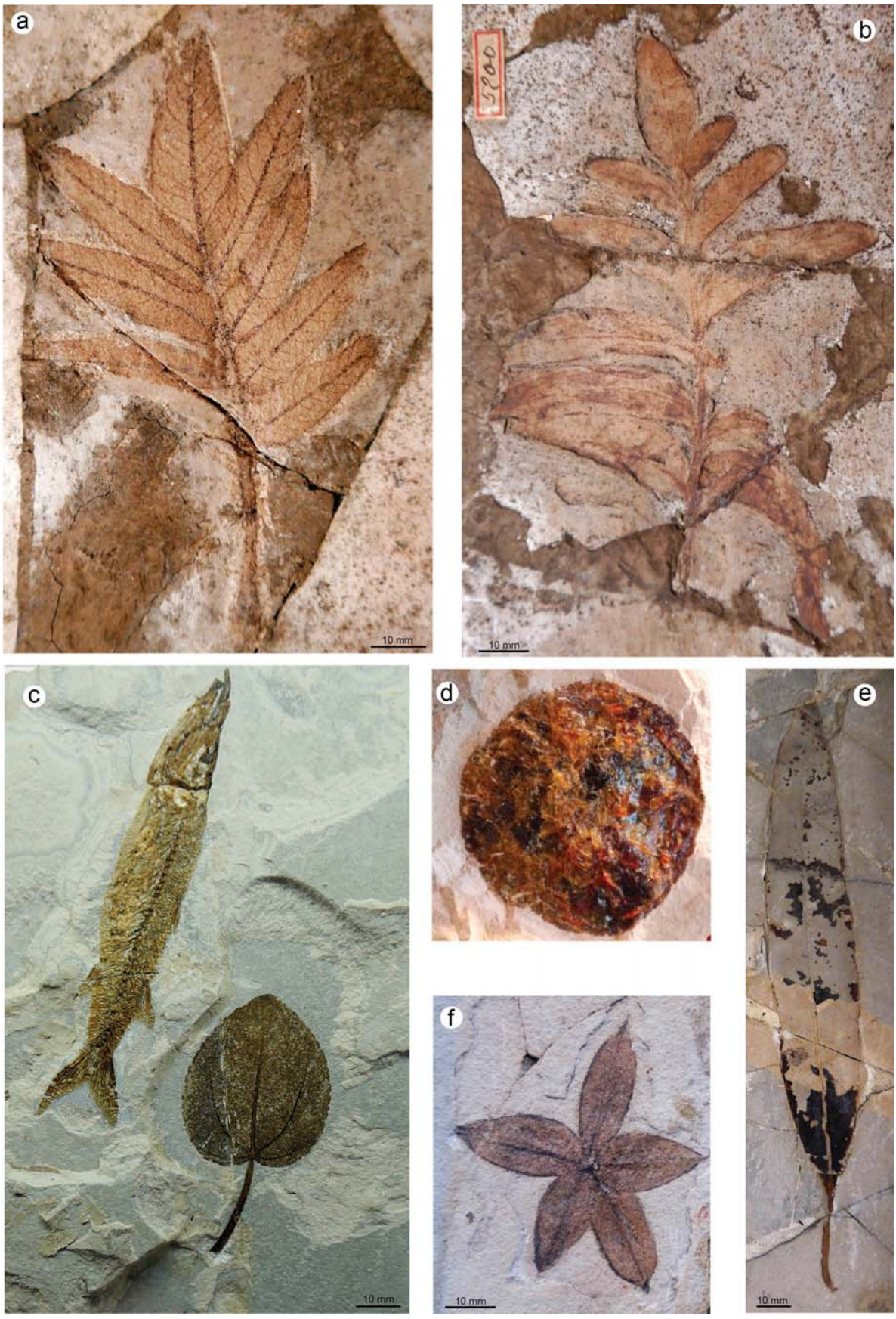

FIG. 2 - a) Imparipinnate legume leaf similar to "Leguminosae sp. 5" from Messel (Wilde 1989), MGPPD23. b) Imparipinnate composite leaf with decurrent leaf bases and potential affinities to *Zanthoxylon* (Rutaceae), MGPPD 5200. c) Leaf of "*Dombeyopsis*" with crenulate margin on a slab together with a ramphognathids fish (*Latellagnathus teruzzii* Bannikov, 2008). d) Large piece of resin, probably derived from legumes (diameter 3.5 cm). e) Entire-margined leaf of "*Laurophyllum*" with remnant organic material possibly suitable for cuticular analysis, MCSNV fM179. f) Winged fruit of the "*Getonia*"-type, MCSNV fG399.

From a systematic point of view, the Pesciara-Monte Postale macroflora is remarkably rich in remains of marine macroalgae, especially the leaf-like thalli of *Delesserites* (red algae; Fig. 1a). Interestingly, red algae have also been suggested by biomarker studies of the host rock (Schwark et al., 2009). Ferns have not been detected, and conifers are putatively represented only by long needle-like leaves showing transverse wrinkling possibly caused by sclereids, such as seen in *Amentotaxus* today. The most frequent angiosperms are floating salt-tolerant or even marine monocotyledons, such as seagrasses (Figs 1b-c), commonly preserved as large fragments or almost whole plants. Remains of other monocotyledons are rare and do not include palms, except for some of the large fruits.

Dicotyledonous angiosperms are mainly represented by leaves together with some fruits, fruiting twigs/infructescences and rare flowers. In addition, there are whole-plant specimens including roots and fruits ("*Maffeia*"), but at least some of them appear artificially (re)constructed (Fig. 3d). The leaves are dominated by compound leaves and their leaflets. About five legume taxa may probably be distinguished (Fig. 2b), including a double-compound caesalpinioid leaf type and leaves morphologically quite similar to those described as "Leguminosae sp. 5" from the Middle Eocene of Messel (Germany; Wilde, 1989; Figs 2a-b). There is another type of compound leaves characterized by decurrent leaf bases which were compared to leaves of extant *Zanthoxylum* (Rutaceae). *Weinmannia* (Cunoniaceae) has commonly been suggested for small imparipinnate leaves in the Italian collections, carrying leaflets with a crenulate margin (Figs 3a-b). But, a single specimen of the same distinct type in the Berlin collection has later been assigned to Burseraceae (*Boswellia*) by Kahlert & Rüffle (2007). There are surprisingly few types of mostly medium-sized entire-margined leaves in the collections which have been assigned to genera like, e.g., *Ficus* (Moraceae), *Laurophyllum* (Lauraceae) and *Salix* (Salicaceae), but their true affinities need to be checked by careful comparisons. Putative malvalean leaves are common and have been assigned to genera such as e.g. *Dombeyopsis* or *Grewia* (Fig. 2c). However, some of them show a crenate margin which is uncommon in the malvalean alliance, but makes them sometimes similar to leaves of *Cercidiphyllum* (Jähnichen et al., 1980).

Among the fertile material, branched infructescences (or fruiting twigs) should be mentioned which were called "*Bubulcia*". They are superficially similar to the infructescences of extant and fossil *Decodon* (Lythraceae) as described by Kvaček & Sakala (1999), but detailed comparisons are needed. Furthermore, there are few winged fruits which were traditionally assigned to *Getonia* (Fig. 2f), but also need detailed comparisons. Some of the quite large fruits were obviously fibrous and may have been derived from palms, possibly including *Nypa* (Fig. 3c).

Frequency and diversity of marine elements such as macroalgae and seagrasses among the plant macrofossils at Pesciara-Monte Postale is not surprising in a sheltered lagoonal basin as suggested for the time of deposition (Papazzoni & Trevisani, 2006; Schwark et al., 2009). Compared to the similarly well collected earliest Middle Eocene lacustrine oil shale of Messel, the rest of the association is only moderately diverse with a surprising dominance of legume leaves and leaflets. Except for lobed leaves (Fig. 3e), only entire-margined leaves have been noted otherwise (Fig. 2e). Fruits and seeds are comparatively rare, but even include specimens of considerable size, most of them probably palm fruits. Major deficiencies are ferns and legume pods, conifers and winged fruits are rare. The comparatively selective taphocoenosis can mostly be explained by taphonomic processes. Probably most of the plant material (including amber; Trevisani et al., 2005) was washed from nearby sources into the lagoon by rain or minor tributaries leaving no obvious record in the sediments except for dispersed fine grained material. This excluded leaves of indehiscent herbaceous plants, especially ferns and monocotyledons.

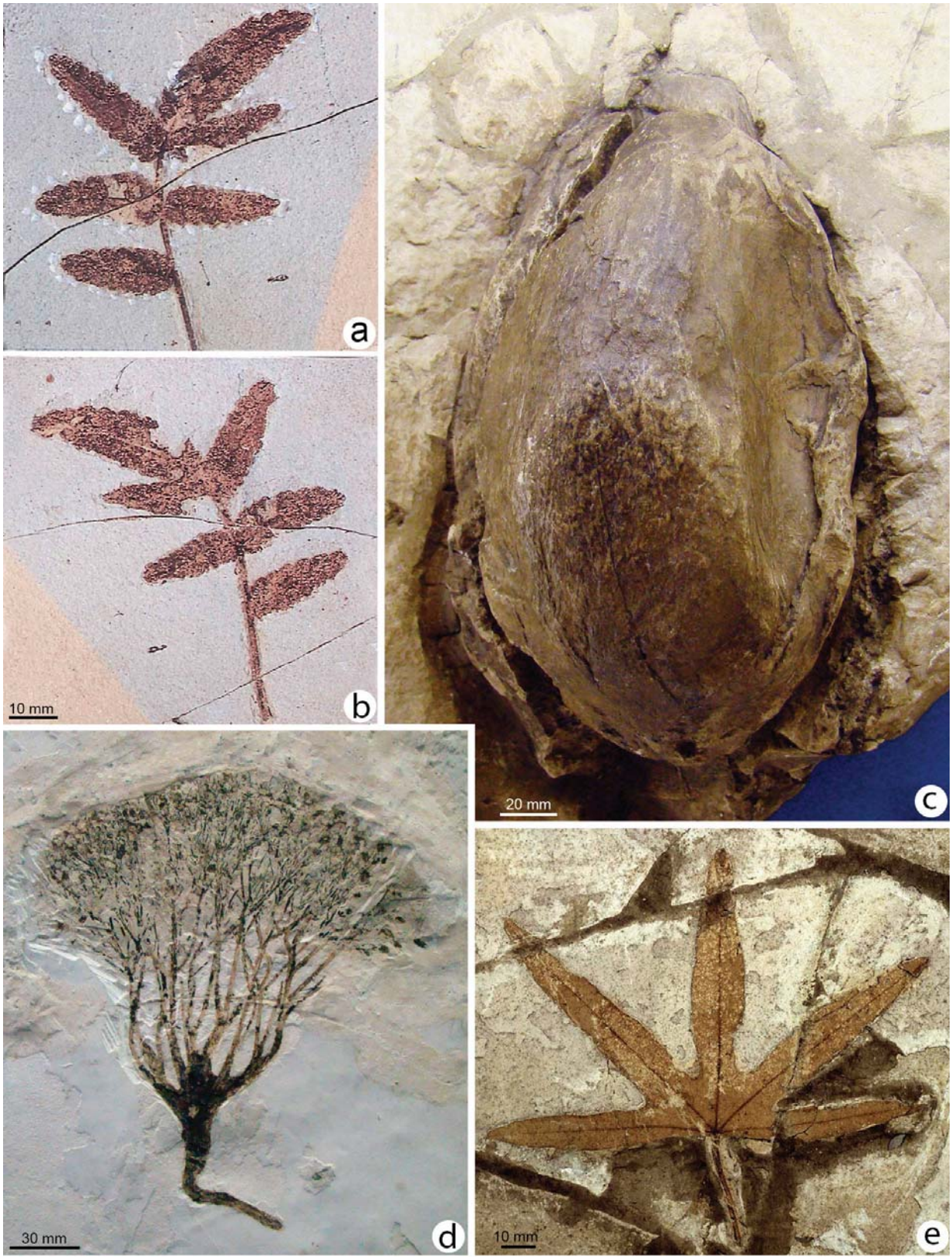

Fig. 3 - a) Small compound leaf showing leaflets with a crenulate margin which have been assigned either to *Weinmannia* (Cunoniaceae), or to *Boswellia* (Burseraceae), MCSNV fB221. b) Counterpart of a, MCSNV fB222. c) Large fibrous fruit similar to fruits of the mangrove palm *Nypa*, MCSNV fG416. d) Partly (re) constructed whole-plant specimen ("*Maffeia*"), MCSNV fB203. e) Leaf of a kind which has frequently been assigned to "*Sterculia*" (Sterculiaceae), MGPPD 20V.

Floating of the plant material at the surface before sinking to the bottom led to further selection. Still surprising is the frequency of legumes which are not only represented by

leaves but also by amber (Trevisani et al., 2005). They may have been blown directly into the lagoon from trees growing nearby on a well-drained (drier) substrate by occasional storms (Papazzoni & Trevisani, 2006), and large palm fruits may just have fallen down into the water. Storms may also be responsible for occasionally removing whole-plant specimens from the substrate. Similar to the macroflora, ferns and gymnosperms are rare in the microflora, however, there is considerably more diversity in pollen of angiosperms than in macroscopic remains (Kedves & Zsivin, 1970; Trevisani et al., 2005). Since pollen is more easily transported for some distance, they may have been derived from a diverse tropical forest in some distance to the lagoon. Summing up, we have to envisage a tropical lagoon for the Ypresian of Pesciara-Monte Postale which was probably surrounded especially by legumes and palms including the mangrove palm *Nypa*. A regular tropical forest followed with distance.

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