



LATE MESSINIAN FLORA FROM THE POST-EVAPORITIC DEPOSITS OF THE PIEDMONT BASIN (NORTHWEST ITALY)

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Abstract: In the Piedmont Basin (PB), one of the northernmost Mediterranean basins recording the Messinian Salinity Crisis (MSC), pollen and plant macroremains (leaves, fruits and seeds) were studied in four sedimentary sections of the post-evaporitic interval (5.6–5.33 Ma). The joint palaeobotanical investigations of the two datasets allowed the reconstruction of a floristic assemblage which consists of 133 taxa (95 woody and 38 non-woody taxa). The lowland/coastal vegetation reconstructed by integrating macro- and microfossil data exhibits several analogies with existing “types/formations” of South-Southeast Asia, whereas taxa occurring solely in the pollen record suggest the existence of altitudinal forests with conifers and a few angiosperms. We suggest that the generalized type of lowland, zonal palaeovegetation in the post-evaporitic Messinian of the PB was of no-analog type, but most similar to either “mixed mesophytic forests” or “broad-leaved evergreen forests”, which indicates a Köppen-Trewartha subtropical palaeoclimate.

Key words: palaeobotany, carpology, palynology, whole-plant concept, Messinian Salinity Crisis, palaeoenvironment

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Introduction

The Messinian Salinity Crisis (MSC) represents an important palaeoceanographic and palaeoclimatic event that occurred in the Mediterranean basin between 5.97 Ma and 5.33 Ma (e.g., Krijgsman et al. 1999a, b, Roveri et al. 2008, 2014a, b, Cosentino et al. 2012). The foremost widely shared hypothesis (Roveri et al. 2014a, b) foresees a succession of different steps marking the history of both marginal and deep basins. Accordingly, the onset of the MSC (5.97 Ma) is marked in the marginal basins by evaporitic deposits (Primary Lower Gypsum, PLG) whereas in deep basins the sedimentation of euxinic shales continues. At ca. 5.6 Ma, a tectonic phase caused an erosion of PLG (Messinian Erosional Surface, MES) in the marginal areas and therefore their subsequent re-deposition in deep basins (Resedimented Lower Gypsum, RLG). Only from 5.5 Ma is the beginning of evaporitic sedimentation also documented in deep basins (Upper Gypsum, UG). At 5.42 Ma biological and geochemical data (e.g., Bertini and Corradini 1998, Grossi et al. 2008, Pellen et al. 2017) support the main arrival

of Paratethyan waters in the Mediterranean Basin (Lago Mare event), i.e., only 90 ka before the reestablishment of the connections between the Mediterranean and the Atlantic Ocean at 5.33 Ma. Previous palaeoenvironmental changes have been documented in several Italian basins, among which the best known and most studied are in Sicily, Tuscany, Emilia Romagna, and Piedmont (e.g., Roveri et al. 2003, Bertini 2006, Manzi et al. 2007, Dela Pierre et al. 2011). The Piedmont Basin (PB, Northern Italy; Text-fig. 1) provides a unique opportunity to document the history of major palaeoenvironmental changes throughout the MSC in the northernmost portion of the Mediterranean area, in a very peculiar palaeogeographic context linked to the close presence of the Alpine chain.

Its Messinian deposits have been the subject of numerous geological studies (Sturani 1973, Dela Pierre et al. 2003, 2007, 2011, 2014, 2016, Irace et al. 2010, Natalicchio et al. 2013, 2017, Colombero et al. 2014, Gennari et al. 2020, Sabino et al. 2020, 2021) which allow the understanding of their stratigraphic structure and palaeoenvironmental context for the interval between 6.6 Ma and 5.33 Ma,



Text-fig. 1. Geographical location of the studied post-evaporitic sections (Piedmont Basin): Govone (1), Sioneri (2), Ciabòt Cagna (3) and Pollenzo (4).

including the MSC. The Messinian sedimentary succession contains numerous plant macroremains (leaves, wood, and seeds) which have already been the subject of several studies (Cavallo et al. 1986, Guglielmetto and Iguera 1994, Martinetto et al. 2000, 2007, 2022, Kovar-Eder et al. 2006, Cimino et al. 2016, Martinetto and Malacuso 2018). Palynological studies have also been carried out, providing the opportunity for integration and comparison with those of the macrofloristic record (Bertini and Martinetto 2008, 2011) to provide a comprehensive reconstruction of the flora.

In the present work, we analyse the interval between 5.6 Ma and 5.33 Ma to provide an update of the flora in the PB during the instauration of the Messinian post-evaporitic conditions. The integration of the micro- and macrofloristic datasets, according to a “whole-plant” concept (Kvaček 2008), permits more detailed palaeoenvironmental reconstructions, as it reduces the well-known taphonomic biases affecting both methods, e.g., discontinuous presence of macrofossils and non-preservation of some pollen grains.

Material

Four sedimentary sections including post-evaporitic deposits (5.6–5.33 Ma), all located along the southern margin of the PB (Text-fig. 1), were selected for both micro- and macrofloristic sampling. A total of 55 samples were submitted for pollen analysis. Plant macrofossils were recovered episodically from three sections (Govone excepted) over a time span of 40 years. Part of the plant macrofossil samples are stored at the F. Eusebio Civic Museum of Alba (acronym MCEA); other samples are stored at the Museum of Geology and Paleontology of Turin University (acronym MGPT-PU). The main geological-stratigraphical features of the studied

sections are summarized below and in Text-fig. 2. We need to point out that two of the sections treated separately in this work, Ciabòt Cagna and Sioneri, were treated as the composite section of Corneliano d’Alba (or “composite section Sioneri-Ciabòt Cagna”) by Kovar-Eder et al. (2006).

Govone section

The Govone section includes both Messinian pre-evaporitic and MSC (Text-fig. 2) deposits (Dela Pierre et al. 2011, 2016, Gennari et al. 2020, Sabino et al. 2020, 2021, Martinetto et al. 2022). Post-evaporitic deposits about 34 m thick include the Valle Versa chaotic complex here informally defined as the Lago Ario unit (LAU; Dela Pierre et al. 2016); its base marks the beginning of the post-evaporitic phase, just above the MES (5.6 Ma; Roveri et al. 2014a). LAU is ca. 19 m thick and consists of marl-shale alternations; a slump is present at the top. LAU is overlaid by the Conglomerati di Cassano Spinola Formation (CCS; Dela Pierre et al. 2016). A total of 24 palynological samples were collected (15 samples in LAU and 9 samples in CCS).

Sioneri section

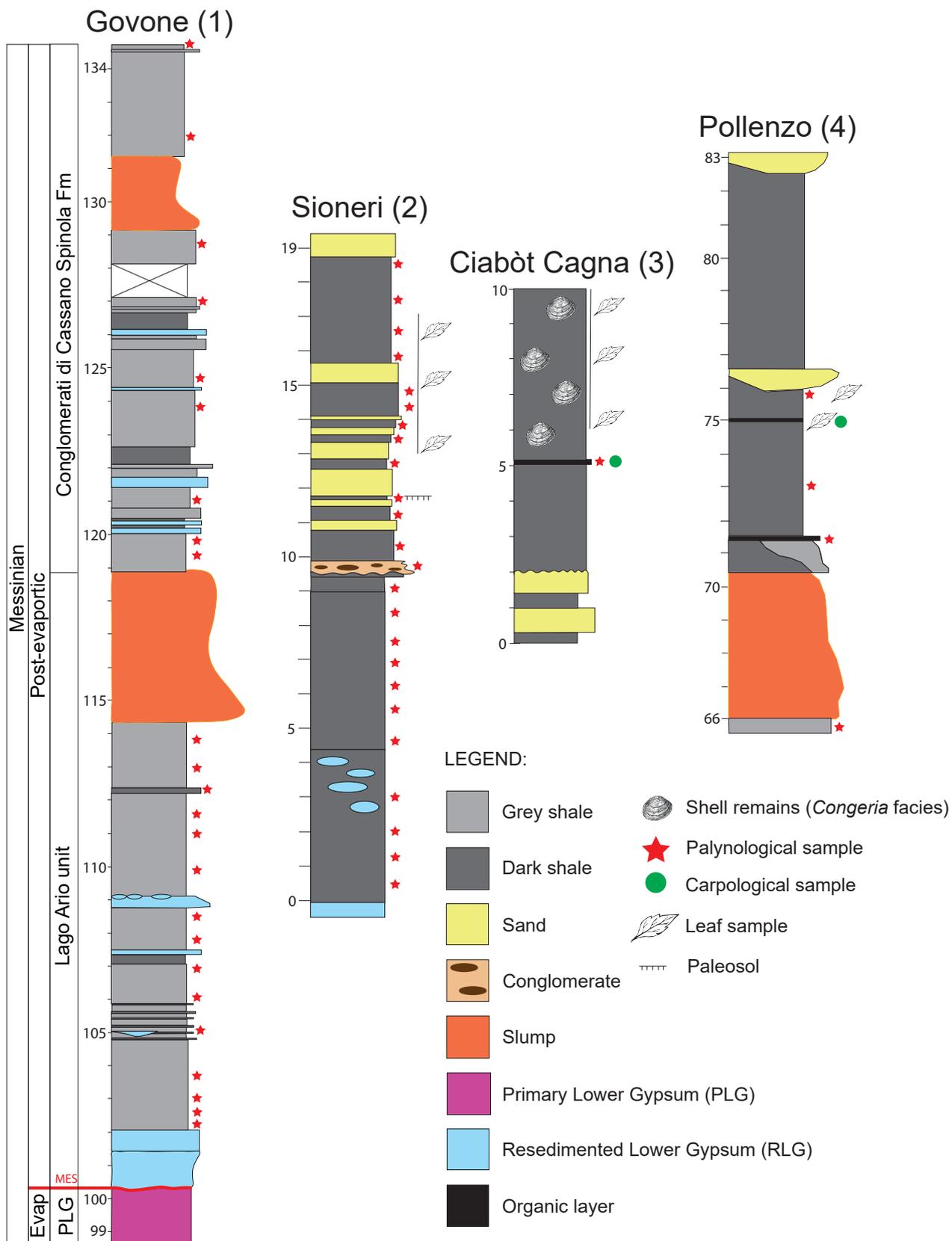
The Sioneri section (Text-fig. 2) has an overall thickness of 20 m. At its base, a bench of resedimented gypsum is followed by 9 meters of clays with reworked gypsum (LAU). It is topped by 1 m of conglomerates, overlaying an erosive contact, followed by a thick alternation of clayey and sandy strata which, towards the top, become massive clays (CCS). A total of 24 palynological samples were collected (11 samples in LAU and 13 samples in CCS). The leaf samples were collected between 13 m and 17 m.

Ciabòt Cagna section

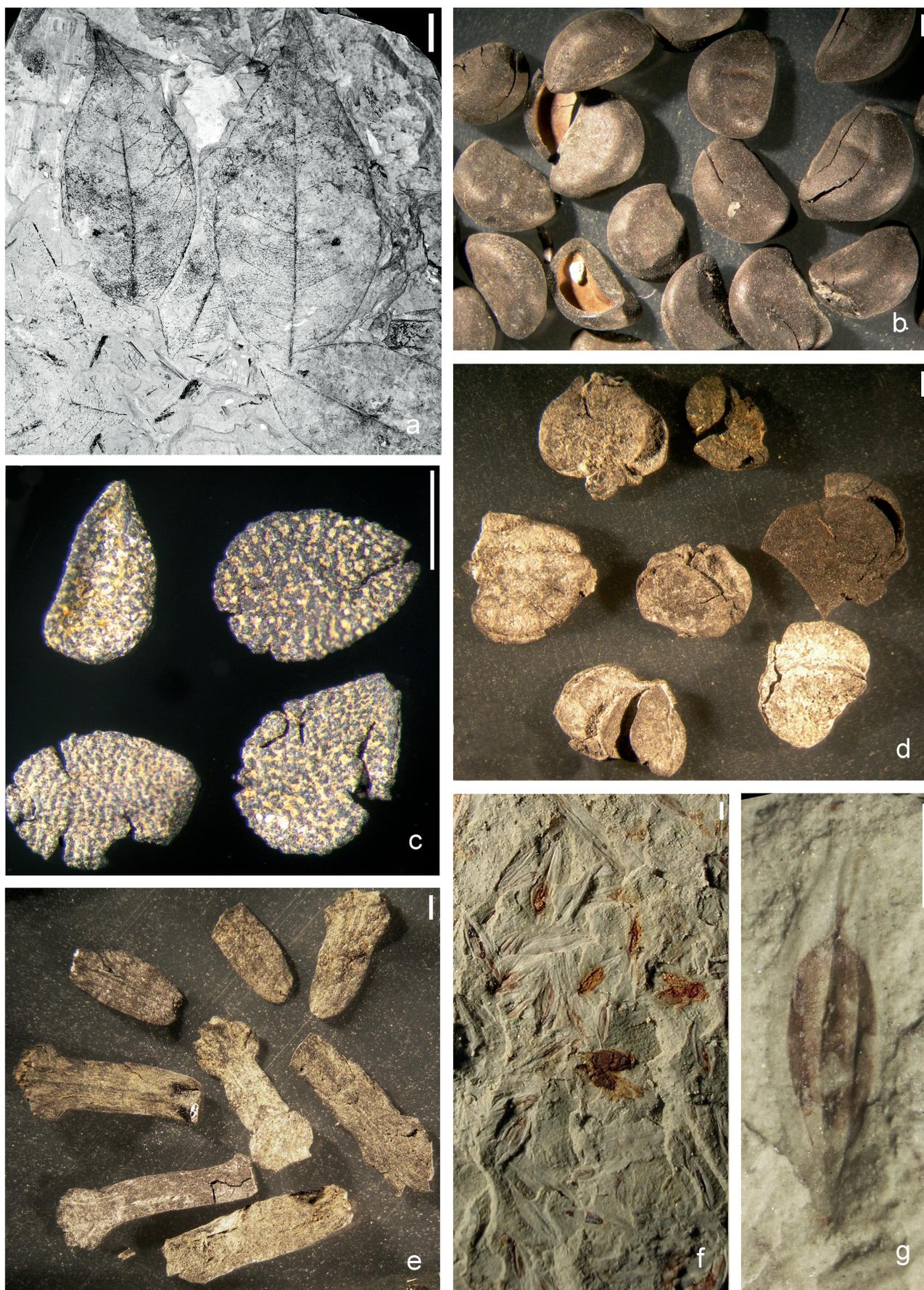
It was an outcrop (about 10 m thick) only during the 1980s and 1990s (Text-fig. 2), just 300 m away from the Sioneri section. At the base, was a 2 m thick interval of sandy and silty-clayey alternations, abruptly interrupted by an erosive surface. Above, three meters of unstratified clays were topped by a brownish organic layer with carpological remains, followed by stratified clays with frequent fossiliferous strata up to the top (Cavallo and Repetto 1988, Cavallo et al. 1993, Angelone 2007, Angelone and Cavallo 2010, Bertini and Martinetto 2011, Colombero et al. 2013). This upper portion, from 6 m to 10 m of the section, was referred to the *Congerina* facies (a subunit of the CCS) by Cavallo and Repetto (1988) and yielded several fossil leaves (Text-fig. 3a). One sample in the organic layer was submitted to both carpological (Kovar-Eder et al. 2006) and palynological analyses.

Pollenzo section

The Pollenzo section includes both Messinian pre-evaporitic and MSC (Text-fig. 2) deposits (total thickness: 83 m) which have been the subject of several stratigraphical studies (Lozar et al. 2008, 2009, 2010, 2015, 2018, Dela Pierre et al. 2011, 2014, 2016, Violanti et al. 2013, Natalicchio et al. 2017, Lozar and Negri 2019). The post-evaporitic deposits are represented by both LAU (4 m thick) and alternating clayey and sandy strata of CCS. A total of 5 palynological samples



Text-fig. 2. Stratigraphic columns of Govone (1), Sioneri (2), Ciabòt Cagna (3) and Pollenzo (4) sections.



Text-fig. 3. Examples of plant macrofossil assemblages from post-evaporitic sections. a: bedding plane from Ciabòt Cagna covered by impressions of plant parts, with dominance of leaves of cf. *Oleinites liguricus* M.SACHSE, MCEA-P05038. b: waterlogged-compressed seeds of *Toddalia latisiliquata* (R.LUDW.) H.-J.GREGOR sieved out of a bulk sediment sample from Pollenzo, MGPT-PU141033. c: millimeter-sized, waterlogged-compressed seeds of *Sambucus pulchella* C.REID et E.REID with abundant cracks, probably formed during both diagenesis and extraction of the fossils (bulk sediment sample from Ciabòt Cagna), MGPT-

Table 1. Number of samples analysed and total amount of pollen counted for each section.

Section	Samples	Total pollen counted
Govone	24	9,147
Pollenzo	4 (1 barren)	1,820
Sioneri	24 (1 barren)	5,747
Ciabòt Cagna	1	2,111

were collected (1 in LAU, 4 in CCS) from a basal, 17 m thick portion of post-evaporitic deposits. The occurrence of leaves was recorded in 2 layers (75 m, 76 m) while a carpological sample was analysed from 75 m.

Methods

The micro- and macropalaeobotanical datasets have been integrated to assess the most accurate floristic list. The last one has been used to infer similarities with the “vegetation types/formations” of Kovar-Eder et al. (2021). The palaeoclimatic conditions have been hypothesised on the basis of the present distribution of the recovered “vegetation types/formations” within the climatic zones of the Köppen-Trewartha classification (Belda et al. 2014).

Pollen analysis

A chemical-physical treatment was applied to separate the organic fraction, including pollen grains, from the embedding sedimentary rock. This procedure involved a series of acid (HCl 20%, HF 40%, HCl 20%) and basic attacks (KOH 10%) as well as other procedures including the use of sodium hexametaphosphate at pH 7, and a separation method based on the density gradient (ZnCl₂ with a density of 2 g/cm³). The final residues were subject to ultrasonic sieving using a 10 µm nylon filter. A *Lycopodium* tablet of known concentration was added to each sample, prior to the chemical treatment to obtain the palynomorphs concentration (gr/g). The samples were mounted in glycerol that allows movement/rotation of pollen grains facilitating their identification. Palynological analyses were carried out using an optical microscope at 400× and 1,000× magnification.

The total pollen counts for each section are listed in Table 1; the floristic list is summarized in Table 2.

Analysis of plant macroremains

The simplest way to obtain plant macrofossil samples from the four selected sections consisted of splitting slabs of sediment parallel to the laminae and thus isolating the fossil plant specimens (mostly leaves). The sampling effort was low in the Pollenzo section, and more intense in the Sioneri and Ciabòt Cagna sections. A second sampling method

was applied to a few poorly consolidated deposits, where resistant and more or less three-dimensionally preserved organic plant fragments had been observed (waterlogged-compressed plant remains). This kind of preservation allowed us to sieve bulk sediment samples and carry out palaeocarpological analyses. However, sediments of this type are not known in the post-evaporitic portion of the Govone section and are absent in the Sioneri section and rare in the Pollenzo section. Their main occurrence was in the short Ciabòt Cagna section, which was sampled by O. Cavallo in the 1980s. Fruits and seeds extracted by this second sampling method (Text-fig. 3b, c) proved to be especially relevant because they revealed the occurrence of several taxa that were not detected by other methods.

Identification of the remains isolated via the methods described above (slabs or bulk samples), was carried out by consulting the extensive literature on similar fossils and by direct comparison with reference fossil material and extant specimens. Fruits and seeds, also those already identified by Kovar-Eder et al. (2006), were analysed anew and compared to fossils stored in the CENOFITA collection (Martinetto and Vassio 2010) and to extant reference material in the Modern Carpological Collection of the Turin University (Martinetto et al. 2014). Additionally, an extant reference seed of *Sideroxylon* L. was selected by Mats Hjertson from the herbarium of Uppsala University and images from USDA Plant Database were also consulted. Digitized herbarium sheets were examined for a clearer understanding of leaf morphology in some extant species of *Vitex* L. (see below).

Palaeoflora

The combination of results from the analyses of pollen, leaves, seeds and fruits resulted in a list of 133 taxa for the post-evaporitic palaeoflora, 95 woody and 38 non-woody. Even when the features of these records were not suitable for convincing whole-plant reconstructions (Kvaček 2008), we deemed it useful to bear in mind a “whole-plant concept”, i.e., to consider the possible combination of different fossil plant parts as components of a single ancient, hypothetical “whole-plant” (Bateman and Rothwell 1990, Sakala 2004, Kvaček 2005, 2008, Martinetto and Macaluso 2018). The studied Italian fossils usually represent non-combined records of different plant parts, often from distinct layers and localities. Therefore, we mostly made a suggestion on the possibility, and not the certainty, that separate fossil remains (leaves, fruits, pollen and seeds) might be the product of a single ancient biological species. Such an approach was selected to facilitate the understanding of palaeobotanical data and to stimulate the search for clearer evidence of the Late Miocene “whole-plant” species of Italy.

PU141034. d: waterlogged-compressed cones of *Tetraclinis salicornioides* (UNGER) KVAČEK extracted from a bulk sediment sample of Ciabòt Cagna, MGPT-PU141035. **e:** *Tetraclinis salicornioides* (UNGER) KVAČEK shoots from the same sample as the previous cones, MGPT-PU141036. **f:** Sioneri, mass occurrence of impressions of *Carex* sp. utricles containing achenes, possibly highlighted by formation of iron minerals (dark), MGPT-PU141037. **g:** same assemblage, detail of an impression of a *Carex* sp. utricle containing a darker achene, MGPT-PU141038. Scale bar 1 mm, apart in Text-fig. 3a (1 cm).

Table 2. Floristic list containing all the taxa recognized in the sections of Govone (1), Pollenzo (2), Sioneri (3) and Ciabot Cagna (4) during the post evaporitic phase (upper Messinian). The palynological (P) and plant macroremains (M) contributions are distinguished for each section.

Floristic list	Sections			
	1	2	3	4
GYMNOSPERMAE Cupressaceae				
Cupressoidae undiff.	P	P	P	P
<i>Tetraclinis salicornioides</i>			M	
<i>Sequoia</i> -type	P	P	P	P
Taxodioidae/Sequoioideae undiff.	P	P	P	P
<i>Taxodium/Glyptostrobus</i> -type	P	P	P	P
Ephedraceae				
<i>Ephedra</i>		P	P	
Pinaceae				
<i>Abies</i>	P	P	P	
<i>Cathaya</i>	P	P	P	
<i>Cedrus</i>	P	P	P	
<i>Picea</i>	P	P	P	
<i>Picea</i> small-type				
Pinaceae undiff.				P
<i>Pinus</i> undiff.				P
<i>Pinus</i> haploxyylon-type		P	P	
<i>Pinus</i> diploxyylon-type	P	P	P	
<i>Tsuga</i> undiff.		P		
<i>Tsuga canadensis</i> -type	P	P	P	
<i>Tsuga diversifolia</i> -type	P	P	P	
<i>Tsuga</i> small-type	P			
Pinaceae "trisaccate" ind.	P		P	
Sciadopityaceae				
<i>Sciadopitys</i>	P	P	P	P
ANGIOSPERMAE				
Alismataceae				
<i>Alisma plantago</i> -type			P	
Altingiaceae				
<i>Liquidambar</i>	P	P	P	P
Amaranthaceae				
Anacardiaceae				
<i>Pistacia</i>	P	P	P	P
Apiaceae				
Aquifoliaceae				
<i>Ilex</i>	P		P	P
Araliaceae				
<i>Hedera</i>	P		P	P
Arecaeae				
Asteraceae				
Asteroidae				
<i>Artemisia</i>	P	P	P	P
Cichorioideae	P	P	P	P
Betulaceae				
<i>Alnus</i>	P	P	P	P
<i>Betula</i>	P	P	P	P
<i>Carpinus orientalis</i> -type	P	P	P	P
<i>Carpinus betulus</i> -type	P	P	P	P
<i>Corylus</i>	P	P	P	P
<i>Ostrya</i>	P	P		
Boraginaceae				
Brassicaceae				
Buxaceae				
<i>Buxus</i>	P	P	P	
Camabaceae				
<i>Celtis</i>	P	P		P-M
Caprifoliaceae				
<i>Lonicera</i>		P		
<i>Sambucus pulchella</i>			M	
<i>Suaeda</i>	P			
Caryophyllaceae				
Clethraceae/Cyrtillaceae				
Cistaceae				
<i>Cistus</i>	P	P	P	P
<i>Helianthemum</i>	P	P		
Convolvulaceae				
Comaceae				
<i>Cornus discimontana</i>			M	
Cucurbitaceae				
Cyperaceae				
<i>Carex</i> sp.	P	M	P	P
Ericaceae				
Euphorbiaceae				
Fabaceae				
<i>Podocarpium podocarpum</i>		M		
Fagaceae				
<i>Castanea</i>	P	P	P	P
<i>Castanopsis</i> -type				
<i>Fagus</i>	P	P	P	P
<i>Quercus</i>	P	P	P	P
<i>Quercus ilex-coccifera</i> -type	P	P	P	P
Geraniaceae				
<i>Geranium</i>	P			

Palynoflora

The relatively rich and diversified pollen flora (Tab. 2) consists of 103 taxa (69 woody and 33 non-woody). Photographs of selected pollen grains are shown in Plates 1, 2. The taxa below are organized as woody and non-woody gymnosperms and angiosperms; families are in alphabetic order, genera and species (when specified) are in parenthesis.

Among gymnosperms, the woody taxa are represented by Cupressaceae (Cupressoideae SWEET undifferentiated: Pl. 1, Figs 2, 3; *Sequoia* ENDL.-type: Pl. 1, Fig. 1; *Taxodium* RICH./*Glyptostrobus* ENDL.-type: Pl. 1, Figs 10, 11; Taxodioideae/Sequoioideae undifferentiated: Pl. 1, Figs 4–9); *Ephedra* L.; Pinaceae (*Abies* MILL.: Pl. 1, Fig. 23; *Cathaya* CHUN et KUANG: Pl. 1, Fig. 16; *Cedrus* TREW: Pl. 1, Fig. 15; *Picea* MILL.: Pl. 1, Figs 20–22; *Picea* small-type; *Pinus* L. haploxylo-type: Pl. 1, Fig. 13; *Pinus* diploxylo-type: Pl. 1, Fig. 17; *Pinus* undifferentiated; Pinaceae undifferentiated; *Tsuga* (ENDL.) CARRIÈRE undifferentiated; *Tsuga* small-type; *Tsuga canadensis* CARRIÈRE-type: Pl. 1, Fig. 19; *Tsuga diversifolia* (MAXIM.) MAST.-type: Pl. 1, Fig. 18) and Sciadopityaceae (*Sciadopitys* SIEBOLD et ZUCC.: Pl. 1, Fig. 12).

Among angiosperms, the woody taxa include Altingiaceae (*Liquidambar* L.); Anacardiaceae (*Pistacia* L.); Aquifoliaceae (*Ilex* L.); Araliaceae (*Hedera* L.); Arecaceae; Betulaceae (*Alnus* MILL.: Pl. 2, Figs 5, 6; *Betula* L.: Pl. 2, Fig. 2; *Carpinus orientalis* MILL.-type: Pl. 2, Fig. 4; *Carpinus betulus* L.-type; *Corylus* L.: Pl. 2, Fig. 3; *Ostrya* SCOP.); Buxaceae (*Buxus* L.); Cannabaceae (*Celtis* L.); Caprifoliaceae (*Lonicera* L.); Clethraceae/Cyrtaceae; Ericaceae (Pl. 2, Fig. 25); Fagaceae (*Castanea* MILL.; *Castanopsis* (D.DON) SPACH-type; *Fagus* L.: Pl. 2, Figs 18, 19; deciduous *Quercus* L.: Pl. 2, Fig. 8; *Quercus ilex* L.-*coccifera* L.-type); Hamamelidaceae (*Distylium* SIEBOLD et ZUCC.; *Hamamelis* L.; *Parrotia* C.A.MEY.); Juglandaceae (*Carya* NUTT.: Pl. 2, Fig. 20; *Engelhardia* LESCH. ex BLUME: Pl. 2, Fig. 7; *Juglans* L.: Pl. 2, Fig. 21; *Pterocarya* KUNTH; *Rhoiptelea* DIELS et HAND.-MAZZ.); Loranthaceae; cf. Magnoliaceae; Malvaceae (cf. *Craigia* W.W.SM. et W.E.EVANS: Pl. 2, Figs 10–12; *Tilia* L.: Pl. 2, Fig. 13); Myricaceae (*Morella* LOUR./*Myrica* L.); Myrtaceae; Nyssaceae (*Nyssa* L.); Oleaceae (Pl. 2, Fig. 1; *Fraxinus* L.; *Olea* L., *Phillyrea* L.); Rosaceae (*Poterium* L.); Salicaceae (*Salix* L.; cf. *Populus* L.); Sapindaceae (*Acer* L.: Pl. 2 Fig. 9); Sapotaceae; Symplocaceae (cf. *Symplocos* JACQ.) and Ulmaceae (*Ulmus* L.: Pl. 2, Figs 16, 17; *Zelkova* SPACH: Pl. 2, Figs 14, 15).

The non-woody taxa of angiosperms include Alismataceae (*Alisma plantago* R.BR.-type); Amaranthaceae (Pl. 2, Figs 22, 23); Apiaceae; Asteraceae, Asteroideae (Pl. 2, Fig. 26; *Artemisia* L.); Asteraceae, Cichorioideae; Brassicaceae; Boraginaceae; Caprifoliaceae (*Succisa* HALLER); Caryophyllaceae; Cistaceae (*Cistus* L.; *Helianthemum* MILL.); Convolvulaceae; Cyperaceae; Euphorbiaceae; Geraniaceae (*Geranium* L.); Iridaceae; Lamiaceae; Liliaceae; Plantaginaceae (*Plantago* L.); Plumbaginaceae (*Limonium* MILL.); Poaceae (Pl. 2, Figs 24, 27; *Lygeum* LOEFL. ex L.); Potamogetonaceae (cf. *Potamogeton* L.); Polygonaceae (*Rumex* L.); Ranunculaceae (*Thalictrum* L.); Rubiaceae (*Galium* L.); Saxifragaceae; Typhaceae (*Sparganium* L.; *Typha latifolia* L.-type) and Vitaceae (*Parthenocissus* PLANCH.). *Tricolporopollenites sibiricum* (LUBOMIROVA)

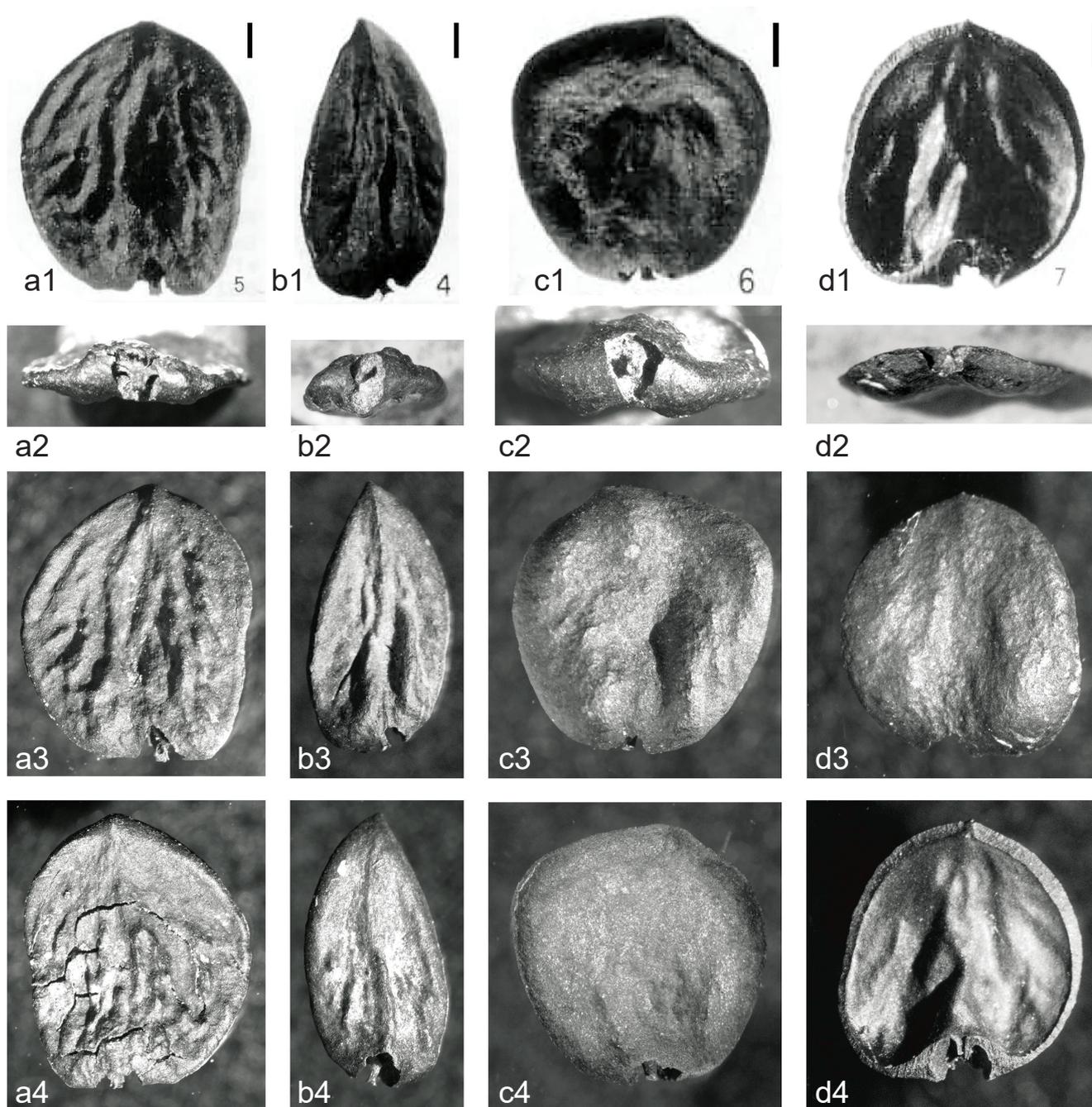
E.NAGY (Pl. 2, Figs 28–31) is also present. Some pollen grains are unidentifiable/undeterminable (e.g., some inaperturates and Pinaceae with three sacci; Pl. 1, Fig. 14).

Plant macrofossil evidence

In the post-evaporitic sediments, plant macrofossils proved to be generally uncommon, even though rich assemblages were preserved in a few layers of each section, mainly in muddy sediments. These layers were prevalently poorly stratified, which hampered the collection of entire leaf fossils. An exception was a layer of mud from the Ciabòt Cagna section, organized in horizontal laminae with good preservation of complete leaf remains (Text-fig. 3a), possibly in part still bearing their organic cuticle (not yet analysed). Two further leaf-bearing layers of rather massive muds occurred in the Pollenzo section, the lower one with poor preservation of the organic matter (Pl. 3, Fig. 2), and the overlaying one with complete, compressed leaf remains (Pl. 3, Fig. 1). A 4 m thick set of leaf-bearing layers also occurred in the Sioneri section, where some bedding planes were covered by many superposed leaf impressions of a few types, mainly referable to *Populus balsamoides* GÖPP. and *Salix* (Pl. 3, Fig. 3). These assemblages possibly represent leaf litter of riparian vegetation composed by a few specialized taxa, buried by occasional flooding (parautochthonous assemblages). In this section, the organic matter is not preserved anywhere, and the morphology of plant remains is recorded only by impressions.

The presently available list of plant macrofossils (Tab. 2) from the three sections studied yielded 37 taxa (28 woody and 9 non-woody). Photos of selected leaf specimens are shown in Plate 3, whereas carpological remains are mostly shown in Plates 4, 5. Elements of the Taxodioideae and Sequoioideae subfamily, as well as Pinaceae and *Sciadopitys* are missing, whereas Cupressoideae are represented by remains of *Tetraclinis salicornioides* (UNGER) KVAČEK, being relatively common only at Ciabòt Cagna (Text-fig. 3d, e, Pl. 5, Figs 1–3).

Anemophilous woody angiosperms are much scarcer than in the pollen record, except for Salicaceae (*Salix*: Pl. 3, Fig. 3; *Populus balsamoides*, whose leaves are abundant at Sioneri). Most of the plant macroremains belong to entomophilous plants, such as *Ampelopsis ludwigii* (A.BRAUN) P.I.DOROF. (Pl. 4, Figs 1–3), *Berchemia multinervis* (A.BRAUN) HEER (Pl. 3, Fig. 7), *Celtis*, *Cornus* L., Cucurbitaceae (Pl. 4, Fig. 4), Fabaceae (*Podocarpium podocarpum* (A.BRAUN) HEREND.); *Ficus potentilloides* MAI, Lauraceae (*Laurophyllum* GÖPP. spp.; *Litsea sonntagii* H.-J. GREGOR: Pl. 4, Figs 5, 6), *Magnolia allasoniae* MARTINETTO sp. nov., validated here (Text-fig. 4), cf. *Myrtus* sp. (Pl. 4, Fig. 7), Menispermaceae (*Cyclea palatinata-bavariae* H.-J.GREGOR: Pl. 4, Fig. 8), ?Oleaceae (cf. *Chionanthus* sp.: Pl. 4, Fig. 9; cf. *Oleinites liguricus* M.SACHSE: Text-fig. 3a, Pl. 3, Figs 8, 9), *Prunus* aff. *laurocerasus* L. (Pl. 5, Fig. 10), Rutaceae (cf. *Fagaropsis*: Pl. 4, Fig. 10; *Toddalia latisiliquata* (R.LUDW.) H.-J.GREGOR: Text-fig. 3b, Pl. 5, Fig. 14; *Toddalia rhenana* H.-J.GREGOR: Pl. 5, Figs 12, 13; *Zanthoxylum* cf. *ailanthiforme* (H.-J.GREGOR) H.-J.GREGOR); *Sambucus pulchella* C.REID et E.REID (Text-fig. 3c); Sapindaceae (*Acer integerrimum* VIV.: Pl. 3, Fig. 1; *Acer* sp.



Text-fig. 4. Type specimens of *Magnolia allasoniae* MARTINETTO sp. nov. from the Pliocene locality Ca' Viettone. a1–a4: Holotype (MGPT-PU141081) in different views, i.e., as originally figured in Martinetto (1995: pl. 1, fig. 5) in a black and white print (a1), in a new digital photograph in basal view (a2), ventral view (a3) and dorsal view (a4); b1–b4: Paratype MGPT-PU141082 in different views, i.e., as originally figured in Martinetto (1995: pl. 1, fig. 4) in a black and white print (b1), in a new digital photograph in basal view (b2), ventral view (b3) and dorsal view (b4); c1–c4: Paratype MGPT-PU141083 in different views, i.e., as originally figured in Martinetto (1995: pl. 1, fig. 6) in a black and white print (c1), in a new digital photograph in basal view (c2), ventral view (c3) and dorsal view (c4); d1–d4: Paratype MGPT-PU141084 in different views, i.e., as originally figured in Martinetto (1995: pl. 1, fig. 7) in a black and white print (d1), in a new digital photograph in basal view (d2), ventral view (d3) and internal view (d4). Scale bars 1 mm.

(sect. *Platanoidea*): Pl. 3, Fig. 2, Pl. 5, Fig. 11); *Sideroxylon* sp. (Pl. 5, Figs 20–25); *Visnea germanica* MENZEL (Pl. 5, Figs 15–18) and *Vitex* (Pl. 3, Fig. 4). Remains of non-woody taxa, such as Amaranthaceae (Pl. 4, Fig. 11), *Arundo* L., Lamiaceae (*Teucrium* sp.), Solanaceae (*Solanum* spp.) are scarce, except for mass occurrences of hardly identifiable monocotyledon leaves and *Carex* L. sp. fruits at Sioneri (Text-fig. 3f, g). At Ciabòt Cagna, seeds of *Najas* cf. *marina*

L. (Pl. 4, Figs 12, 13) and fruits of *Potamogeton* (Pl. 5, Figs 7, 8), together with abundant gyrogonites of Characeae, constitute the record of an aquatic plant community.

Systematic palaeobotany

This section includes a selection of taxa which have been singled out from the floristic list (Tab. 2) in view of

the following needs: i. to indicate possible associations of different plant parts in terms of derivation from a single “whole-plant”; ii. to discuss problematic or uncertain taxonomic assignments; iii. to confirm or modify the nomenclature of selected taxa (see *Magnolia* and *Sideroxylon*). The arrangement of conifer taxa follows Christenhusz et al. (2011), while the angiosperms are arranged according to Angiosperm Phylogeny Group IV (APG IV 2016).

New species is registered in the Plant Fossil Names Registry, which is hosted and operated by the National Museum, Prague for the International Organisation of Palaeobotany and in The International Fossil Plant Names Index (IFPNI), which is operated by National Institute of Carpology, Moscow.

Order Pinales GOROZH., 1895
Family Cupressaceae GRAY, 1822 nom. cons.
Subfamily Cupressoideae SWEET, 1826

Cupressoideae gen. et sp. indet.
Pl. 1, Figs 2, 3

Material. Pollen grains from the Govone, Sioneri and Ciabòt Cagna sections.

Remarks. Under the optical microscope Cupressoideae pollen grains do not show clear morphological features essential for identification at the genus or species level (Van Campo-Duplan 1953, Kurmann 1994). In the pollen record, indistinct Cupressoideae are always present, sometimes at high percentages (Bertini and Martinetto 2008) as recorded here for the Sioneri and Ciabòt Cagna sections.

Genus *Tetraclinis* MAST., 1892

***Tetraclinis salicornioides* (UNGER) KVAČEK, 1989**
hypothetic “whole-plant”
Text-fig. 3d, e, Pl. 5, Figs 1–3

Material. Macrofossils of *Tetraclinis* occurred only at Ciabòt Cagna where its shoot fragments represent some of the most abundant plant remains (Text-fig. 3d). Cones are brittle and heavily deformed (Text-fig. 3e).

Remarks. According to Kvaček (2007) two species, *T. brachyodon* and *T. salicornioides*, were widespread in the Eocene to Pliocene of Europe. The fossils from Ciabòt Cagna can be assigned to *T. salicornioides* based on the following diagnostic characters (Kvaček et al. 2000): leaf fusion complete, bract of the seed cone broader than long, micro typically subcentral to subbasal. Italian macrofloristic records indicate the occurrence of this same species in the pre-evaporitic and evaporitic intervals (fragments of shoots: Martinetto et al. 2000). In the Pliocene, shoots and cones have been recorded abundantly in association, but never in connection (Martinetto 1999, Macaluso et al. 2018). The origin of both shoots and cones from the same “whole-plant” is supported by the respective morphological correspondence to the same parts of fossil specimens described by Kvaček (1989), in which cones are connected to shoots. The stratigraphic distribution of the occurrences suggests that *T. salicornioides* must have persisted in the NW Italian flora throughout the Messinian and Zanclean.

Subfamily Taxodioideae ENDL. ex K.KOCH, 1873
and/or

Subfamily Sequoioideae SAXTON, 1913

Taxodioideae/Sequoioideae gen. et sp. indet.
Pl. 1, Figs 1, 4–11

Material. Pollen grains from the Govone, Pollenzo, Sioneri, Ciabòt Cagna sections. No macroremains were found.

Remarks. Pollen grains generally are well preserved but difficult to recognize at the genus or species level in the absence of SEM analyses (Hernández-Castillo et al. 2005, Sokolova et al. 2017, Bouchal and Denk 2020). In this study, only *Taxodium*/*Glyptostrobus*-type (Pl. 1, Figs 10, 11) and *Sequoia*-type (Pl. 1, Fig. 1) are distinguished based on, e.g., size and shape of papillae. The other pollen grains referable to Taxodioideae and Sequoioideae subfamilies, but with uncertain morphological characteristics, have been grouped in the category Taxodioideae/Sequoioideae undiff. (Pl. 1, Figs 4–9).

Taxodium/*Glyptostrobus*-type and Taxodioideae/Sequoioideae undiff. are present in all four sections, while *Sequoia*-type has been recognized in all sections except in Pollenzo. This latter pollen type is always present in small quantities in Govone and Sioneri, but only a single pollen grain was found in Ciabòt Cagna. *Taxodium*/*Glyptostrobus*-type and Taxodioideae/Sequoioideae undiff. appear more abundant in the sections of Govone and Pollenzo than in those of Sioneri and Ciabòt Cagna.

Taxodioideae/Sequoioideae undiff. could represent a few genera of Taxodioideae (*Taxodium*, *Glyptostrobus*, and *Cryptomeria* D.DON) or *Sequoia*. Since the different genera of Taxodioideae or *Sequoia* do not represent the same ecological niche nowadays, vegetational reconstruction is even more challenging. For example, it includes, e.g., *Taxodium* and *Glyptostrobus*, typical of a swampy environment, and *Sequoia*, which instead nowadays lives on better drained substrates.

Order Magnoliales JUSS. ex BERCHT. et J.PRESL, 1820
Family Magnoliaceae JUSS., 1789 nom. cons.

Genus *Magnolia* L., 1753

***Magnolia allasoniae* MARTINETTO sp. nov.**

validation of the species formerly described by Martinetto (1995: Chronological framing etc., pp. 90–91, in Italian)

Holotype. MGPT-PU141081, figured by Martinetto (1995: pl. 1, fig. 5), black and white photograph (Text-fig. 4a), and newly photographed for this paper (Text-fig. 4a2–a4).

Paratypes. MGPT-PU141082 (Text-fig. 4b1–b4), figured by Martinetto (1995: pl. 1, fig. 4); MGPT-PU141083 (Text-fig. 4c1–c4), figured by Martinetto (1995: pl. 1, fig. 6); MGPT-PU141084 (Text-fig. 4d1–d4), figured by Martinetto (1995: pl. 1, fig. 7).

Plant Fossil Names Registry Number. PFN002957 (for new species).

Registry number. IFPNI (Doweld 2016) registration record for the new species: C615F793-17A4-68DD-56D5-7936C0A204D3.

Repository. Presently, Museo di Geologia e Paleontologia dell'Università di Torino (acronym MGPT; see Pavia et al. 2017), Turin, Italy.

Etymology. In honour of Dr. Barbara Allason, the first person who investigated the fossil (pollen) flora of Ca' Viettone.

Type locality. Ca' Viettone fossil site (45° 19' N, 7° 37' E), i.e., a series of outcrops along the Ca' Viettone brook, close to the village of Levone Cavavese, Piemonte Region, Italy.

Type stratum. Silty clays of section 21 of the Ca' Viettone locality (fig. 3.12 in Martinetto 1995), 15 m above the bed of the brook, on the right bank; named "Villafranchiano lithostratigraphic unit" by Martinetto et al. (2018), Zanclean. This informal name is still in use in the Piemonte region, solely for historical reasons, and designates the nonmarine deposits which conformably overlie the Pliocene marine successions.

Diagnosis. Fossils consisting of the sclerotesta of seeds (Manchester 1994), narrowly to broadly ovate or broadly obovate (heart shaped), mostly asymmetrical, dorsiventrally compressed, narrowly lenticular to narrowly ellipsoidal in cross-section, usually with a median longitudinal trough on the ventral side, mostly obtusely pointed at the micropilar end, rounded or truncated basally, without any bulge at the heteropyle, length 6.0 to 8.7 mm, length to width ratio of seeds 2.7–1.0 : 1, length to thickness ratio 7.0–3.0 : 1, thickness of sclerotesta 0.3–0.5 mm, rugulate surface carrying through the inside of the sclerotesta, heteropyle located centrally, c- or v-shaped in ventral view, stalk oriented almost parallel to the long axis of seed or bent up to 20°.

Description of holotype. Seed with a heart-shaped outline and obtuse apex; size 8.2 × 7.0 mm; length to width ratio of seed 1.2 : 1; external wall of the seed with a few, longitudinal and oblique, differently long round-edged ridges and furrows; chalaza pit 1.4 mm wide, heteropyle located centrally, v-shaped in ventral view, stalk oriented parallel to the long axis of seed.

Remarks to species validation. The work Martinetto (1995) represented the publication by Servizio EDSU (institution for the right of university studies of the Turin University) of 100 printed copies of a doctorate thesis, which were in part distributed to palaeobotanists around the world and in part remained available upon request. This publication can also be requested, since at least 30 years, at the Central National Library of Florence (<https://opac.bncf.firenze.sbn.it/bncf-prod/resource?uri=TSI9700142&v=l&dcnr=7>). Therefore, we suggest that such conditions fulfilled the ICN requirements for effective publication (see Art. 43.2., 43.3; Turland et al. 2018).

Martinetto (1995) introduced the new name *M. allasoniae* but failed to fulfill all the basic requirements of the International Code for Nomenclature (ICN; Turland et al. 2018) for effective publication: the collection hosting the holotype was not indicated (Art. 40.7 of the ICN). The name *M. allasoniae* was also cited in Bertoldi and Martinetto (1995), with an obscure reference to the collection hosting

the holotype, but "a full and direct reference to the place of valid publication, with page or plate reference and date" (Art. 41.5 of the ICN; Turland et al. 2018) was not provided either there or in other publications, which indicates that the name *M. allasoniae* was not yet validly published. In order to validate the species (Martinetto 1995), here we provide the information required by the ICN, including a diagnosis in English and a new description of the holotype (Art. 43.1, required after 1 January 1996), with terminology adapted from Manchester (1994). New photographs of the holotype and paratypes are also provided (Text-fig. 4).

***Magnolia allasoniae* MARTINETTO
hypothetic "whole-plant"**

Pl. 5, Figs 4–6

Material. About 20 seeds, showing the typical morphology of the fossil-species *Magnolia allasoniae* (see above), have been retrieved at Ciabòt Cagna. Rare pollen grains which exhibit some morphological features similar to Magnoliaceae have been found only in the Pollenzo and Ciabòt Cagna sections.

Remarks. The rare pollen grains have clear traits (e.g., size, opening) of Magnoliaceae, however it is not possible to examine the exine in detail, therefore they were defined as cf. Magnoliaceae. The pollen grains of cf. Magnoliaceae were found in the same sample from the Ciabòt Cagna section subjected to carpological analyses in which seeds of *M. allasoniae* were also found. This could support the taxonomic attribution of the pollen to the Magnoliaceae, which was not so clearly proven by morphological characters alone. The seeds of *M. allasoniae* are one of the most common types at Ciabòt Cagna and in the post-evaporitic sediments of the PB these are the only macrofossils of Magnoliaceae. Since the extant seeds of members of this family, including those of *Liriodendron* L., are strongly lignified and resistant to decay, the lack of records of species other than *M. allasoniae* points to the absence or scarcity of magnoliaceous plants in the palaeoenvironment, and not to a taphonomical bias. Therefore, due to the lack of evidence for other species, it is very probable that the above-cited pollen of cf. Magnoliaceae gen. et sp. indet. could be a production of the conceptual *Magnolia allasoniae* "whole-plant". Concerning the leaves, none of the remains at Ciabòt Cagna, associated with the seeds, can be consistently referred to *Magnolia*. An affinity to extant leaves of this genus could be recognized in the leaf morphotype here treated as cf. *Oleinites liguricus* (see below).

**Order Alismatales R.BR. ex BERCHT. et J.PRESL, 1820
Family Potamogetonaceae BERCHT. et J.PRESL, 1823**

Genus *Potamogeton* L., 1753

***Potamogeton* sp.**

hypothetic "whole-plant"

Pl. 5, Figs 7, 8

Material. A few fruits occurred at Ciabòt Cagna. Pollen grains of cf. *Potamogeton* were found in Sioneri and Ciabòt Cagna sections.

Remarks. The pollen grains have clear traits (e.g., size, opening) of *Potamogeton*, however, it is not possible to correctly examine the exine, therefore they were defined as cf. *Potamogeton*. The pollen grains of cf. *Potamogeton* were found in the same sample from the Ciabòt Cagna section subjected to carpological analyses in which some fruits of *Potamogeton* were found. This could support the possible production of both parts by the same, hypothetical “whole-plant”.

The fossil fruits from Ciabòt Cagna are consistently deformed, but still show several diagnostic characters which could enable a detailed comparative analysis (not carried out here) and permit assignment to a definite species. In fact, the morphology of *Potamogeton* fruits is known to have a relevant taxonomic value (Aalto 1970) and several fossil-species have been described from the European Neogene (e.g., Dorofeev 1986).

Genus *Prunus* L., 1753

***Prunus* aff. *laurocerasus* L., 1753**

Pl. 5, Fig. 10

Material. An incomplete, strongly compressed endocarp from Ciabòt Cagna.

Remarks. The fossil endocarp bears a narrow ventral keel, an acute apex and a round base, with a ventral vascular bundle extended from the apex to the basal attachment scar. The finely mottled surface, the lanceolate outline and the dimensions seemed at first glance similar to those of endocarps of *Prunus laurocerasus* shown in the USDA Plant Database (Pl. 5, Fig. 9). An overview of material of the Modern Carpological Collection of the Turin University confirmed that the fossil endocarp was similar in all visible details to the extant ones of *P. laurocerasus* (from the Palmengarten of Frankfurt am Main). Most of the other *Prunus* species showed clearly different endocarps (e.g., larger dimensions, different shape, thicker wall or strongly ornamented surface), apart from *P. lusitanica* L. (again from the Palmengarten of Frankfurt am Main). It could be suggested that the fossil may be more similar to *P. laurocerasus* (length range 8–10 mm), as its length (9 mm) exceeds the length range of *P. lusitanica* L. (6–8 mm). The latter species was indicated as occurring in Italy during the Chibanian in Pianico (Martinetto 2009).

In consideration of the still poorly understood phylogeny of *Prunus* (Hodel et al. 2021) and of the well-assessed dating of the Ciabòt Cagna deposit (5.5–5.3 Ma), the single fossil endocarp described above could be relevant for future investigations on the time of the first appearance of phylogenetically diagnostic characters.

Family Rhamnaceae Juss., 1789 nom. cons.

Genus *Berchemia* Neck. ex DC., 1825 nom. cons.

***Berchemia multinervis* (A. Braun) Heer, 1857**

Pl. 3, Fig. 7

Material. Remains of an elliptic leaf, divided into two parts before burial, with delicate and dense tertiary venation (rhamnoid) almost perpendicular to the primary vein.

Remarks. This leaf type is rare in the Neogene of Italy and was only reported in recent times from the Zanclean flora of Fossano (Macaluso et al. 2018). The assignment of the leaves to the genus *Berchemia* is not supported by strong features, however fruit remains morphologically similar to the extant *Berchemia* fruit occurred at the Fossano locality (Martinetto, pers. observation), but have not been studied in detail yet.

Order Fagales ENGL., 1892

Family Betulaceae Gray, 1822 nom. cons.

Genus *Carpinus* L., 1753

***Carpinus* spp.**

Pl. 2, Fig. 4

Material. Two pollen types have been recognized: *Carpinus orientalis*-type and *Carpinus betulus*-type.

Remarks. *Carpinus orientalis*-type appears to be present in all four sections while *Carpinus betulus*-type has been found in small quantities only in the Pollenzo and Ciabòt Cagna sections. A previously reported fruit remain is here revised as an unidentified plant remain (see below). Although Kovar-Eder et al. (2006) reported a fruit of *Carpinus* cf. *miocenica* TANAI from Ciabòt Cagna, a new analysis of the single fossil remain (never previously figured, see Pl. 4, Fig. 14) led us to detect only a superficial morphological resemblance to *Carpinus miocenica*. Furthermore, the peripheral thickening surrounding the outline of the fossil has not been observed in any extant or fossil fruit of *Carpinus*, nor in any other fruit known to us, thus indicating that this remain represents an unidentified plant part.

Order Sapindales Juss. ex Bercht. et J. Presl, 1820

Family Sapindaceae Juss., 1789 nom. cons.

(including Xanthoceraceae Buerki, Callm. et Lowry, 2010)

Genus *Acer* L., 1753

***Acer* sp.**

Pl. 2, Fig. 9

Material. A few pollen grains of *Acer* sp. indet. were observed in the Govone and Sioneri sections.

Remarks. Pollen grains are quite well preserved; however, it is not possible to identify the species they belong to.

***Acer integerrimum* Viv. in Keferstein 1834 and *Acer* sp.**

hypothetic “whole-plant”

Pl. 3, Fig. 1 (*A. integerrimum*), Pl. 3, Fig. 2,
Pl. 5, Fig. 11 (*Acer* sp.)

Material. A leaf photographed in the field. In addition, four *Acer* endocarps and a complete winged fruit (see below for taxonomy), which were found in a layer just below the leaf-bearing one, fulfil one of the lines of evidence cited by Kvaček (2008): “identical or similar systematic affinities” to infer connection to the foregoing leaf in a hypothetical “whole-plant” reconstruction (Martinetto and Macaluso 2018).

Remarks. The fossil-species “*Acerites integerrima*” was first described from the gypsum-bearing (Messinian) successions of Italy (Viviani 1833), but the original diagnosis was not detailed, and the drawing of the single cited specimen (possibly lost) was rather poor. However, Viviani (1833: 131) gave no diagnosis for the new genus *Acerites* and, because he included two new species in this genus – *Acerites ficifolia* and *Acerites integerrima* (although with diagnosis) –, both these names could be considered as invalid, being combined with an invalidly published genus. Keferstein (1834: 817) included the species “*integerrima*” in a list of fossils of the genus *Acer* and gave (indirect) reference to Viviani’s diagnosis. So, the name *Acer integerrimum* may be considered validated in this way.

A specimen from another Messinian site of Italy (as *Acer integerrimum*) was later described by Massalongo and Scarabelli (1859). In the late 20th century this fossil-species was considered to occur in other parts of Europe (e.g., Mai and Walther 1988: 172) with specimens which were suitable for a better description of the diagnostic characters, recently summarized by Kvaček et al. (2020). Further leaf specimens of *Acer integerrimum* (e.g., Martinetto 2003, Teodoridis et al. 2015), showed more consistently the characters of the leaves attributed to this fossil-species and their variation in the Neogene of Italy. The recovered image of a leaf with entire-margined lobes from the Pollenzo section shows all the characters of this fossil-species, and in particular is very similar to a reference specimen (Massalongo and Scarabelli 1859: pl. 18, fig. 3) cited by Mai and Walther (1988). The morphology of the leaves of this fossil-species, also studied in other European localities, permits its assignment to sect. *Platanoidea* (Kvaček et al. 2020). Additionally, sect. *Platanoidea* is also indicated by the morphology of the flat, almost smooth (with only faint ribs) and poorly lignified body of a winged fruit from Pollenzo (Pl. 3, Fig. 2). Four associated endocarps show a fingerprint-like ornamentation (Pl. 5, Fig. 11) corresponding to that observed in extant analogs of sect. *Platanoidea*.

Our joint treatment of the various remains cited above indeed points to considering a hypothetical “whole-plant” concept (Martinetto and Macaluso 2018). However, in order to assess if both leaf and fruits originate from the same “whole-plant” an exceptional fossil bearing both parts (presently unknown) would be needed, as illustrated by Kvaček and Sakala (1999) for *Decodon gibbosum*. Therefore, at the present state of the art, the fruits have to be treated as *Acer* sp.

Family Rutaceae Juss., 1789 nom. cons.

Genus *Toddalia* Juss., 1789 nom. cons.

***Toddalia latisiliquata* (R.LUDW.) H.-J.GREGOR, 1979**

Pl. 5, Fig. 14

Material. 21 seeds from Pollenzo and 6 seeds from Ciabòt Cagna.

Remarks. Seeds occur in all sites and sometimes are more common than other taxa, possibly due to their very strongly lignified tegument (testa), which is more resistant to decay and compression than that of other taxa.

***Toddalia rhenana* H.-J.GREGOR, 1979**

Pl. 5, Figs 12, 13

Material. 3 seeds from Ciabòt Cagna.

Remarks. The seeds of this species are smaller than those of *T. latisiliquata* and have a thinner seed coat.

Order Malvales Juss. ex BERTH. et J.PRESL, 1820

Family Malvaceae Juss., 1789 nom. cons. (sensu lato)

Subfamily Tilioideae Arn., 1832

cf. *Craigia* W.W.SMITH et W.E.EVANS, 1921

Pl. 2, Figs 10–12

Material. Rare pollen grains have been found in Govone and Ciabòt Cagna sections. No plant macroremains have been reported from the post-evaporitic sediments of the PB.

Remarks. The palynological record of *Craigia* turns out to be problematic as the pollen grains are difficult to identify, due to a consistent similarity to *Tilia* as evidenced by the morphological description of *Craigia* pollen by Kvaček et al. (2002) and Zetter et al. (2002).

Under the optical microscope, the pollen is a monad, oblate, brevicolporate, the exine is reticulate with apertures characterised by a thickening of the circular horseshoe-shaped nexin (Kvaček et al. 2002).

In contrast, *Tilia* is thicker and much wider and less convex (Perveen et al. 2004). Furthermore, *Tilia* pollen is larger and with more prominent sculpture (Grimsson et al. 2020). Despite the difficulty to recognize *Craigia* pollen under the optical microscope, rare pollen grains associated to this genus (cf. *Craigia*) are reported here for the first time in the post-evaporitic phase of the PB.

Fruits of *Craigia* are known from the evaporitic interval (Martinetto et al. 2000, Bertini and Martinetto 2008) and leaves usually associated with this same fruit type (“*Dombeyopsis lobata* UNGER”; Kvaček et al. 2005) have been reported from the Pliocene of the PB (Martinetto 2003).

Order Ericales BERTH. et J.PRESL, 1820

Family Pentaphylacaceae ENGL., 1897 nom. cons.

Genus *Visnea* L., 1782

***Visnea germanica* MENZEL, 1913**

Pl. 5, Figs 15–18

Material. 18 fruits from Ciabòt Cagna.

Remarks. The fossil fruits of Ciabòt Cagna have a very variable aspect due to different states of preservation: some fruits are completely covered by calyx lobes (Pl. 5, Fig. 16), others have only the receptacle preserved, and other fruits seem to be more altered and are covered by a multitude of filaments and may show some remains of the style (Pl. 5, Fig. 17). The same situation was observed in the few European Neogene localities that provided abundant material of this type. Probably, only the observation of some well-preserved specimens allowed Mai (1971) to confirm the assignment of such fossil material to the extant genus *Visnea*. For strongly compressed specimens, such as those from Ciabòt Cagna, assignment to *Visnea* can be demonstrated by means of anatomical observations, as shown by Schübler (2020).

Family Sapotaceae JUSS., 1789 nom. cons.

Genus *Sideroxylon* L., 1753

***Sideroxylon* sp.**

hypothetic “whole-plant”

Pl. 5, Fig. 20 (Ca' Viettone, Pliocene), Figs 21–25
(Ciabòt Cagna, latest Miocene)

Material. Concerning the sites studied in the present paper, several seeds were found at Ciabòt Cagna. Similar fossils from other Italian sites are cited below.

Remarks. The flattened and strongly lignified circular objects occurring at Ciabòt Cagna have smooth external ornamentation, but the internal structure (Pl. 5, Figs 24, 25b), is clearly diagnostic of the external tegument of an originally spherical ruminant seed. The reconstruction of the original shape was facilitated by comparative analyses with almost undeformed specimens from the Ca' Viettone Pliocene locality (Martinetto 1995, Bertoldi and Martinetto 1995, Martinetto et al. 2018). Since a ruminant structure in extant globose seeds was cited for *Sideroxylon* (Swenson and Anderberg 2005), the fossils were compared to seed samples of five extant species of this genus located by Rubén Barone (and now incorporated in the Modern Carpological Collection of the Turin University; Martinetto et al. 2014). The most diagnostic characters of the fossils, i.e., spherical shape with smooth surface and apparent internal ridges, were found to be shared (Pl. 5, Fig. 20) with the extant *Sideroxylon mascatense* (A.DC.) T.D.PENN. from western Asia (Pl. 5, Fig. 19), whereas the seeds of other extant species differed in the ribbed external surface (*S. canariense* LEYENS, LOBIN et A.SANTOS, *S. marginatum* COUT., *S. mirmulans* R.BR.) or the elongated shape (*S. spinosum* L.). The morphology of seeds of *S. mascatense* was verified and photographed in an herbarium specimen (V-067541) which was made available by the Museum of Evolution of the Uppsala University (UPS) and checked by an expert in the taxonomy of Sapotaceae (U. Swenson).

We concluded that the shared characters are significant for the assignment of the fossils from Ca' Viettone and Ciabòt Cagna to *Sideroxylon*. Fossils of the same type had been formerly reported from several Italian sites, but they were identified as *Sapindoidea margaritifera* (R.LUDW.) KIRCHH. (Bertoldi and Martinetto 1995, Cavallo and Martinetto 1996, Basili et al. 1997, Ravazzi and Martinetto 1997, Martinetto 1999, 2001, Martinetto et al. 2018). The detection of this member of the Sapotaceae at the Ciabòt Cagna Messinian site and at several Italian Pliocene sites suggests that the seed-bearing plant may have produced, at least in part, the Sapotaceae pollen grains that were reported in Italian Neogene palynofloras since several years (Bertoldi et al. 1994, Bertini 2001, Bertini and Martinetto 2011).

Order Lamiales BROMHEAD, 1838

Family Oleaceae HOFFMANNS. et LINK, 1809 nom. cons.

Oleaceae div. taxa

Pl. 2, Fig. 1

Material. Pollen grains of Oleaceae were found in all four sections. *Fraxinus* was reported in Govone, Pollenzo and Sioneri sections; *Olea* in Sioneri and Ciabòt Cagna

sections and *Phillyrea* in the Sioneri section. Oleaceae undifferentiated occurred in the Ciabòt Cagna section.

Remarks. Pollen grains are usually well preserved. However, the strong corrosion of the exine in the Oleaceae pollen grains from Ciabòt Cagna prevents their attribution at genus level.

?Genus *Chionanthus* D.ROYEN, 1753

cf. *Chionanthus*

Pl. 4, Fig. 9

Material. A fossil fruit remain, although heavily compressed, could possibly belong to Oleaceae (Kovar-Eder et al. 2006).

Remarks. The single fruit remain has a few characters, but due to the thick coat, straight seed chamber and basal attachment it seems to be compatible with a “pyrenarium of *Olea* type” from the family Oleaceae (Bobrov and Romanov 2019). However, the smooth external surface represents a contrasting feature not observed in extant Oleaceae (*Chionanthus*-included – ribbed pyrenarium) but allowed in two fossil-species from the European Miocene that were assigned to *Chionanthus* (Gregor 1978). In our opinion all these fossils (Ciabòt Cagna included) would be better compared with the extant Oleaceae to confirm assignment to this family.

cf. *Oleinites liguricus* M.SACHSE, 2001

Text-fig. 3a, Pl. 3, Figs 8, 9

Material. The macrofossil material potentially belonging to Oleaceae is represented by about twenty leaves from the Ciabòt Cagna locality, stored at the MCEA.

Remarks. The leaves occurring at Ciabòt Cagna (the commonest type at this site) are entire-margined and leathery, with brochidodromous venation. In general, even if we could not study the cuticle (and this is the main reason for using open nomenclature), their venation pattern agrees with that in *Oleinites liguricus* described by Sachse (2001) based on more fragmentary specimens, also from post-evaporitic sediments of the PB. The long, unwrinkled petiole preserved in two specimens from Ciabòt Cagna is important as a character indicating Oleaceae rather than the very similar Fabaceae; furthermore, there is no evidence that any of these common laminae may represent a leaflet (leaflet petiolules with prominent striations may indicate Fabaceae or Connaraceae; Dilcher and Lott 2005). Comparable leaves are produced by the extant plants *Chionanthus* and *Picconia* (AITON) DC., whereas affinity to *Fraxinus*, *Osmanthus* LOUR. and *Phillyrea* can be excluded due to their toothed leaf margin.

Family Labiatae JUSS., 1789 nom. cons.

Genus *Vitex* L., 1753

***Vitex* sp.**

Pl. 3, Fig. 4

Material. A leaf from the Sioneri locality, MCEA-P05042.

Remarks. The fossil leaf is chartaceous, palmately compound with 5 leaflets of different dimensions (Pl. 3, Fig. 4a). The leaflets are broadly lanceolate, with entire margins, attenuate apex and either very short or missing petiolules (leaflets sessile). Secondary veins relatively densely spaced and gradually becoming thinner towards the margin, thus hampering perception of a brochidodromous pattern. Tertiary veins densely spaced, slightly oblique and sometimes percurrent (Pl. 3, Fig. 4b).

A morphology very similar to that shown by the Sioneri leaf was first noticed in extant shrubs of *V. agnus-castus* L. cultivated in the public gardens in the town of Turin. Later, hundreds of images of this and other extant species of *Vitex* were examined in digitized herbarium sheets available through the following portals: JStor Global Plants (<https://plants.jstor.org>), iDigBio (<https://www.idigbio.org>), Plants of the World Online (<https://powo.science.kew.org>), ReColNat (<https://www.recolnat.org>). Several reliably identified specimens confirm that the combination of characters found in the fossil leaf occurs in extant leaves of *V. agnus-castus*, even though the leaflets of this species usually bear distinct petiolules and tend to be narrowly lanceolate. Only the image of a plant cultivated in Denmark (Botanisk Have Aarhus, photo Egon Krogsgaard, 18 October 2020: <https://powo.science.kew.org>), labeled as *V. agnus-castus*, corresponds 100% with the Sioneri leaf due to the sessile and broadly lanceolate leaflets. However, other species of *Vitex* bear more regularly leaves with these characters, such as *V. rehmannii* GÜRKE of South Africa (Pl. 3, Fig. 5). The pattern of tertiary veins of this last species corresponds well with both the fossil (Pl. 3, Fig. 4b) and *V. agnus-castus* (Pl. 3, Fig. 6).

The characters shared by the fossil leaf and the leaves of the two above-mentioned extant species seem to be sufficient to suggest assignment of the fossil leaf to the genus *Vitex*, but a possible determination at species level would require further research.

Family Adoxaceae E.MEV., 1839 nom. cons.

Genus *Sambucus* L., 1753

***Sambucus pulchella* C.REID et E.REID, 1915**

Text-fig. 3c

Material. Four seeds were retrieved from Ciabòt Cagna.

Remarks. The sculpture of the seeds is typical of the fossil-species *Sambucus pulchella* (Reid and Reid 1915).

Discussion

The present micro- and macrofloristic datasets of the Messinian post-evaporitic deposits contribute to the reconstruction of the palaeoflora and palaeoenvironment in the PB (e.g., Bertini and Martinetto 2011), an area surrounded by Alpine reliefs both to the West and to the North. The palaeoflora is well-diversified and characterised by the dominance of woody rather than non-woody taxa (Tab. 2). The occurrence in the PB of fossil remains of plants now growing in different areas (North America: *Sequoia*, *Taxodium*; North Africa to West Asia: *Tetraclinis*, *Visnea*; South-Southeast

Asia: *Cyclea*, *Craigia*, *Distylium*, *Engelhardia*, etc.) points to no-analog types of palaeovegetation (Williams and Jackson 2007). Nevertheless, the indication of those existing types of vegetation which share several taxa with the fossil assemblages can be useful for interpretation of the palaeovegetation and palaeoclimate, as shown by Kovar-Eder et al. (2021). Most of the taxa detected in the sections sampled by us (Tab. 2) co-occur today in that part of South-Southeast Asia (Kovar-Eder et al. 2021) which is comprised of the subtropical and temperate climatic zones according to the Köppen-Trewartha classification (Belda et al. 2014). Such zones host different zonal vegetation belts, i.e., zonal temperate to warm-temperate broad-leaved deciduous forests “BLDF”, zonal warm-temperate to subtropical mixed mesophytic forests “MMF” and zonal subtropical broad-leaved evergreen forests “BLEF” (Kovar-Eder et al. 2021, Teodoridis et al. 2021). The occurrence of macrofossils of *Cyclea*, *Ficus* and *Toddalia* at Ciabòt Cagna excludes the affinity of the zonal palaeovegetation of this site with the BLDF, and rather suggests an affinity with either BLEF or MMF. The most diagnostic occurrences in the other three sites are pollen grains of *Engelhardia*, *Distylium* and *Nyssa*, sometimes associated with pollen of cf. *Craigia* (Govone) and seeds of *Toddalia* (Pollenzo). These genera do not occur in the BLDF, therefore the palaeovegetation of these sites can be indicated as most similar to either BLEF or MMF, or their ecotone. These communities require a subtropical climate (Baker et al. 2010, integrated with data from Kovar-Eder et al. 2021), which is also required today in North America by *Taxodium* (the *Taxodium/Glyptostrobus*-type is frequent in the studied sections). Other thermophilous taxa (*Olea*, *Phillyrea*, *Sideroxylon*, *Tetraclinis*, *Visnea*), possibly associated with the above-cited ones in no-analog plant communities, may provide further support in favor of a generalized Köppen-Trewartha subtropical type of palaeoclimate. However, we must point out that pollen of taxa currently characterising Mediterranean vegetation (e.g., *Olea* and *Quercus ilex-coccifera*-type) has been detected in small quantities and does not provide any clue to the existence of separated Mediterranean-type communities requiring a subhumid subtropical climate.

The composite analysis of the micro- and macro-palaeobotanical records can lead to a reduction in some of the more frequent taphonomic biases occurring when they are analysed separately. The resolution of more accurate taxonomy is more frequent for plant macroremains than for pollen grains in some taxa (e.g., the occurrence of some species such as *Acer integerrimum* and *Magnolia allasoniae*) and macrofossils indicate the presence of some taxa absent in the pollen record due to the very limited preservation of their pollen grains (e.g., Lauraceae) or low pollen production by the mother-plants (e.g., Rutaceae). On the other hand, palynology allows the identification of many taxa absent in the macrofossil record, possibly due to the poor production/transportability of fruits and seeds (e.g., *Carya*, *Quercus*, Hamamelidaceae) and/or preservation of leaves (e.g., *Alisma plantago*-type and other herbs). It also provides a more continuous and longer stratigraphic record and a broader view of the extralocal (extrazonal) components of the vegetation. This is the case for *Sciadopitys*, *Picea*, *Abies* and *Tsuga*, which may be indicated as growing in distal areas.

When we consider the components of the local vegetation, it is quite amazing to observe an apparent inconsistency among the micro- and macropalaeobotanical records. *Taxodium* or/and *Glyptostrobus* are absent from the macrofloristic record whereas pollen data support the persistence of freshwater swamps, yet to a reduced extent when compared to the previous times (Bertini and Martinetto 2011, Martinetto et al. 2022). Possibly, a significant shrinkage of swamps caused the removal of *Taxodium* or/and *Glyptostrobus* to areas far from the sedimentation basin, thus reducing the possibility of their macroscopic remains being fossilized. Such a change in distribution is worthy of note because it supports the occurrence of less humid conditions during the Messinian post-evaporitic period in comparison to the evaporitic and Zanclean (Bertini and Martinetto 2011). We recall here the hypothesis (Kovar-Eder et al. 2006) that, in the post-evaporitic Messinian palaeoenvironments, the highest humidity-requiring woody taxa could have found a suitable ecological niche in some form of gallery forests situated along rivers. This means that our view of the zonal vegetation could be biased towards humidity, in particular by pollen contributed by the hypothetical gallery forests.

Conclusions

Micro- and macrofloristic records for the post-evaporitic deposits of the PB enabled the detection of a high number of taxa, thus confirming the importance of an integrated approach for comprehensive palaeofloristic and palaeovegetational reconstructions. Moreover, when the pollen record of a hypothetic “whole-plant” was available and the taphonomic factors were carefully considered, the presence of macroremains in at least one of the studied sections provided a robust clue as to the proximal position of the original growth place of the mother plant. Conversely, the presence of pollen and absence of related macrofossils from all the studied sections suggested that the hypothetic “whole-plant” grew far away from the depositional basin. Therefore, the integrated approach allowed us to reconstruct different altitudinal belts of vegetation which were relevant for the definition not only of the environmental scenarios, but also of the climatic context. The generalized type of zonal palaeovegetation in the post-evaporitic Messinian of the PB can be indicated as most similar to either BLEF or MMF, or their ecotone. The single type of palaeoclimate that may be reliably documented is the Köppen-Trewartha subtropical.

This contribution documents the response of flora and vegetation to the latest phase of the Messinian Salinity Crisis, just before the re-establishment of the Atlantic-Mediterranean connection.

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Explanations of the plates

For all Plates: CC – Ciabòt Cagna, G – Govone,
P – Pollenzo, S – Sioneri.

PLATE 1

Pollen grains from Messinian post-evaporitic phase in Piedmont Basin (Italy)

1. *Sequoia*-type, pollen grain from CC.
- 2., 3. Cupressoideae undiff., pollen grains from CC (2) and G (3).
- 4.–9. Taxodioideae/Sequoioideae undiff., pollen grains from G.
- 10., 11. *Taxodium/Glyptostrobus*-type, pollen grains from G (10) and CC (11).
12. *Sciadopitys*, pollen grain from G.
13. *Pinus haploxylon*-type, pollen grain from G.
14. Pinaceae trisaccatae, pollen grain from G.
15. *Cedrus*, pollen grain from G.
16. *Cathaya*, pollen grain from G.
17. *Pinus diploxylon*-type, pollen grain from G.
18. *Tsuga diversifolia*-type, pollen grain from G.
19. *Tsuga canadensis*-type, pollen grain from G.
- 20.–22. *Picea*, pollen grains from G.
23. *Abies*, pollen grain from G.

PLATE 2

Pollen grains from the Messinian post-evaporitic phase in the Piedmont Basin (Italy)

1. Oleaceae, pollen grain from CC.
2. *Betula*, pollen grain from CC.
3. *Corylus*, pollen grain from CC.
4. *Carpinus orientalis*-type, pollen grain from CC.
- 5., 6. *Alnus*, pollen grains from G (5) and S (6).
7. *Engelhardia*, pollen grain from G.
8. *Quercus*, pollen grain from CC.
9. *Acer*, pollen grains from S.
- 10.–12. cf. *Craigia*, pollen grain from CC.
13. *Tilia*, pollen grain from G.
- 14., 15. *Zelkova*, pollen grains from CC (14) and G (15).
- 16., 17. *Ulmus*, pollen grains from CC (16) and G (17).
- 18., 19. *Fagus*, pollen grain from G (18) and CC (19).
20. *Carya*, pollen grain from G.
21. *Juglans*, pollen grain from G.
- 22., 23. Amaranthaceae, pollen grain from G (22) and CC (23).
24. Poaceae, pollen grain from G.
25. Ericaceae, pollen grain from G.
26. Asteraceae-Asteroideae, pollen grain from G.
27. Poaceae, pollen grain from G.
- 28.–31. *Tricolporopollenites sibiricum*, pollen grain from CC.

PLATE 3

Plant macrofossils from the Messinian post-evaporitic phase in the Piedmont Basin (Italy)

1. *Acer integerrimum* VIV. (P), compressed leaf, specimen photographed in the field.
2. *Acer* sp. (sect. *Platanoidea*) (P), fruit impression with a complete wing, MGPT-PU141039.
3. *Salix* cf. *varians* GÖPP. (S); a: detail of a leaf with small salicoid teeth, b: leaf impressions from an almost monotypic assemblage, MCEA-P05041.
4. *Vitex* sp. (S); a: view of the entire, palmate leaf impression with contrast enhanced by iron minerals, MCEA-P05042, b: detail of the leaflet to the right, showing venation pattern and entire margin.
5. *Vitex rehmannii* GÜRKE, photograph of an extant leaf reproduced from a reliable website (<https://treesa.org>), photo David Becking.
6. *Vitex agnus-castus* L., detail of a leaflet of the extant *V. agnus-castus* from the Botanical Garden of Palermo, showing venation pattern and entire margin (<http://dryades.units.it/>), photo Andrea Moro.
7. *Berchemia multinervis* (A.BRAUN) HEER (P); a: leaf impression with scanty organic remains of veins, possibly damaged by bioturbation, MGPT-PU141040, b: reconstruction of the possible original leaf shape of the fossil shown in (a).
8. cf. *Oleinites liguricus* M.SACHSE (CC), leaf impression with scanty organic remains of veins and, possibly, patches of cuticle, MGPT-PU141041 (counterpart = MCEA-P05039).
9. cf. *Oleinites liguricus* M.SACHSE (CC), leaf impression with complete, long and slender petiole, MGPT-PU141042.

Scale bar 1 cm, apart in 2 and 4b (1 mm).

PLATE 4

Carpological remains from Messinian post-evaporitic phase in the Piedmont Basin (Italy), not treated in the systematic section and partly uncertain or enigmatic (all specimens from Ciabòt Cagna)

1. *Ampelopsis ludwigii* (A.BRAUN) P.I.DOROF., seed in dorsal-lateral view, MGPT-PU141053.
2. *Ampelopsis ludwigii* (A.BRAUN) P.I.DOROF., seed in dorsal view, MGPT-PU141054.
3. *Ampelopsis ludwigii* (A.BRAUN) P.I.DOROF., fragmentary (possibly dehisced) seed showing the internal side and wall thickness, MGPT-PU141055.
4. Cucurbitaceae, seed with morphological affinity to the extant seeds of *Bryonia* (see Cervantes and Martin Gomez 2018), MGPT-PU141056.

5. *Litsea sonntagii* H.-J.GREGOR, endocarp with morphological traits that correspond to those of hundreds of specimens from the Pliocene of NW Italy, MGPT-PU141043.
6. *Litsea sonntagii* H.-J.GREGOR; a: fragment of endocarp showing the wall thickness, MGPT-PU141044, b: detail of the endocarp wall formed by a layer of palisade cells.
7. cf. *Myrtus* sp., poorly preserved seed, corresponding to decayed seeds of the extant *Myrtus communis* L. for morphology and shape plus radial orientation of cells, MGPT-PU141045.
8. *Cyclea palatinati-bavariae* H.-J.GREGOR, endocarp which was poorly compressed and with typical shape (as the Pliocene ones figured by Martinetto and Ravazzi 1997) during the first observations in the late 1990s. This was due to pyrite mineralization, which however determined its decay, so that today it is terribly damaged, with pieces falling apart and abundance of white acicular crystals (right, top), MGPT-PU141046.
9. cf. *Chionanthus* L., remain of a possible pyrenarium which split longitudinally into two parts before burial, similar to *Chionanthus kornii* H.-J.GREGOR, MGPT-PU141047.
10. cf. *Fagaropsis* MILDBR., seed morphologically similar to *Fagaropsis huardii* H.-J.GREGOR, but with narrower hilum. An alternative affinity to Capparaceae should be considered, MGPT-PU141048.
11. Amaranthaceae, seed from both flattened faces (a, b), MGPT-PU141049.
12. *Najas* cf. *marina* L., strongly lignified seed that has lost the layer with foveolate ornamentation, as it may happen in extant seeds of *N. marina*, MGPT-PU141050.
13. *Najas* cf. *marina* L., narrower seed with foveolate ornamentation, coarser than the one observed on the extant seeds of *N. flexilis* (WILLD.) ROSTK. et W.L.E.SCHMIDT, MGPT-PU141051.
14. Enigmatic plant remain, interpreted as a nut of *Carpinus* in Kovar-Eder et al. (2006), but actually showing contrasting characters (inframarginal ridge), not diagnostic for identification, MGPT-PU141052.
6. *Magnolia allasoniae* MARTINETTO sp. nov. (CC), halved seed from inside and outside, with ridges coarser than in the previous one, MGPT-PU141063.
7. *Potamogeton* L. (CC), fruit from both flat sides, MGPT-PU141064.
8. *Potamogeton* L. (CC), smaller fruit from both flat sides, MGPT-PU141065.
9. *Prunus laurocerasus* L. (extant), endocarp, showing the same diagnostic morphological traits as the compressed fossil endocarp. From USDA Plant Database (<https://plants.sc.egov.usda.gov>), photo Tracey Slotta.
10. *Prunus* aff. *laurocerasus* L. (CC), strongly compressed endocarp seen from both flattened sides, MGPT-PU141066.
11. *Acer* sp. (sect. *Platanoidea*) (P), endocarp in side view, MGPT-PU141067.
12. *Toddalia rhenana* H.-J.GREGOR (CC), seed in side view with open chamber, showing the wall thinner than in *T. latisiliquata*, in proportion to the width, MGPT-PU141068.
13. *Toddalia rhenana* H.-J.GREGOR (CC), seed in ventral view, MGPT-PU141069.
14. *Toddalia latisiliquata* (R.LUDW.) H.-J.GREGOR (CC), longitudinally split seed from the outer and inner side, the last one showing the thick wall and the lighter inner coat, MGPT-PU141070.
15. *Visnea germanica* MENZEL (CC), decayed fruit with cracks, base of the style preserved, MGPT-PU141071.
16. *Visnea germanica* MENZEL (CC), fruit with part of the receptacle preserved, MGPT-PU141072.
17. *Visnea germanica* MENZEL (CC); a: decayed fruit with apparent filaments on the exposed surface, MGPT-PU141073, b: detail of the filaments (arrow) below the style remain (top), MGPT-PU141073.
18. *Visnea germanica* MENZEL (CC), less altered fruit still wrapped in leathery calyx lobes, MGPT-PU141074.
19. *Sideroxylon mascatense* (A.DC.) T.D.PENN. (extant), cross-sectioned spherical seed from above and from the sectioned side, showing internal ridges and remains of the light-colored tegmen. Specimen V-067541 in UPS.
20. *Sideroxylon* sp., cross-section of a fossil seed from the Pliocene locality Ca' Viettone showing internal ridges and remains of the light-colored tegmen. MGPT-PU141075.
21. *Sideroxylon* sp. (CC), seed in oblique side view showing the circular scar, MGPT-PU141076.
22. *Sideroxylon* sp. (CC), seed (diagenetically compressed) with buttressed external surface in side view, MGPT-PU141077.
23. *Sideroxylon* sp. (CC), seed in side view, MGPT-PU141078.
24. *Sideroxylon* sp. (CC), fragment of a seed broken before burial, internal view showing the ridges, MGPT-PU141079.
25. *Sideroxylon* sp. (CC); a: seed broken before burial in side view, MGPT-PU141080, b: the same seed from above, in cross section, showing the internal ridges (arrows), MGPT-PU141080.

Scale bar 1 mm.

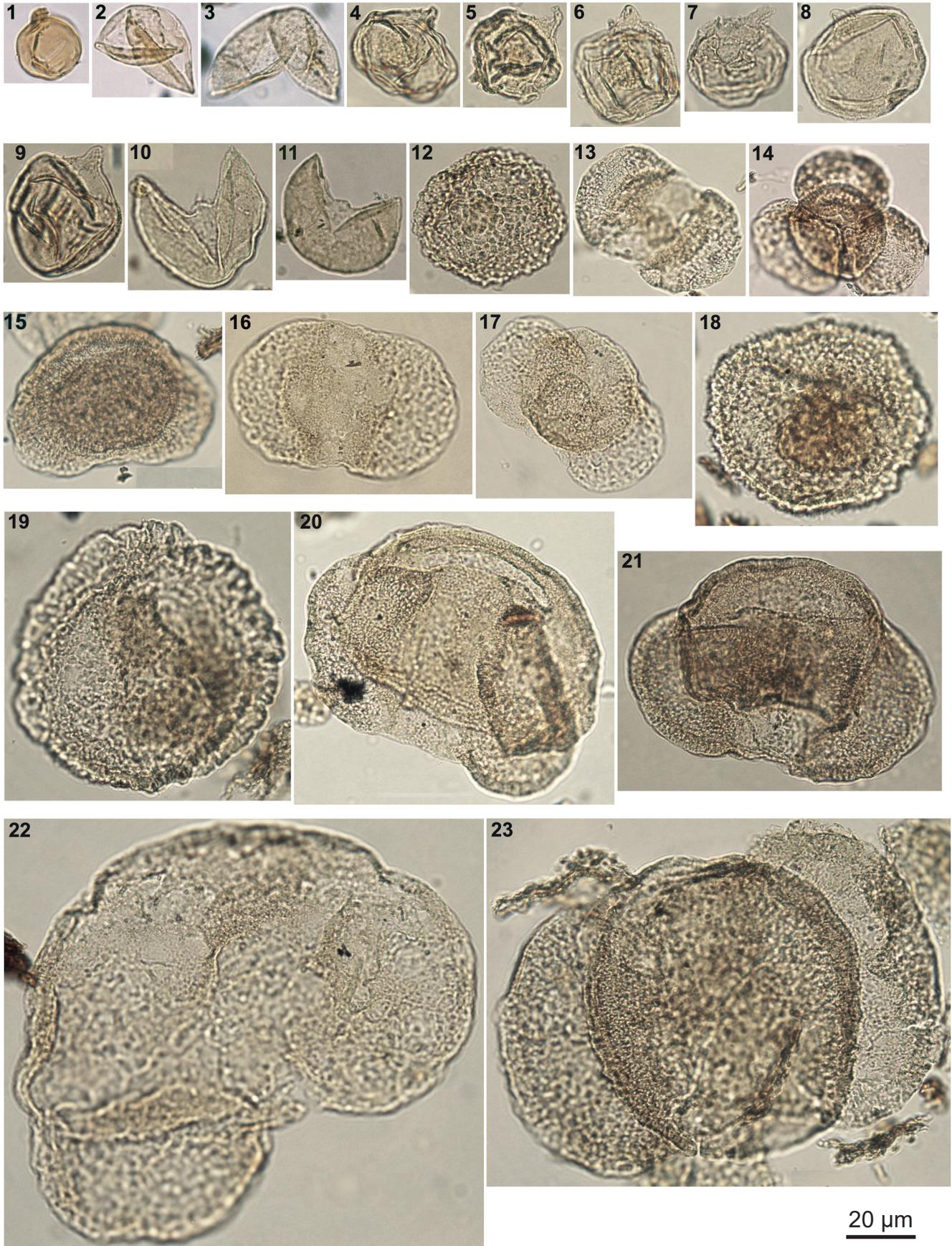
PLATE 5

Carpological remains from deposits of the Messinian post-evaporitic phase in the Piedmont Basin (Italy)

1. *Tetraclinis salicornioides* (UNGER) KVAČEK (CC), seed cone in lateral view, MGPT-PU141058.
2. *Tetraclinis salicornioides* (UNGER) KVAČEK (CC), another seed cone in oblique-subapical view and in a lateral view that shows two cone scales, MGPT-PU141059.
3. *Tetraclinis salicornioides* (UNGER) KVAČEK (CC), shoot fragment, MGPT-PU141060.
4. *Magnolia allasoniae* MARTINETTO sp. nov. (CC), seed with partly preserved sarcotesta, MGPT-PU141061.
5. *Magnolia allasoniae* MARTINETTO sp. nov. (CC), seed with low ridges from both flat sides, MGPT-PU141062.

Scale bar 1 mm.

PLATE 1



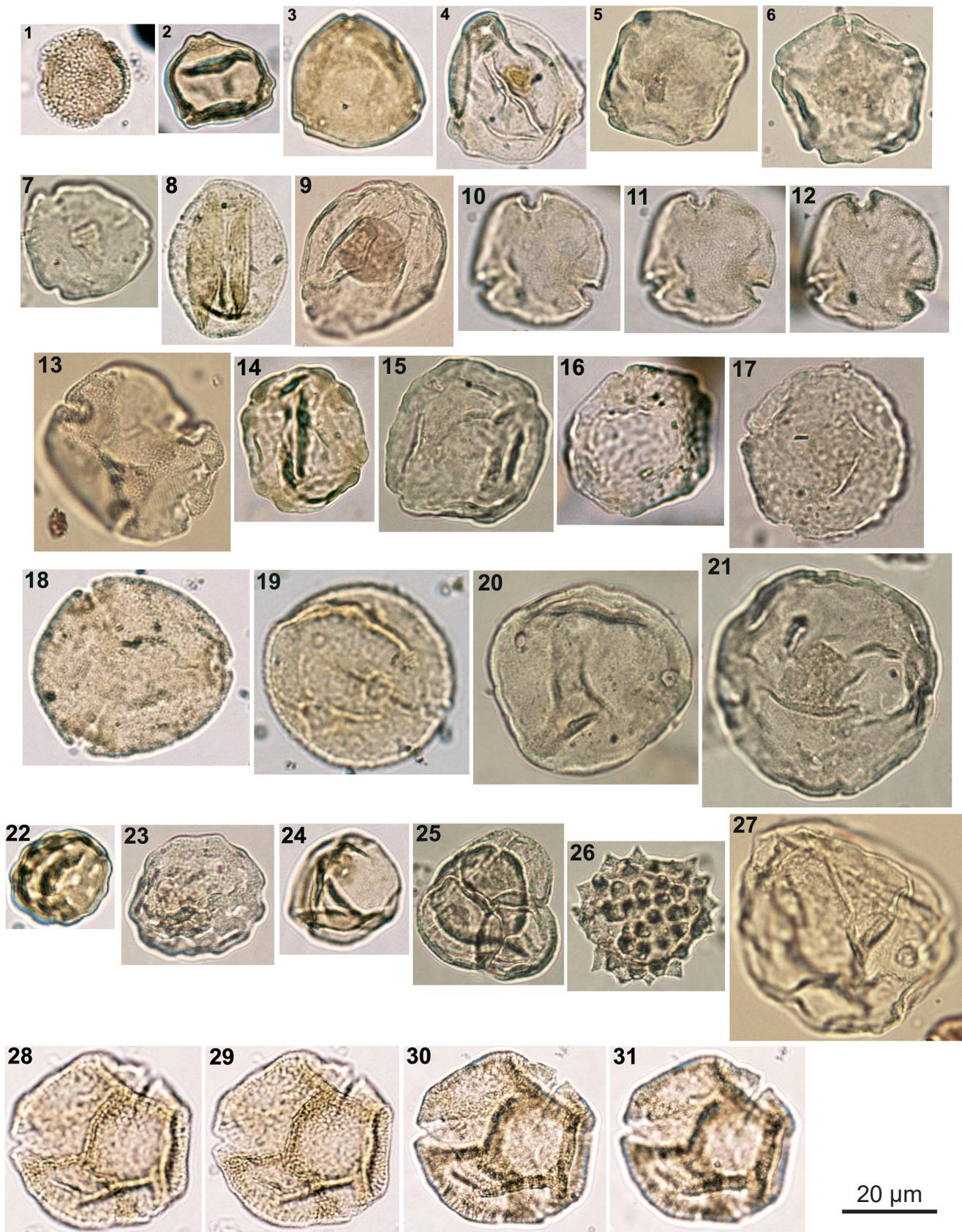


PLATE 3

