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Taxodioxylon gypsaceum in the fossil forest of Dunarobba (Umbria, Central Italy)*

Abstract

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The anatomy of a fossil, mummified wood sample is described in detail and illustrated. It is identified as belonging to *Taxodioxylon gypsaceum*, a fossil taxon closely related to the living species *Sequoia sempervirens*. The fossil species has been found in many European, mainly Tertiary deposits. On the basis of palynological data from neighbouring Umbrian deposits, the age of the fossil forest is tentatively dated as upper Pliocene.

Introduction

At Dunarobba near Avigliano Umbro, Province of Perugia (Fig. 1), in about 1980, in a clay quarry supplying a brick-kiln, numerous fossil trunks of big size were brought to light, measuring from 2 m up to over 8 m in circumference and reaching 10 m in height (Fig. 2). A peculiar feature of the deposit is the fact that the trunks have kept their live upright position though being slightly bent to NE. For some of them it was possible to display the root system as well (Fig. 3). Since fossilization occurred through mummification, the woody substance of the trunks is still present. The good state of preservation of the wood is due to the impermeability of the embedding clay, which was compacted by early diagenetic events so that mineralization and decomposition were avoided (Ambrosetti & al. 1988). This paper discusses the identity of one of the wood samples taken from these trunks. The above-mentioned deposit lies on the SW border of the old Lago Tiberino, which covered a good part of present-day Umbria in the Plio-Pleistocene (upper and lower Villafranchian). During this period a thick sediment cover was deposited that almost completely filled the lake, giving origin to a large plain on which the present hydrographic system is placed.

The first historical record of an Umbrian deposit goes back to 1637 when the scientist Francesco Stelluti, one of the founders of the Accademia dei Lincei, published his work "Trattato del legno fossile minerale nuovamente scoperto" (Biondi 1984), presenting the results of his studies on fossil woods found in the area between Todi and Acquasparta. His

* The Superintendence of Archaeology for Umbria has placed under special custody the area in which the fossils have been found, and is promoting a series of studies on the paleoenvironment of the deposits and with the aim of conserving the fossil record. The present study is a contribution to this research program.

descriptions, however accurate, did not result in correct conclusions, being the culture of that time deeply influenced by medieval prejudices.

Material

40 wood samples from trunks found in the so-called "fossil forest of Dunarobba" have been studied so far. The following anatomical description refers to sample n° 19. The slides used for our observations and measurements are kept in the wood sample collection of the Faculty of Agriculture, University of Ancona.

Results

Transversal section. — Homoxylous wood without any resin canals, either normal or traumatic, with very evident annual growth rings, visible to the eye, 1-1.5 mm thick, with a neat limit between the early (1-15 cell tiers) and the late wood (2-7 cell tiers) (Fig. 6).

The fibre tracheids are polygonal at the early wood level and quadrangular at the late wood level. In the early wood they are elongated radially and are thin-walled; in the late wood the cells have a reduced radial diameter, a mostly slit-shaped lumen and much thicker walls. Sizes are reported in Tab. 1. The lumen in the late wood cells measures 5-25 μm x 1.2-10-25 μm (tangential diameter x radial diameter). The average number of fibre tracheids per mm^2 is 13. Rays are separated by 2 to 9 rows of fibre tracheids (4-5 on average).

The wood parenchyma cells are rather few and can be easily recognized by being filled with a reddish-orange substance. They are found mainly in the late wood, where they form a kind of tangential band, and in the late portion of the early wood. In the late wood these cells have the same shape as the fibre tracheids, whereas in the early wood they are square or slightly rectangular (Fig. 7). Tab. 2 reports the size of the wood parenchyma cells.

Tangential section. — The tangential walls of the fibre tracheids show small, bordered, roundish and spaced pits (Fig. 4). They are uniseriate or biseriate and arranged in very irregular rows, mostly occurring in the late wood. The diameter of the bordered pits varies from 6 to 10 μm in the early as well as in the late wood. In the late wood, however, the perforations take the shape of vertical slits measuring 3-4 μm x 1-1.5 μm (major axes x minor axes), while in the early wood they are circular with a diameter of 3-4 μm (Fig. 8).

The rays are uniseriate (in one case a biseriate ray, only two cells high, has been observed), formed by roundish ellipsoidal cells; their ends are slightly elongated. The rays are 1 to 33 cell tiers high and their size is between 20 μm and 620 μm ; they are very narrow (10-12 μm in uniseriate rays). The ray cells are 15-20 μm high, and their wall is about 3 μm thick. The average number of rays per mm^2 is 32.

The wood parenchyma cells are abundant and contain deposits in the form of globular and rectangular clumps. They are rectangular, 80-250-400 μm high and 20-50 μm wide. The vertical and transversal walls are thin, smooth, and 1-2 μm thick (Fig. 9).

Fig. 1. The deposit of Dunarobba, in Umbria. The borders of the old Lake Tiberino, of Gubbio and of Rieti are indicated.

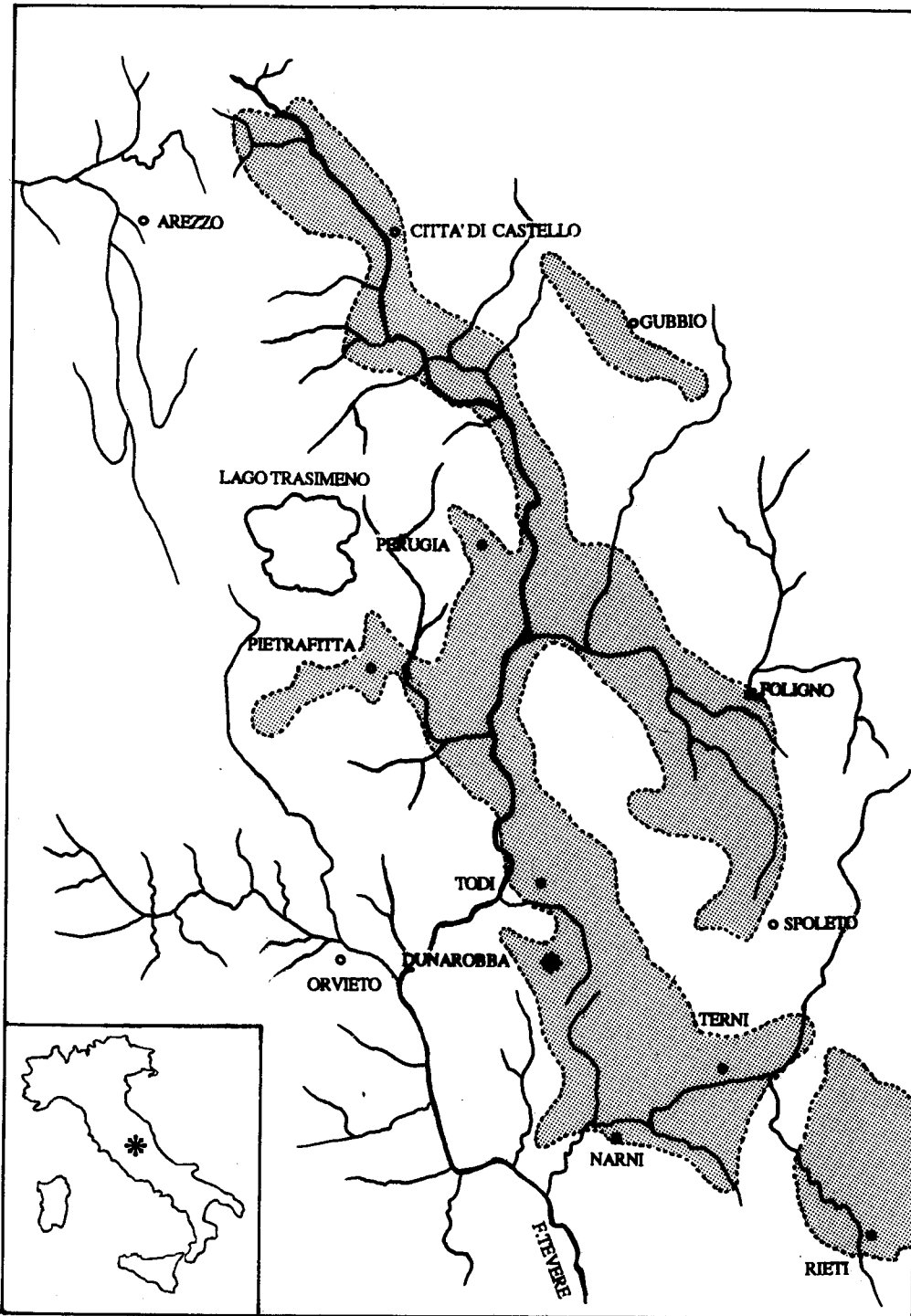




Fig. 2. Fossil tree trunks in situ in the deposit of Dunarobba.

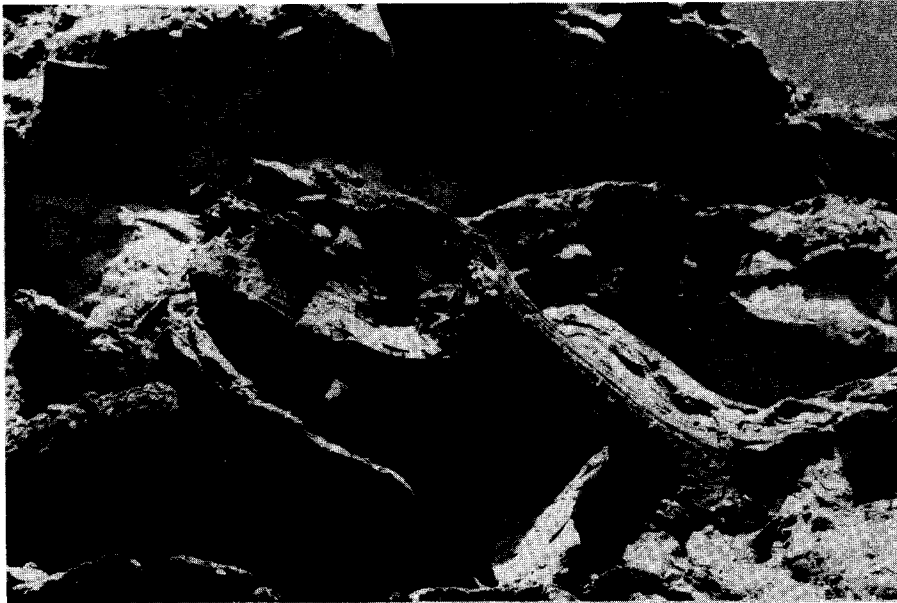


Fig. 3. Root system embedded in clays.

Table 1.

	Tangential diameter μm	Radial diameter μm	Thickness of the radial tangential wall (double) μm	
Early wood	20-75	(40) 50 - 100 (110)	3	
Late wood	9-50	10-35 (50)	12-36	18-24

Table 2.

	Tangential diameter μm	Radial diameter μm	Wall thickness (double) μm
Early wood	15-50	15-30	3-4
Late wood	15-50	10-20	3-4

Table 3

	Tangential diameter μm	Radial diameter μm
Pits	12-18	12-15
Perforation	3-4, 5	

Radial section. — On the radial walls of the early wood fibre tracheids many bordered pits can be observed, ranging from uni- to quadriseriate, exceptionally quinquiseriate (Fig. 5). Uniseriate pits are spaced, roundish, and situated more or less in the centre of the fibre tracheids; whereas the bi-, tri- and quadriseriate pits are opposite and either in contact or sometimes slightly spaced. Crassulae are abundant. In a few cases we can see 4 or 5 alternate pits on the same horizontal line (Fig. 10). All pits are slightly flattened. Their dimensions are reported in Tab. 3. The pits on their radial wall are mostly uniseriate, and their areole takes the whole width of the fibre tracheids; they are spaced or in a few cases just slightly contiguous. The fibre tracheids are narrower in the late wood.

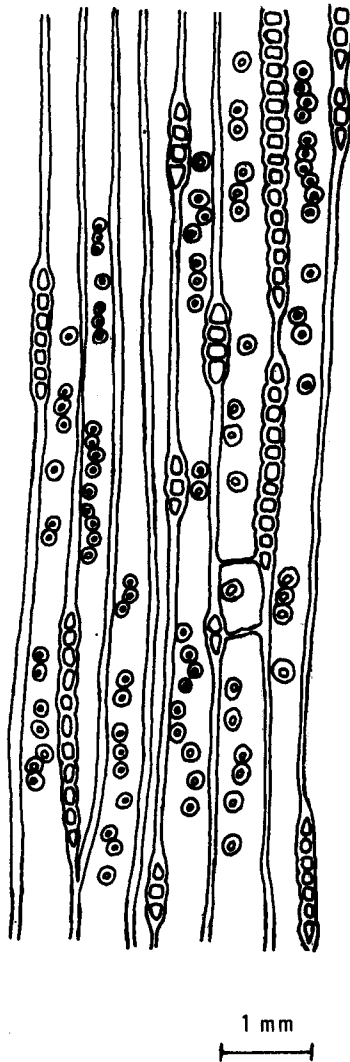


Fig. 4. Tangential section of a wood sample.

Rays are homogeneous and are formed by more or less elongated cells. The horizontal and terminal walls are smooth and thin, about 3 μm thick; the tangential walls are smooth as well (Fig. 11). The radial length ranges from 50 μm to 200 μm , rarely up to 250 μm . Pits of an "oculipore" type occur in cross-fields. In the early wood they are taxodioid, elliptical, with a wide horizontally oriented opening, while in the late wood they tend to become smaller and oblique. The number of pits in any single field ranges from 1 to 6, 5 in most cases. They are arranged in one line, more rarely in two parallel lines (in end cells) near the late wood. The size of the taxodioid pits (length x width) is 6-9 μm x 4-9 μm (Fig. 12).

Conclusions

On the basis of the occurrence of taxodioid pits in the cross-fields and abundant wood parenchyma with smooth transversal walls this wood sample can undoubtedly be attributed

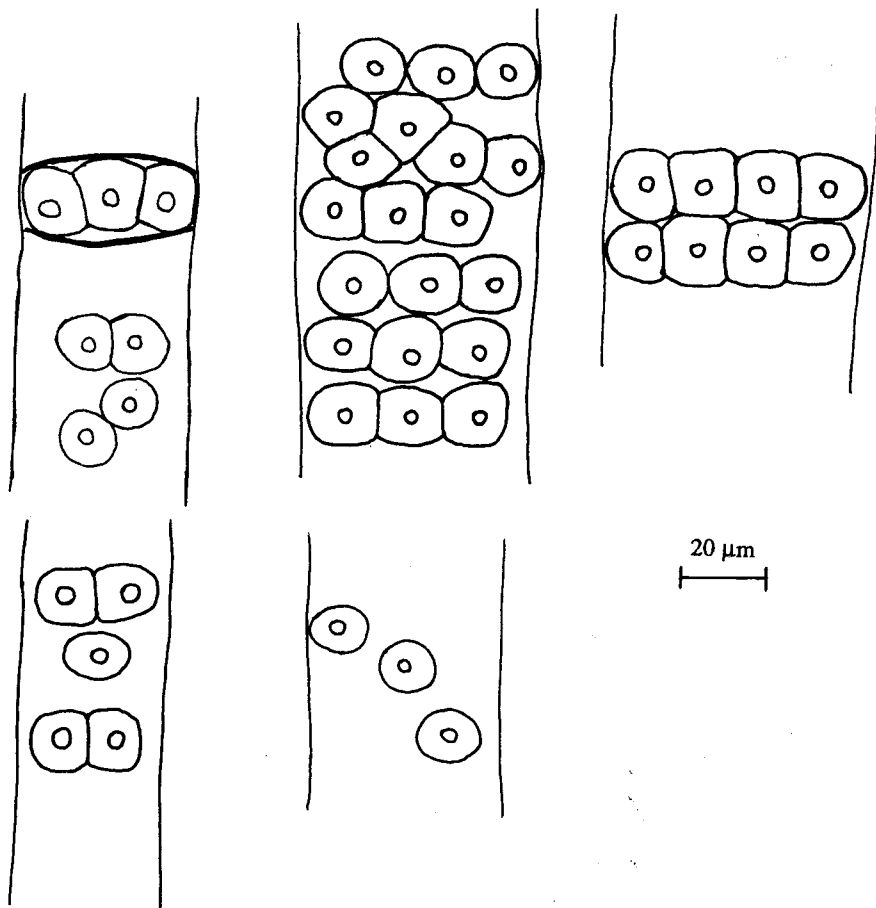
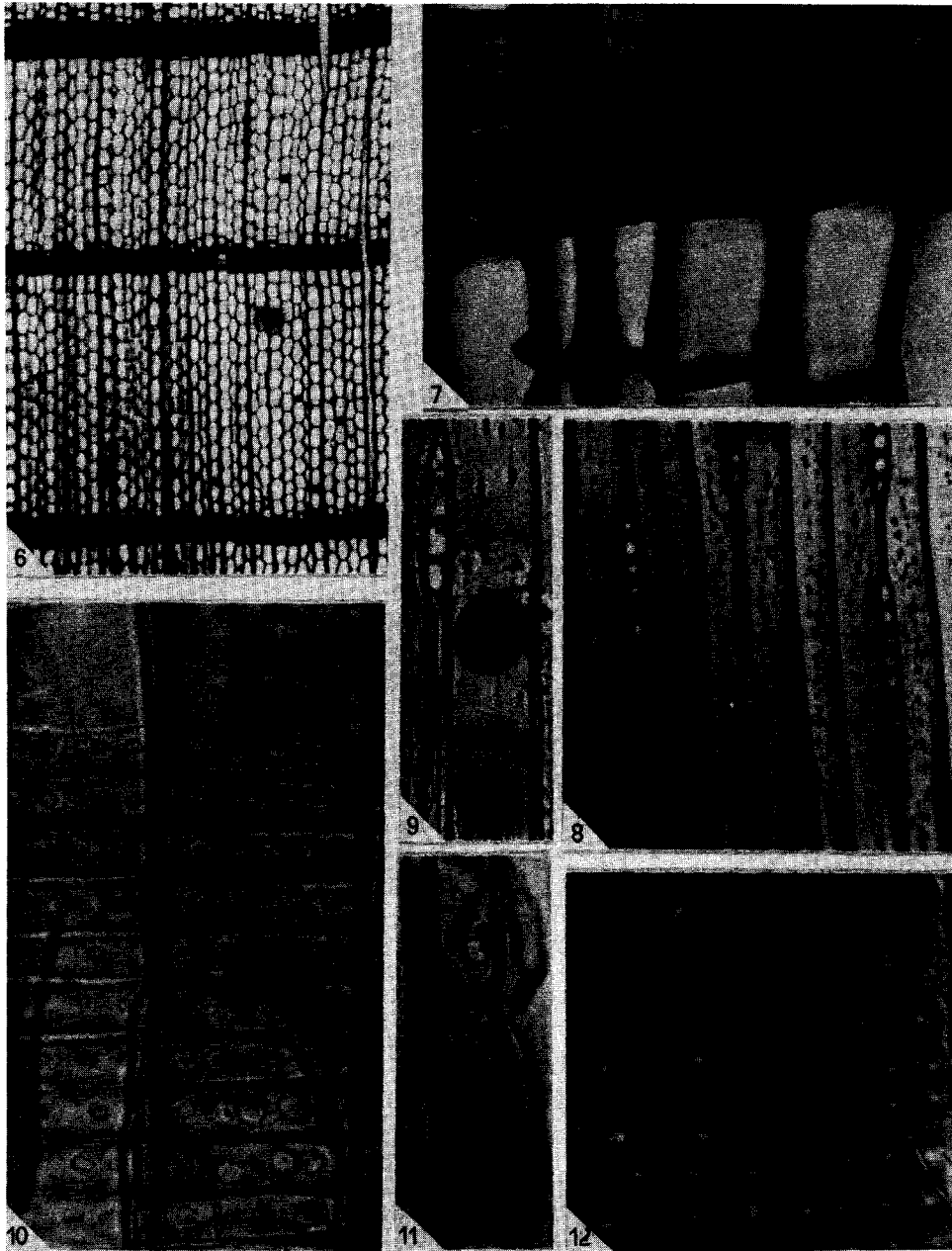


Fig. 5. Different types of bordered pits in the radial walls of the fibre tracheids.



Figs. 6-12. 6: Transversal section (x 7.5): fibre tracheids in the early and late wood. The wood parenchyma cells are characterized by their dark content; 7: Transversal section (x 30): transition between the early and late wood; 8: Tangential section (x 18.7): the bordered pits in the tangential wall of the fibre tracheids are clearly visible; 9: Tangential section (x 30): the wood parenchyma cells are in evidence; 10: Radial section (x 30): cross-field with "taxodioid" pits; 11: Radial section (x 30): the smooth transversal walls of a wood parenchyma cell is shown; 12: Radial section (x 30): bordered and quadriseriate pits, opposite on the radial walls.

to the *Taxodiaceae*. Within this family, by comparing our own data with the detailed analysis of Bailey & Faull (1934), the strongest analogy is found with the living *Sequoia sempervirens* Endl.

Among the fossil species, *Taxodioxylon gypsaceum* (Göppert) Kräusel [= *Sequoioxylon gypsaceum* (Göppert) Greguss, *Taxodioxylon sequoianum* (Mercklin) Gothan], though broadly defined, shows the greatest anatomic affinity with *Sequoia sempervirens*. Therefore, our samples from the fossil forest of Dunarobba are referred to *Taxodioxylon gypsaceum*. This taxon is known from many European Tertiary deposits (Burgh 1973) and from a Turkish one (Özgüven-Ertan 1981). In Italy the species had been previously found only once, in the Miocene formations of Monte Castellaro near Pesaro (Biondi 1982).

The palynological analysis of samples from the Pietrafitta deposit, north of Dunarobba and also linked to the old Lago Tiberino, led to the identification of a bio-horizon attributed to the last part of the Upper Pliocene. Above this horizon the woody vegetation completely changes, and the *Taxodiaceae* disappear. This change, placed at the limit between Pliocene and Pleistocene, has been named "Tiberian limit" (Lona 1971). A study on fossil pollen from a deposit even closer to that of Dunarobba, at Monte Santo near Todi, has revealed the existence of a thermophilous forest of Tertiary genera such as *Taxodium*, *Nyssa* and, in smaller numbers *Dacrydium*, *Podocarpus*, *Sciadopitys*, *Sequoia*, *Cryptomeria*, *Keteleeria*, *Engelhardtia*, and traces of *Carya*, *Pterocarya* and *Zelkova*. This deposit has been attributed to the Pliocene and is therefore older than that of Pietrafitta (Follieri 1977).

On the basis of the available data, and since the trunks studied so far belong to *Taxodioxylon gypsaceum*, this sector of the deposit of Dunarobba is attributed to the late part of the Upper Pliocene. This study has a preliminary character. Research at Dunarobba continues, and further investigations extending to other strata will allow to reconstruct the variations in the composition of the flora in times that preceded and followed those of the wood deposit studied here.

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