Early Cretaceous Araucarian driftwood from hemipelagic sediments of the Puez area, South Tyrol, Italy

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A B S T R A C T

We describe a calcareously permineralised fossil tree-trunk, preserved as driftwood, within hemipelagic sediments of the Cretaceous Puez Formation near Wolkenstein, South Tyrol, Italy. Planktic foraminiferal assemblages recovered from the marls containing the fossil wood indicate a latest middle Albian age. Based on its wood anatomy, the trunk is assigned to Agathoxylon and probably has an affinity with the conifer family Araucariaceae. The wood lacks pronounced tree-rings consistent with tree growth within the broad humid tropical belt that existed at that time. The trunk contains cylindrical chambers filled within faecal pellets, demonstrating that oribatid mites infested the tree, either during life, or shortly after death. Prior to final burial, the tree-trunk drifted out into the open sea for a considerable period as indicated by extensive borings assigned to the ichnospecies Teredolites longissimus and produced by teredinid bivalves. Relatively little is known about the Cretaceous floras of Italy, so this new finding fills a gap in our knowledge of the composition and ecology of the vegetation of this region.

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1. Introduction

The Cretaceous fossil plant record of Italy is relatively poorly known and in most cases dominated by conifers (for an overview see Gomez et al., 2002, fig. 2). Most of these fossils come from the Campania region of southern Italy. These include early Albian megafloral assemblages from Pietraroja in Benevento, which contain putative cycads, bennettites (?Zamites) and conifers (Brachyphyllum; Bravi and Garassino, 1998a), a middle Albian angiosperm fructification, Sagaria cilentana from Monti Alburni near Patina (Bravi et al., 2010), and late Albian conifers (Pagiophyllum; ?Podozamites) and bennettites (?Zamites) from Petina in Salerno (Bravi, 1995; Bravi and Garassino, 1998b; Dalla Vecchia, 2000). In contrast Cretaceous megafloral assemblages from northern Italy are, so far, represented only by unidentified conifers from the late Barremian of Cornappo Valley near Torlano (Friuli-Venezia-Giulia region; Muscio and Venturini, 1990; Dalla Vecchia, 2000) and Albian—?Cenomanian ferns and monocotyledons from a bituminous limestone near Faierazzo (Friuli-Venezia-Giulia region; Taramelli, 1873; Gomez et al., 2002).

In addition to these megafloral assemblages there are five records of fossil wood (see database in Peralta-Medina and Falcon-Lang, 2012). A fossil trunk of putative Cretaceous age found near Guiglia, Modena was described as Araucarioxylon (Bertolani Marchetti, 1963), and compared to Araucarioxylon scarabelli Clerici from Quaternary sediments near Imola (Clerici, 1902). A second silicified trunk was discovered in the Aptian—Albian “Marne a Fucoidi” beds, east of Camerino (Deiana and Pierucci, 1974); unfortunately, local collectors stole this fossil, and only a small fragment, assigned to Araucarioxylon, has been preserved (Biondi, 1976). A third fossil wood fragment from the “Marne a Fucoidi” beds at Monti Sibillini (Biondi, 1980) is assigned to Protophylocladoxylon aff. subdipterica Dupéron Laudoueneix. Finally, from the Southern Alps, Lehner et al. (1987) mentioned a silicified fragment from the Cretaceous of the Scaglia Bianca of Costa Valley, Brescia, and Biondi (1978) described a specimen of Protopodocarpoxylon pedrottii from Albian strata near Trento.

Here, we describe a new specimen of permineralised wood from the Cretaceous (Albian) of the Southern Alps, and the first from the Puez area in South Tyrol (Fig. 1A). Considering the poor record of Cretaceous fossil plants from Italy (Dalla Vecchia, 2000; Gomez et al., 2002),
Fig. 1. Geological context for fossil wood. A, Location of fossil site in Italy, and specifically, in Puez area of South Tyrol. B, Photograph of the section (P2) at Col de Puez, highlighting Bed 160 (inset), from which the fossil wood originated. C, Palaeogeographic location of the Puez area during the Cretaceous. D, Palaeogeography of the Southern Alps during the Cretaceous showing the inferred source area of the drifted tree-trunk. The star indicates the location of the Puez area.

Fig. 2. The new fossil wood specimen from the Puez area. A, A polished transverse section with some teredinid molluscan borings, arrowed, scale: 20 mm. B, Marl matrix adhering to the specimen containing radiolaria (arrow, left) and foraminifera (arrow, right), scale: 300 μm.
Fig. 3. Wood anatomy of fossil wood specimen (Agathoxylon sp.) from Puez area, accessioned as 2010/0095/0001 in Naturmuseum Südtirol, Italy. A, Uniseriate, flattened bordered tracheid pits (left) and biseriate, alternate, bordered tracheid pits, with a polygonal outline (right), RLS, scale: 30 μm. B, Uniseriate, circular tracheid pits with circular aperture, RLS.
et al., 2002), the discovery of this new tree-trunk adds important information to our knowledge of the Cretaceous flora of Italy.

2. Geological context

The permineralised tree-trunk was discovered in an outcrop located on the southern slope of the Col de Puez, a mountain situated within Puez-Geisler Nature Park in the Dolomites of Northern Italy (46°35′30″N, 11°49′15″E; Fig. 1B, C). In 2009, this area was inscribed on the UNESCO list of world heritage sites (Fig. 2). The permineralised tree-trunk was found in Bed 160 in the middle part of the Puez (P2) section (Lukeneder, 2010). This horizon is within the Puez-Marl Member, the uppermost member of the ~121 m thick Puez Formation (Lukeneder, 2008, 2010, 2011, 2012; Lukeneder and Aspmair, 2006). A detailed overview of the geology of the Puez area is given in Lukeneder (2010, 2011).

The Puez-Marl Member consists of marked alternations of dark grey to black marls with intercalated grey limestones, marly limestones and calcareous marls (Lukeneder, 2008, 2010). The darker marl beds (up to 0.1–1 m thick) dominate over the intercalated limestone beds (up to 0.01–0.5 m thick), and bed-thickness and marl content varies throughout. The frequency and thickness of intercalated limestone beds increases in the upper part of the Puez-Marl Member (section P2, beds 249–268; Lukeneder, 2010, 2011, 2012). The Puez-Marl Member is a pelagic–hemipelagic deposit (Lukeneder, 2008, 2010) with TOC values ranging from 0.0–0.74%, S values ranging from 0.2–0.6%, and CaCO3 ranges from 41.8–95.8%.

Biostratigraphical data for the Puez-Marl Member indicate its age ranges from early Albian to latest Albian/early Cenomanian (Lukeneder, 2010). Specifically, planktonic foraminiferal assemblages indicate a latest middle Albian (Rotalipora subtinctensis Zone) age for the sediments in which the tree-trunk was found (Jan Sotak, personal communication, 2012). According to Ogg et al. (2008), this would suggest a numerical age of ca. 105–107 million years for the fossil wood.

During the Cretaceous, the western Tethys region— in which the Southern Alps (containing the Puez area) were located — was characterised by various microplates situated in the middle of the oceanic corridor between Africa and Europe (Lukeneder, 2010; Scotese, 2001; Stampfl and Mosar, 1999; Stampfl et al., 2002). The Puez area was specifically located on one of the submarine plateaus (the Puez-Gardenaccia part of the Trento Plateau), which started to form during the Triassic and ended during the Lower Cretaceous (Bosellini, 1998; Weissert, 1981). Terrigenous influx (clay minerals) in the Albian portion of the Puez Formation may reflect erosion from first islands uplifted by early Alpine tectonics (Bosellini, 1998), a possible source for the fossil wood (Fig. 1D). According to Muttoni et al. (2005), the Lombardian Basin — and thus the adjacent Trento Plateau to the east — were located at ~30°N in the Early Cretaceous (Aptian).

3. Material and methods

The fossil tree-trunk studied here, which measures approximately 0.15 × 0.2 m in diameter, is accessioned as 2010/0095/0001 in the collections of the Natural History Museum Vienna. A layer of yellow limonite covers the specimen, and some dark grey calcareous marl containing radiolarians and foraminifera adheres to its exterior (Fig. 2). The trunk is well preserved and shows a branch arising from the main axis. The stem is permineralised with calcium carbonate, showing good preservation of wood anatomy. Thin sections were prepared in transverse (TS), radial longitudinal (RLS) and tangential longitudinal (TLS) sections using the Buehler PetroThin Sectioning System, and studied using an Olympus BH-5 microscope with digital camera attachment.

4. Wood anatomy

Fossil wood characters were described quantitatively using the standard approach (Falcon-Lang and Cantrill, 2000), whereby 50 measurements are obtained for each character, and the mean and range determined. This approach is useful for circumscribing fossil wood taxa because wood anatomy is typically rather variable (Falcon-Lang, 2005).

4.1. Description

The fossil comprises pycnoxyloconifer wood (Fig. 3) with the following features: In RLS, the wood comprises tracheids, 28–53 μm in diameter (mean 39 μm diameter), which show contiguous bordered pits that are dominantly (72%) biseriate and alternate, or uniseriate (28%). Biseriate pit borders are circular to polygonal, 12–16 μm in diameter, with a circular or oblique/slit border, typically 5–6 μm in diameter. Uniseriate pit borders may be slightly longitudinally flattened (14–17 μm by 11–15 μm in diameter) with circular borders, typically 5–6 μm in diameter. Rays comprise short procumbent cells (90–115 μm long), showing 2–5 oval araucarioid pits per cross-field. Cross-field pits are 6–11 μm in diameter.

In TLS, uniseriate rays are 1–18 cells high, but most typically 1–7 cells high (mean 4.13). A relatively common feature is resin plugs, which may occur as a solitary plug, or in series of up to 8 plugs. Plugs are always positioned adjacent to rays. Approximately 50 mm from the pith (not preserved), there is a vascular trace, 280 μm wide by 680 μm high.

In TS, no growth rings are present but weakly defined growth interruptions do occur, highlighted by very minor fluctuations in tracheid diameter. Growth interruptions may fade in and out around the observed circumference of the axis and may not be concentric.

4.2. Identification and palaeoclimatic implications

Wood showing alternately arranged, multiseriate bordered pitting and araucarioid cross-field pits has been traditionally assigned to Araucarioxylon Krass in Schimper, although as Bamford and Philippe (2001) have noted, this is a nomen illegitimum. The genus Agathoxylon Hartig, which we use here, has been suggested as a valid alternative by Bamford and Philippe (2001), but we note that the nomenclature for this wood type remains mired in debate.

Wood of this type is highly characteristic of all three extant genera (Araucaria, Agathis, and Wollemia) of the conifer family Araucariaceae (Phillips, 1948), and this is the most likely affinity for our specimen. Although Biondi (1980), in his review of the Aptian—Albian woods of Italy, inferred that all described taxa (Araucarioxylon, Protopodocarpoxylon, Protophylocladaxyylon) probably belong
to the Protopinaceae, an extinct family of conifers, the specimen we
describe here does not show the characteristic pitting of the Pro-
topinaceae (Philippe, 1992), and an araucarian affinity is more likely
in our view.

The vascular trace, if interpreted as a leaf trace, is of comparable
size to araucarian traces, and suggests a significant leaf retention
time, also consistent with the Araucariaceae (Falcon-Lang, 2000). In
terms of its common resin plugs, and relatively high proportion
of uniseriate tracheid pits, our specimen is most similar to the extant
Wollemia (Heady et al., 2002). In Cretaceous times, wood of this
araucarian type was extremely abundant comprising over a quarter
of all fossil wood records from the period (Peralta-Medina and
Falcon-Lang, 2012). This identification is consistent with the re-
cognition of aromatic sequiterpenoids identified in the fossil wood
(Lukeneder et al., 2012), a compound suggestive of the conifer
families Araucariaceae, Podocarpaceae, or possibly Cupressaceae
(Noble et al., 1985; Otto and Wilde, 2001).

The absence of true tree-rings in the wood, and the occurrence
of very weakly defined growth interruptions that cannot be traced
around the full circumference of the axis, are characteristic of
growth under humid tropical climates, and consistent with the
broad tropical belt that existed in Cretaceous times (Peralta-Medina
and Falcon-Lang, 2012).

5. Animal borings

The araucarian wood preserves two phases of borings by dif-
ferent groups of animals, which shed light on palaeoecology. The

Fig. 4. Animal borings in the fossil wood specimen (Agathoxylon sp.) from Puez area, accessioned as 2010/0095/0001 in Naturmuseum Südtirol, Italy. A, Cylindrical chamber, orientated longitudinally, with faecal pellets of orbibdit mites, TLS, scale: 200 μm. B, Close-up of orbibdit mite faecal pellets in A, TLS, scale: 100 μm. C, Teredinid borings (arrow) in transverse view, oblique TS, scale: 250 μm. D, Teredinid borings, expanding in diameter along length in longitudinal view, oblique TS, scale: 500 μm.
first type (Fig. 4, A, B) comprises cylindrical borings, ~225 μm in diameter, orientated in a longitudinal direction, and packed with oval to circular, unstructured faecal pellets, 28–106 μm in diameter (mean 61 μm). These features are highly characteristic of oribatid mites, one of the most important group of xylephagous arthropods (Labandeira et al., 1997), and were probably emplaced either while the tree was still alive, or shortly after death while the trunk lay on the litter layer.

A second phase of borings (Fig. 4, C, D) comprises a series of cylindrical, slightly sinusuous structures, which widen in diameter along their length, from the exterior to the interior of the fossil, reaching a maximum diameter of 10–12 mm. The borings are locally infilled with marl containing marine microfossils. This type of borings has been attributed to the ichnospecies Teredolites longissimus Kelly and Bromley, which is known from the Cretaceous locally in reaching a maximum diameter of 10 mm. These features are highly characteristic of oribatid mites, emplaced while the tree was alive, or shortly after death, suggestive of oceanic growth under humid tropical conditions.

2. Wood anatomy and geochemistry suggest an affinity with the conifer family Araucariaceae, which was widespread during Cretaceous times, while the absence of tree-rings indicates growth under humid tropical conditions.

3. The wood contains chambers and faecal pellets of oribatid mites, emplaced while the tree was alive, or shortly after death, and also extensive teredinid borings, suggestive of oceanic drifting from emergent Alpine islands some distance away.

4. The new discovery is important, shedding light on the poorly known composition and ecology of Cretaceous vegetation in Italy.

6. Conclusions

1. We report the sixth record of fossil wood (Agathoxylon sp.) from Cretaceous of Italy, and the first from the Puez area of the Southern Alps. The fossil occurs in the late middle Albian (Rotalilipora subtexitensis Zone) hemipelagic sediments of the Puez Formation.

2. Wood anatomy and geochemistry suggest an affinity with the conifer family Araucariaceae, which was widespread during Cretaceous times, while the absence of tree-rings indicates growth under humid tropical conditions.

3. The wood contains chambers and faecal pellets of oribatid mites, emplaced while the tree was alive, or shortly after death, and also extensive teredinid borings, suggestive of oceanic drifting from emergent Alpine islands some distance away.

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References


Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.cretres.2013.01.002.