Cretaceous Research 41 (2013) 270–276

Contents lists available at SciVerse ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

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

Evelyn Kustatscher [a,*], Howard Falcon-Lang [b], Alexander Lukeneder [c]

[a] Naturmuseum Südtirol, Bindergasse 1, 39100 Bolzano, Italy
[b] Department of Earth Sciences, Royal Holloway, University of London, Egham, Surrey TW20 0EX, UK
[c] Natural History Museum, Geological-Palaeontological Department, Burgring 7, 1010 Wien, Austria

ARTICLE INFO

Article history:
Received 10 May 2012
Accepted in revised form 7 January 2013
Available online 24 January 2013

Keywords:
Albian
Driftwood
Araucariaceae
Teredolites longissimus
Puez Formation
Dolomites
Italy

ABSTRACT

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.

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 scarabellii* Clerici from Quarternary sediments near Imola (Clerici, 1902). A second silicified trunk was discovered in the Aptian–Albian "Marne a Fucoidi" beds, east of Camerino (Deiana and Pieruccini, 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 *Protophyllocladoxylon* aff. *subdiphtericum* 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

* Corresponding author. Tel.: +39 0471 412963; fax: +39 0471 412979.
E-mail addresses: evelyn.kustatscher@naturmuseum.it (E. Kustatscher), h.falcon-lang@es.rhul.ac.uk (H. Falcon-Lang), alexander.lukeneder@nhm-wien.ac.at (A. Lukeneder).

0195-6671
http://dx.doi.org/10.1016/j.cretres.2013.01.002

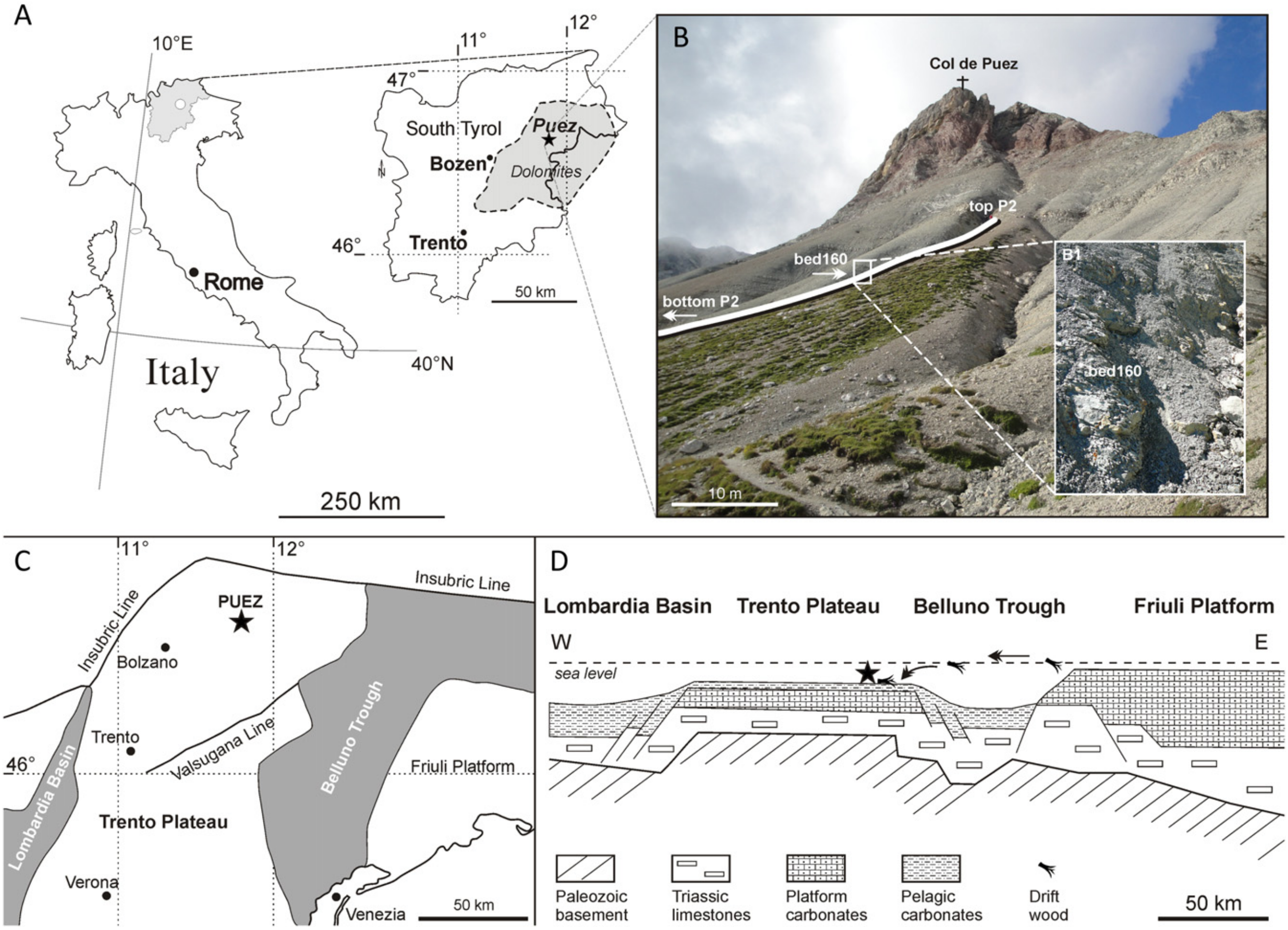

Fig. 1. Geological context for fossil wood. A, Location of fossil site in Italy, and specifically, in Puez area of South Tyrol. B, Photograph of the section (P2) at Col de Puez, highlighting Bed 160 (inset), from which the fossil wood originated. C, Palaeogeographic location of the Puez area during the 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.

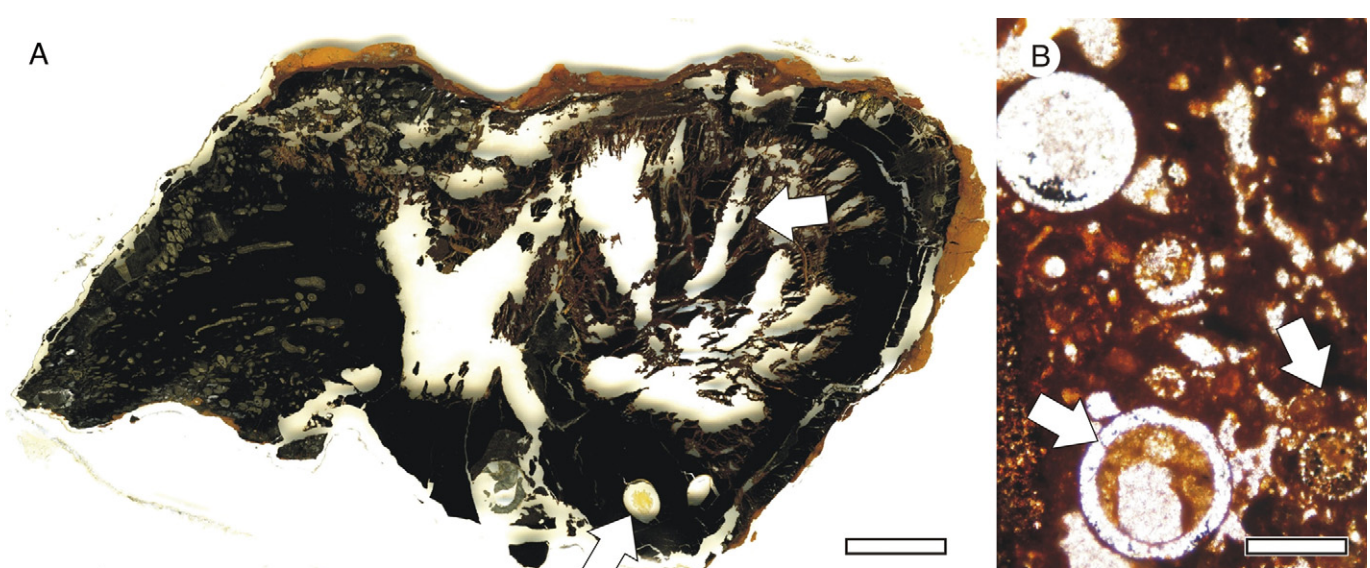

Fig. 2. The new fossil wood specimen from the Puez area. A, A polished transverse section with some teredinid molluscan borings, arrowed, scale: 20 mm. B, Marl matrix adhering to the specimen containing radiolaria (arrow, left) and foraminifera (arrow, right), scale: 300 μm.

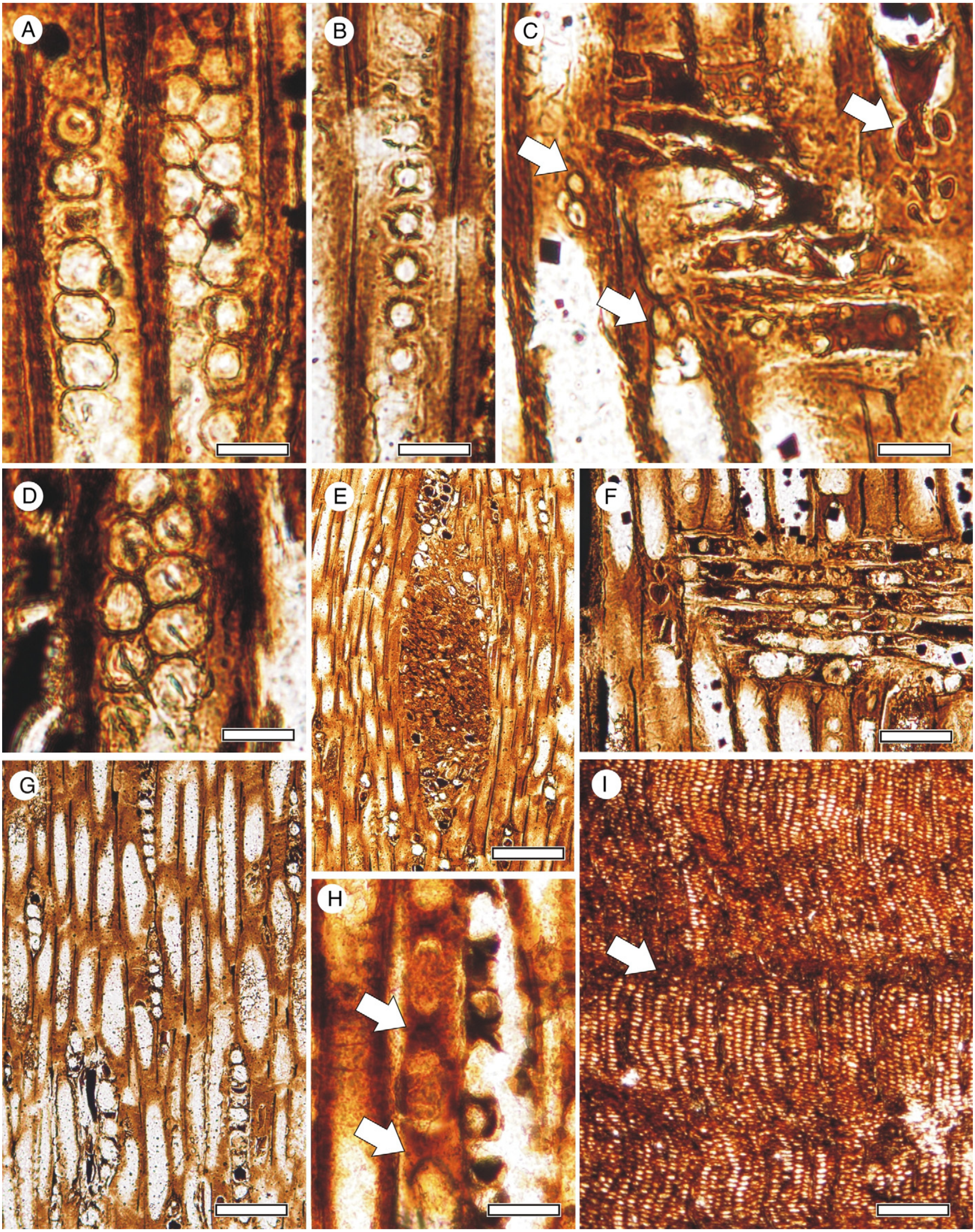

Fig. 3. Wood anatomy of fossil wood specimen (*Agathoxylon* sp.) from Puez area, accessioned as 2010/0095/0001 in Naturmuseum Südtirol, Italy. A, Uniseriate, flattened bordered tracheid pits (left) and biseriate, alternate, bordered tracheid pits, with a polygonal outline (right), RLS, scale: 30 μm. 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 $CaCO_3$ 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 subticinensis* 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; Stampfli and Mosar, 1999; Stampfli 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 Petro Thin 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 pycnoxylic conifer 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* Kraus in Schimper, although as Bamford and Philippe (2001) have noted, this is a *nomen illegitum*. 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*, *Protophyllocladoxylon*) probably belong

scale: 30 μm. C, Cross-field pitting comprising 3–5 araucarioid pits (arrows), RLS, scale: 20 μm. D, Biseriate, alternate, polygonal, bordered tracheid pits with oblique slit-like apertures, RLS, scale: 20 μm. E, Large vascular trace, probably a leaf trace, TLS, scale: 250 μm. F, Ray composed of short, procumbent, resin-filled cells with resin plugs above and adjacent to the ray, RLS, scale: 50 μm. G, Rays, uniseriate and short, TLS, scale: 70 μm. H, A series of resin plugs (arrows) adjacent to a ray, TLS, scale: 30 μm. I, Files of tracheids, with growth interruptions, somewhat obscured by compression, TS, scale: 200 μm.

to the Protopinaceae, an extinct family of conifers, the specimen we describe here does not show the characteristic pitting of the Protopinaceae (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 recognition 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 different groups of animals, which shed light on palaeoecology. The

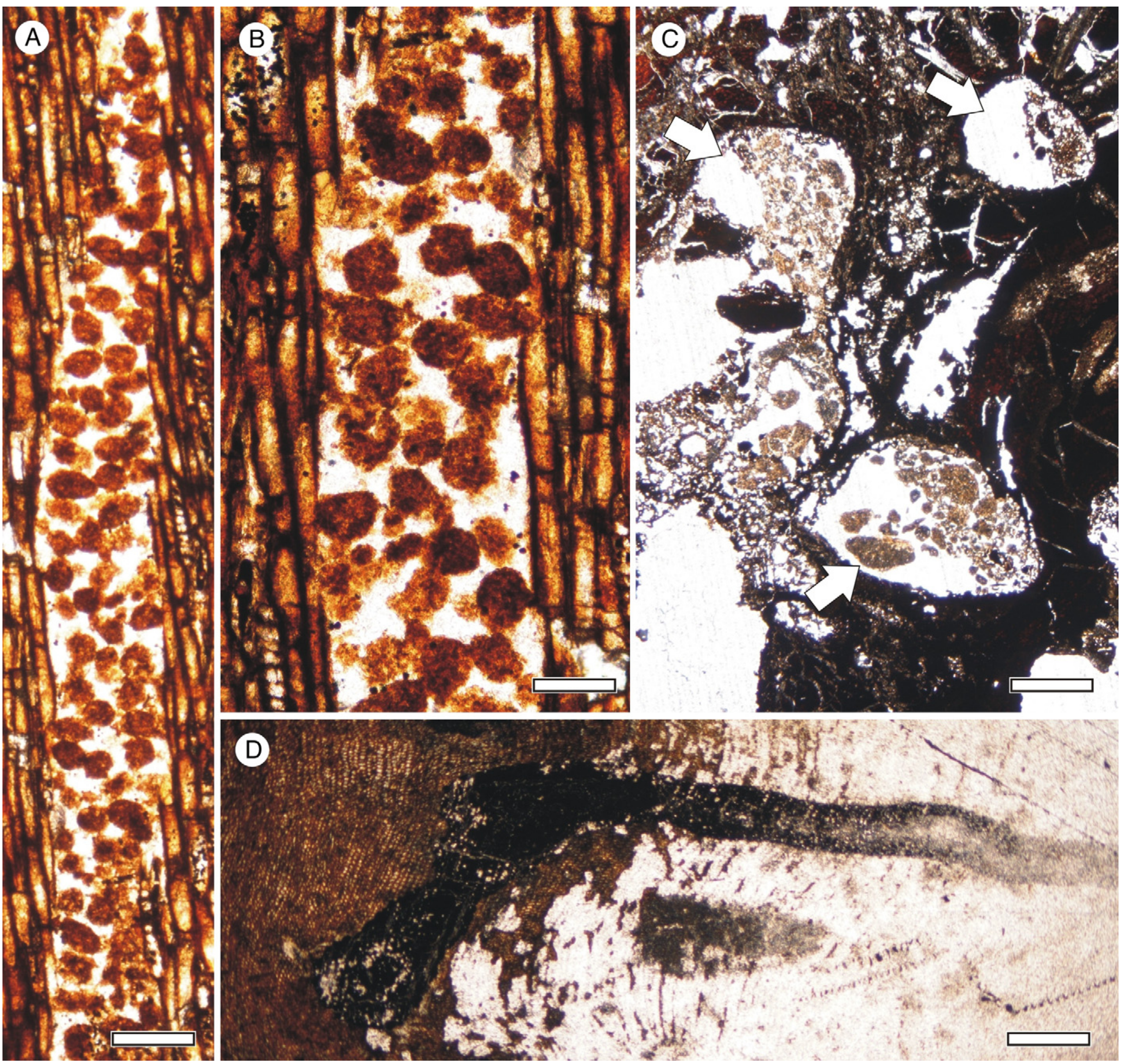

Fig. 4. Animal borings in the fossil wood specimen (*Agathoxylon* sp.) from Puez area, accessioned as 2010/0095/0001 in Naturmuseum Südtirol, Italy. A, Cylindrical chamber, orientated longitudinally, with faecal pellets of oribatid mites, TLS, scale: 200 μm. B, Close-up of oribatid mite faecal pellets 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 xylophagic 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 sinuous 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 to recent (Kelly and Bromley, 1984). These borings may be attributed to the marine teredinid bivalves and suggest that the trunk had been drifting in the sea for some time, before finally becoming waterlogged, sinking, and buried in sediment. This interpretation agrees well with the results of organic geochemical analyses (Lukeneder et al., 2012), which indicate that the fossil wood was probably intensively biodegradated in an aerobic environment prior to deposition.

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

Acknowledgements

EK and AL thank the Austrian Science Fund (FWF) for financial support (P20018-N10). HFL acknowledges receipt of a NERC Advanced Fellowship (NE/F014120/2) held at Royal Holloway University of London. We thank Arthur Kammerer, Astrid Wiedenhofer and Valentin Schroffenegger (Office for Natural Parks South Tyrol) for permits to sample in the Puez-Geisler Nature Park. Anton Englert (Vienna) and Franz Topka (Vienna) kindly prepared the thin sections and Alice Schumacher (Vienna) took the photograph used in Fig. 3. The manuscript benefited greatly from the comments of two anonymous reviewers and Marcin Machalski (Associate Editor of Cretaceous Research).

References

Bamford, M.K., Philippe, M., 2001. Jurassic-Cretaceous Gondwanan homoxylous woods: a nomenclatural revision of the genera with taxonomic notes. Review of Palaeobotany and Palynology 113, 287–297.
Bertolani Marchetti, D., 1963. Un legno di conifera silicizzato nelle argille scagliose del preappenino emiliano. Annali di Botanica 27, 405–409.
Biondi, E., 1976. Un legno fossile di tipo *Araucarioxylon* nelle «marne a fucoidi» del'Appeninno Umbro-Marchigiano (Italia centrale). Webbia 30, 479–486.
Biondi, E., 1978. *Protopodocarpoxylon pedrottii* n. sp. rinvenuta nell'Albiano delle Alpi. Studi Trentini di Scienze Naturali, Biologica 55, 17–34.
Biondi, E., 1980. *Protophyllocladoxylon* aff. *subdiphtericum* Duperon-Laudoueneix nuovo reperto fossile nelle «marne a fucoidi» dell'Appeninno Umbro-Marchigiano (Italia centrale). Webbia 34, 663–676.
Bosellini, A., 1998. Die Geologie der Dolomiten. Verlagsanstalt Athesia, Bozen/Bolzano, p. 192.
Bravi, S., 1995. Studies on old and new Meso-Cenozoic "Plattenkalk" in Southern Italy. In: 2nd International Symposium on Lithographic Limestones, Lleida – Cuenca (Spain), 9th–16th July 1995, extended Abstracts. Ediciones de la Universidad Autónoma de Madrid, Madrid, pp. 39–43.
Bravi, S., Barone Lumaga, M.R., Mickle, J.E., 2010. *Sagaria cilentana* gen. et sp. nov. – a new angiosperm fructification from the middle Albian of Southern Italy. Cretaceous Research 31, 285–290.
Bravi, S., Garassino, A., 1998a. "Plattenkalk" of the Lower Cretaceous (Albian) of Petina, in the Alburni Mounts (Campania, S Italy), and its decapod crustacean assemblage. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale in Milano 138, 89–118.
Bravi, S., Garassino, A., 1998b. New biostratigraphic and palaeoecologic observations on the "Plattenkalk" of the Lower Cretaceous (Albian) of Pietraroia (Benevento, S-Italy), and its decapod crustaceans assemblage. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale in Milano 138, 119–171.
Clerici, E., 1902. Una conifera fossile dell'Imolese. Bollettino delle Società Geologica Italiana 21, 211–215.
Dalla Vecchia, F.M., 2000. Macrovegetali terrestri nel Mesozoico italiano: un'ulteriore evidenza di frequenti emersioni. Natura Nascosta 20, 18–35.
Deiana, G., Pieruccini, U., 1974. Rinvenimento di un tronco silicizzato nella formazione delle "marne a fucoidi" della struttura mesozoica ad Est di Camerino. Bollettino della Società Geologica Italiana 93, 567–573.
Falcon-Lang, H.J., 2000. The relationship between leaf longevity and growth ring markedness in modern conifer woods and its implications for palaeoclimatic studies. Palaeogeography, Palaeoclimatology, Palaeoecology 160, 317–328.
Falcon-Lang, H.J., 2005. Intra-tree variability in wood anatomy, and its implications for fossil wood systematics and palaeoclimatic studies. Palaeontology 48, 171–183.
Falcon-Lang, H.J., Cantrill, D.J., 2000. Cretaceous (Late Albian) Coniferales of Alexander Island, Antarctica. Part 1: Wood taxonomy, a quantitative approach. Review of Palaeobotany and Palynology 111, 1–17.
Gomez, B., Thévenard, F., Fantin, M., Giusberti, L., 2002. Late Cretaceous plants from the Bonarelli Level of the Venetian Alps, northeastern Italy. Cretaceous Research 23, 671–685.
Heady, R.D., Banks, J.G., Evans, P.D., 2002. Wood anatomy of Wollemi pine (*Wollemia nobilis*, Araucariaceae). International Association of Wood Anatomists Journal 23, 339–357.
Kelly, S.R.A., Bromley, R.G., 1984. Ichnological nomenclature of clavate borings. Palaeontology 27, 793–807.
Labandeira, C.C., Phillips, T., Norton, R.A., 1997. Oribatid mites and the decomposition of plant tissues in Paleozoic coal-swamp forests. Palaios 12, 319–353.
Lehner, B.L., Knappertsbusch, M.W., Heer, P.H., 1987. Biostratigraphy, lithostratigraphy and sedimentology of the Maiolica Lombarda and the Scaglia Lombarda on the west side of Lake Garda (northern Italy). Memorie di Scienze Geologiche 39, 1–35.
Lukeneder, A., 2008. The ecological significance of solitary coral and bivalve epibionts on Lower Cretaceous (Valanginian-Aptian) ammonoids from the Italian Dolomites. Acta Geologica Polonica 58, 425–436.
Lukeneder, A., 2010. Lithostratigraphic definition and stratotype for the Puez Formation: formalization of the Lower Cretaceous in the Dolomites (S. Tyrol, Italy). Austrian Journal of Earth Sciences 103, 138–158.
Lukeneder, A., 2011. The Biancone and Rosso Ammonitico facies of the northern Trento Plateau (Dolomites, Southern Alps, Italy). Annalen des Naturhistorischen Museums Wien, Serie A 113, 9–33.
Lukeneder, A., 2012. New biostratigraphic data of an Upper Hauterivian - Upper Barremian ammonite assemblage from the Dolomites (Southern Alps, Italy). Cretaceous Research 35, 1–21.
Lukeneder, A., Aspmair, C., 2006. Stratigraphic implication of a new Lower Cretaceous ammonoid fauna from the Puez area (Valanginian - Aptian, Dolomites, Southern Alps, Italy). Geo.Alp 3, 55–91.
Lukeneder, A., Bechtel, A., Gratzer, R., 2012. New geochemical data on fossil wood from the Albian of the Dolomites (Southern Alps, Italy). Geologia Carpathica 63, 399–405.
Muscio, G., Venturini, S., 1990. I giacimenti a pesci fossili del Friuli orientale. In: Tintori, A., Muscio, G., Bizzarini, F. (Eds.), Pesci fossili italiani, scoperte e riscoperte, Milano, pp. 67–73.
Muttoni, G., Erba, E., Kent, D.V., Bachtadse, V., 2005. Mesozoic Alpine facies deposition as a result of past latitudinal plate motion. Nature 434, 59–63.
Noble, R.A., Alexander, R., Kagi, R.I., Knox, J., 1985. Tetracyclic diterpenoid hydrocarbons in some Australian coals, sediments and crude oils. Geochimica et Cosmochimica Acta 49, 2141–2147.
Ogg, J.G., Ogg, G., Gradstein, F.M., 2008. The Concise Geologic Time Scale. Cambridge University Press, Cambridge.
Otto, A., Wilde, V., 2001. Sesqui-, di-, and triterpenoids as chemosystematic markers in extant conifers – a review. Botanical Review 67, 141–238.
Peralta-Medina, E., Falcon-Lang, H.J., 2012. Cretaceous forest composition and productivity inferred from a global fossil wood database. Geology 40, 219–222.

Phillips, E.W.J., 1948. Identification of softwoods by their microscopic structure. Forest Research Bulletin 46, 1–56.
Philippe, M., 1992. Un déterminisme architectural pour les bois de conifères à ponctuation mixte (Protopinaceae Kraüsel, 1917)?. Canadian Journal of Botany 70, 1834–1839.
Scotese, C.R., 2001. Atlas of Earth History. Paleomap project, Arlington, Texas.
Stampfli, G., Mosar, J., 1999. The making and becoming of Apulia. Memorie di Scienze Geologiche (University of Padova). Special Volume of the 3rd Workshop on Alpine Geology 51, 141–154.
Stampfli, G.M., Borel, G.D., Marchant, R., Mosar, J., 2002. Western Alps geological constraints on western Tethyan reconstructions. In: Rosenbaum, G. (Ed.), Reconstruction of the evolution of the Alpine-Himalayan Orogen, Lister, G.S., Journal of the Virtual Explorer 8, pp. 77–106.
Taramelli, T., 1873. Escursioni geologiche fatte nell'anno 1872. Annali Scientifici del Regio Istituto Tecnico di Udine 6, 3–29.
Weissert, H.J., 1981. Depositional processes in an ancient pelagic environment: the Lower Cretaceous Maiolica of the Southern Alps. Eclogae Geologicae Helvetiae 74, 339–352.

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.