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Seed-cone scales from the upper Maastrichtian document the last occurrence in Europe of the Southern Hemisphere conifer family Araucariaceae

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ABSTRACT

Stratigraphically well-documented seed-cone scales belonging to the conifer genus *Araucaria* have recently been collected from marine upper Maastrichtian (uppermost Cretaceous) limestones in the type area of the Maastrichtian Stage (NE Belgium, SE Netherlands). These fossils document the youngest known occurrences of the Monkey Puzzle family (Araucariaceae) in Europe, extending the last appearance datum (LAD) for Europe 'upwards' in time for c. 18 million years. The cone scales can barely be distinguished from those of the extant *Araucaria heterophylla*, today confined to Australia. Together with an equally close similarity to an Early Jurassic scale from North America, these finds illustrate the great antiquity and constancy of seed-cone morphology within *Araucaria* section *Eutacta*. Climate change and competition with angiosperms, rather than the impact of a large extraterrestrial body (Cretaceous/Paleocene boundary event), led to the demise of *Araucaria* in the Maastrichtian type area.

1. Introduction

The earliest records of the classic Southern Hemisphere conifer family Araucariaceae date back to the Late Triassic, more than 200 million years (Ma) ago, as epitomised by the Petrified Forest, Arizona, USA (Axsmith and Ash, 2006). Nowadays, this family comprises three surviving genera (Farjon, 2001), namely *Agathis* (21 species, e.g. *A. australis*, Kauri), *Araucaria* (19 species, e.g. *A. araucana*, Monkey Puzzle) and a single species of *Wollemia* (*W. nobilis*, Wollemi Pine), which was discovered in an inaccessible gorge near Sydney, Australia as recent as 1994 (Jones et al., 1995). The prickly Monkey Puzzle from temperate South America is a well-known garden plant in Europe. Phylogenetically, *Araucaria* is placed as sister to *Agathis* + *Wollemia* on both morphological and molecular evidence (Kunzmann, 2007).

The extensive fossil record of the Araucariaceae shows that the Jurassic (c. 200–145 Ma) and Cretaceous (c. 145–65 Ma) were periods of high diversity and near-cosmopolitan distribution (Kunzmann, 2007). The trees were probably prominent elements in the landscape, especially in southern continents (Gondwana). From the Late Cretaceous onwards the family gradually declined, in number of species as well as geographically, retreating from the Northern Hemisphere to several relict areas in the Southern Hemisphere. The discovery of araucariaceous seed-cone scales in strata of Late Maastrichtian age in Belgium and The Netherlands now enables an unambiguous statement about the last European representatives of the Araucariaceae and their affinities with extant members of the family.

2. Material, localities and stratigraphy

Three stratigraphically well-documented seed-cone scales have been collected in recent years (2002–2009), two of them by J.W.M. Jagt at the ENCI-HeidelbergCement Group quarry near Maastricht (southern Limburg, The Netherlands), the other by S. Renkens at the Marnebel quarry near Eben-Emael (Liège, Belgium), about four kilometres south of the ENCI quarry. Both localities are within the Maastrichtian type area. The stratigraphically oldest specimen (NHMM JJ 12463) originates from the basal part (lower 0.3 m) of the Gronsveld Member, the two younger ones (NHMM JJ 14282, SR 523) from the upper part (upper 3 m) of the Emael Member (i.e., above the Lava horizon). Both units belong to the fully marine Maastricht Formation, which is of latest Maastrichtian (Late Cretaceous) age (Fig. 1); detailed descriptions and lithological logs of these units were published by Jagt (1999) and Felder and Bosch (2000). Fragmentary tests of two echinoid species (*Hemiaster prunella*, *Hemipneustes striatoradiatus*), an ostreid bivalve ('*Acutostrea*' *uncinella*), a serpulid

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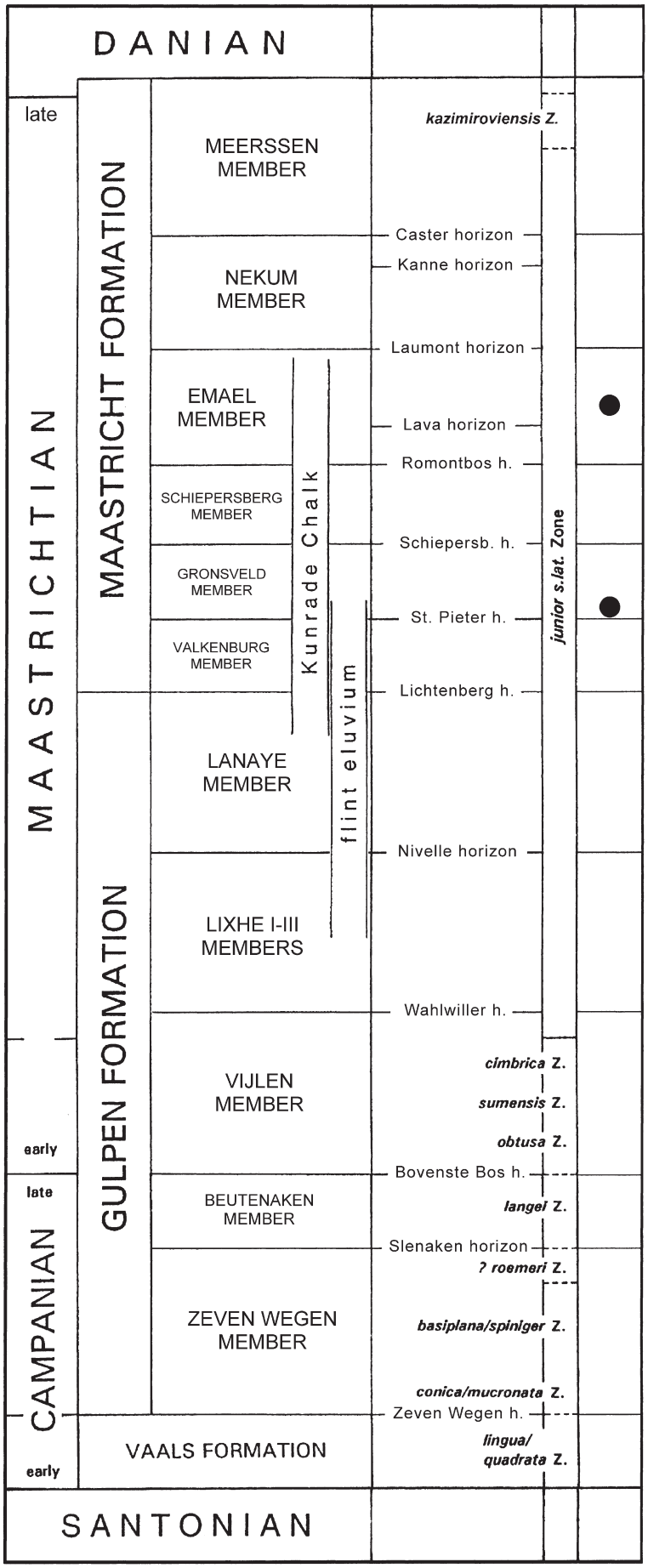

Fig. 1. Stratigraphy of Upper Cretaceous deposits in the Maastrichtian type area, showing the provenance of the *Araucaria* seed-cone scales.