

## JUGLANDACEAE POPULATION DYNAMICS ACROSS THE PALAEOCENE – EOCENE BOUNDARY FROM THE BIGHORN BASIN, WYOMING, USA

GUY J. HARRINGTON

Centre for Palynology, Dept. of Earth Sciences, University of Sheffield, Dainton Building, Brook Hill, Sheffield, S3 7HF, UK;  
e-mail: GLP9SGJH@sheffield.ac.uk

**ABSTRACT.** The Bighorn Basin in northern Wyoming, USA, contains the most comprehensively studied and complete known terrestrial Palaeocene – Eocene transition section in North America. Pollen samples have been taken from carbonaceous shales spanning this interval from the Elk Creek locality and have been studied to gain information of pollen changes across the latest Palaeocene to early Eocene. These sediments represented swamp and ponded water deposition and generally yield autochthonous palynomorph assemblages. Juglandaceous pollen is represented by *Caryapollenites* spp., *Polyatriopollenites vermontensis*, *Momipites* spp. and *Platycaryapollenites* spp. This investigation aims to briefly review the juglandaceous pollen events from the latest Palaeocene to the early Eocene and to place these events into a climate response context with reference to the MAT (mean annual temperature) estimates from leaf physiognomic data of the Bighorn Basin (Wing in press).

**KEY WORDS:** Juglandaceae, Palaeocene-Eocene, Wyoming USA

### INTRODUCTION

Direct palaeoecological modelling of Juglandaceae pollen from the late Palaeocene is difficult to achieve. It is apparent from the pollen record that pollen morphologies referable to the Hicoreae, Juglandae and Engelhardiae tribes of the Juglandaceae are represented by *Caryapollenites* spp., *Polyatriopollenites vermontensis* and *Momipites* spp. but the megafloora fossil record indicates that these tribes were not developed on the basis of fruits until the Eocene (Manchester 1987). Leaves of “*Carya*” *antiquorum* and “*Pterocarya*” *glabra* are present in the Bighorn Basin late Palaeocene but these are not considered as true representatives of either *Carya* sensu stricto or *Pterocarya* sensu stricto (Manchester 1987, Wing 1994, Wing in press). The relationship between the pollen and plants of the fossilised Juglandaceae is thus tentative, on morphological grounds the pollen can confidently be associated with the Juglandaceae but it bears little relationship to either generic or even tribal level plant associations (cf. Manchester 1987). By the early Eocene, however, greater confidence is placed on pollen – plant associations with the development of clearly defined tribal features in other fossil organs of the Juglandaceae (Manchester 1987, Manchester *et al.* 1994, Manchester & Dilcher 1997). Juglandaceous pollen records are thus a highly artificial measure of change that for many form-genera in the Palaeocene are divorced from actual plant ecology and cannot be interpreted in such ecological terms. The presence of juglan-

daceous pollen therefore is taken as a meaningful statement of the presence of the family and possible dynamism of its constituent predecessor tribes which are unknown from the megafloora. Reconstructions of various organs of *Polyptera manningii* Manchester & Dilcher 1997 and *Platycarya castaneopsis* (Lesquerux) Wing & Hickey 1984 suggest that these ancient juglandaceous genera and species behaved in a similar fashion to extant members of the Juglandaceae in being early successional taxa, adapted for growth in stressful environments such as open or unstable ground and being dominant in the late stages of hydrosere. Quaternary pollen fossil evidence suggests that the palynological behaviour of Juglandaceae genera such as *Carya* and *Pterocarya* are consistent with interpretations of increased precipitation in summer, increasing summer warmth and considerable environmental wetness (Bartlein *et al.* 1986, Follieri *et al.* 1988, Prentice *et al.* 1991). From the limited ecological reconstructions of the Palaeogene, presence of the Juglandaceae presumably implies warmth, high precipitation and moist soils.

### RESULTS

#### CLARKFORKIAN (LATE PALAEOCENE)

The middle to late Clarkforkian is characterized by abundant juglandaceous pollen. Particular relative abun-

dances of *Polyatriopollenites vermontensis*, *Caryapollenites* spp. and *Caryapollenites veripites* are noted which are apparently antithetic in their peak abundances. The *Momipites* spp. are stable and essentially static in representation. The interval marked by the carbon isotope excursion is barren but immediately after this the pollen flora demonstrates a large drop in Juglandaceae pollen representation together with a general rise in pollen of Tiliaceae, Ulmaceae, Betulaceae-Myricaceae and Taxodiaceae morphological affinity.

#### WASATCHIAN (EARLIEST EOCENE)

The first appearance of *Platycaryapollenites* spp. marks the start of the Eocene but its pollen representation is highly sporadic. *Caryapollenites wodehousei/Momipites amplius*, *Momipites tenuipolus*, *M. triradiatus*, *M. ventifluminis*, *M. waltmanensis* and *M. wyomingensis* all suffer extinct between the 100 m – 300 m level of the composite Elk Creek section which marks the only noteworthy trend in the *Momipites* form-genus. Between the 300–400 m levels there is the extinction of *Carvapollenites imparalis/inelegans* together with *Momipites anellus*. This decline is associated with the temporary rise in pollen of *Polyatriopollenites vermontensis* and *Platycaryapollenites* spp. Large scale expansion of *Platycaryapollenites* spp. is noted between the 420 m – 620 m levels and at the 620 m level it is the dominant juglandaceous pollen form.

#### PALAEOCENE – EOCENE CLIMATE ESTIMATES

MAT across the Palaeocene – Eocene boundary indicates that a warming trend is traced across the Clarkforkian from circa 13.5° C at the base to circa 18.5° C at the top of the Clarkforkian (Wing in press). A temperature decline is noted in the earliest Eocene from both leaf physiognomy MAT and from oxygen isotopic evidence (Koch *et al.* 1995, Wing in press). The lowest temperature of circa 10.5° C is recorded from the 350 m level on the Elk Creek section which represents a steady drop throughout the previous ~2 million years of Wasatchian time (Wing in press). The onset of the early Eocene temperature maximum is recorded from about the 600 m level and coincides with the *Platycarya abundance* plant zone of Wing *et al.* 1991. Sediment, palaeobotanic and isotopic evidence suggests that seasonality became stronger in the latest Clarkforkian (Wing 1987, Dettmann & Lohmann 1995) although the effects of this on vegetation are currently unclear.

#### CONCLUSIONS

1) Temperature increase alone is insufficient to explain the alterations in *Caryapollenites* and *Polyatriopollenites vermontensis* in the latest Palaeocene but may be controlled some other facet of climate change such as increased seasonality or precipitation changes.

2) This same process may explain the restriction of the Juglandaceae in the latest Palaeocene interval after the carbon isotope excursion which cannot be explained by temperature alone (leaf analysis indicates that the MAT for this time was circa 18.0° C which is only circa 0.5°C lower than the pre-isotope excursion estimates)

3) Pollen of the *Momipites* suffer a degree of extinction when the temperature declines between the 100–300 m level. This implies that the relative stability of the *Momipites* spp. is a function of the thermophilic tendencies of its parent plant groups that thrived in the middle to late Palaeocene.

4) The effects of the carbon isotope excursion on the Juglandaceae are unknown; whether the decline of the Juglandaceae is a direct feature of the excursion is unclear and may be independently related to the post-excursion climate fluctuations

5) The expansion of *Platycaryapollenites* spp. suggests that large scale warming and its unbalancing effect on the early Eocene vegetation aided its domination of the pollen and megafloral fossil records.

6) Juglandaceous pollen within the Palaeocene – Eocene Bighorn basin appears to respond therefore to both climate warming and cooling by the extinction of certain species, the general abundance or absence of the Juglandaceae family, and by the expansion or contraction of some of the juglandaceous constituent form-genera.

7) Palynological abundance of the Juglandaceae seems to compare favourably with the estimated MAT across the Palaeocene – Eocene boundary in that warm temperatures are associated with abundant juglandaceous pollen and cooler climates with species extinction and relatively lower relative pollen representation. However, the comparison is not exact and precipitation and incipient environmental wetness may be of equal importance to temperature in explaining the patterns of pollen change.

#### ACKNOWLEDGEMENTS

The author extends his gratitude to Dr S.L. Wing of the Smithsonian Institution for his work in organising the field collection of pollen samples from the Elk Creek locality, allowing access to the Smithsonian Collection and offering support and advice on all things connected with the Bighorn Basin. This research was conducted under the tenure of NERC grant GT4/95/281/E.

## REFERENCES

- BARTLEIN P.J., PRENTICE I.C. & WEBB T. III. 1986. Climatic response surfaces from pollen data for some eastern North American taxa. *Journal of Biogeography*, 13: 35–57.
- DETTMANN D.L. & LOHMANN K.C. 1993. Seasonal change in Palaeogene surface water  $\delta^{18}\text{O}$ : fresh-water bivalves of western North America. In: Swart, P. K. *et al.* (eds.) *Climate Change in Continental Isotopic Records*. Geophysical Monograph, 78: 153–163.
- FOLLIERI M., MAGRI D. & SADORI L. 1988. 250,000 year pollen record from Valle di Castiglione (Roma). *Pollen et Spores*, 30: 329–356.
- KOCH P.L., ZACHOS J. C. & DETTNIANN D.L. 1995. Stable isotope stratigraphy and palaeoclimatology of the Palaeogene Bighorn Basin (Wyoming, USA). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 115: 61–89.
- MANCHESTER S.R. 1987. The fossil history of the Juglandaceae. *Missouri Botanical Garden Monograph*, 21: 1–137.
- MANCHESTER S.R. & DILCHER D.L. 1997. Reproductive and vegetative morphology of *Polyptera* (Juglandaceae) from the Paleocene of Wyoming and Montana. *American Journal of Botany*, 84(5): 649–663.
- MANCHESTER S.R., COLLINSON M.E. & GOTH K. 1994. Fruits of the Juglandaceae from the Eocene of Messel, Germany and implications for early tertiary phytogeographic exchange between Europe and western North America. *International Journal of Plant Sciences*, 155: 388–394.
- PRENTICE I.C., BARTLEIN P.J. & WEBB T. III. 1991. Vegetation and climate change in eastern North America since the last Glacial maximum. *Ecology*, 72(6): 2038–2056.
- WING S.L. 1987. Eocene and Oligocene floras and vegetation of the Rocky Mountains. *Annals of the Missouri Botanical Garden*, 74(4): 748–784.
- WING S.L. 1994. Fossil plant localities: In: Bown T.M., Rose K.D., Simons E.L. & Wing S.L. *Distribution and stratigraphic correlation of upper Paleocene and lower Eocene fossil mammal and plant localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming*. United States Geological Survey Professional Paper, 1540: 54–60.
- WING S.L. (in press). Late Paleocene – early Eocene floral and climatic change in the Bighorn Basin, Wyoming. In: Berggren W. A., Aubry M. & Lucas S. (eds.) *Late Paleocene – Early Eocene Biotic and Climatic Events*. Columbia University Press, New York.
- WING S.L. & HICKEY L.J. 1984. The *Platycarya perplex* and the evolution of the Juglandaceae. *American Journal of Botany*, 71(3): 388–411.
- WING S.L., BOWN T.M. & OBRADOVICH J.D. 1991. Early Eocene biotic and climatic change in interior western North America. *Geology*, 19: 1189–1192.