Context and palaeobiological potential of one of the earliest known amber deposits, from the lowest Cretaceous of Sussex

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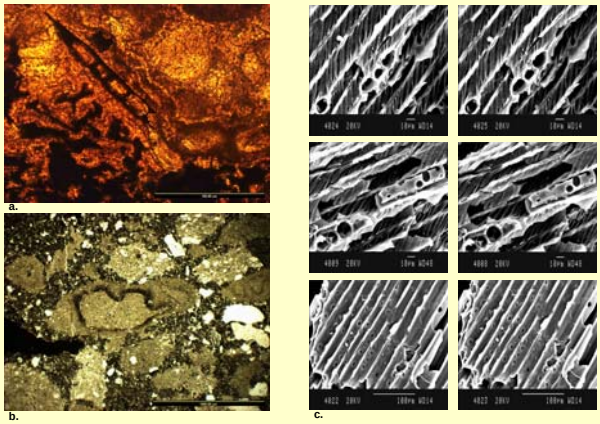
Introduction

Amber is an important lägerstatten deposit, able to preserve organisms in exceptional detail that would otherwise be missing from the fossil record. However, there are few pre-Cretaceous deposits and amber remains rare in the lower Cretaceous, with only a handful of known fossiliferous localities. Amber does not begin to become more widespread until the Aptian-Albian, when large changes have taken place in forest ecosystems. A new discovery of *in situ* amber with inclusions from the Berriasian of Sussex is being studied by the Oxford Palaeobiology Group. The geological setting of the amber is remarkably complete and indicates that forest fires may have played a significant role in early amber formation. Within the amber, inclusions studied by us include the oldest known spiders silk and possible faecal pellets - making this the oldest amber with arthropod traces. The Sussex amber deposit therefore gives important insights into early Cretaceous amber formation and terrestrial ecosystems at that time.

Geological Setting

The amber is found in a fluvial-lacustrine sequence in the Fairlight clays (Berriasian age) of Sussex. The beds consist of a soft grey clay, containing large amounts of gymnospermous fusain in which the amber is usually found. The fusain is also found as inclusions within the amber – indicating a plausible link between charcoalification and the amber formation itself.

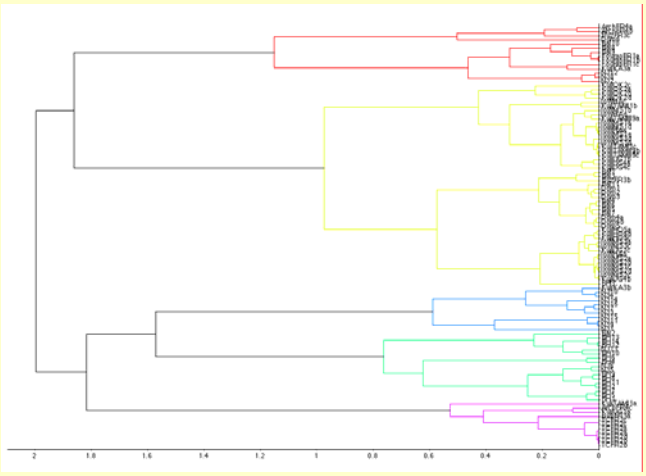


a. b. c.

a) Sussex amber in thin section showing charcoalified ray; b) thin section of amber-bearing rock, rich in organic matter and peloids of probable pedogenic origin; c) stereopaired images of fusain showing fused cell walls, helical structures due to charcoalification (cf. Collinson *et al*., 1999) and bordered pits (bottom) indicating coniferous wood.

FTIR

FTIR (Fourier transform infra red spectroscopy) was used by us to fingerprint the Sussex amber, allowing chemical comparison with other Cretaceous and younger ambers. Cluster analysis of these results allows us to test how such spectra may yet be used to differentiate between the various amber provenances and their possible tree types.

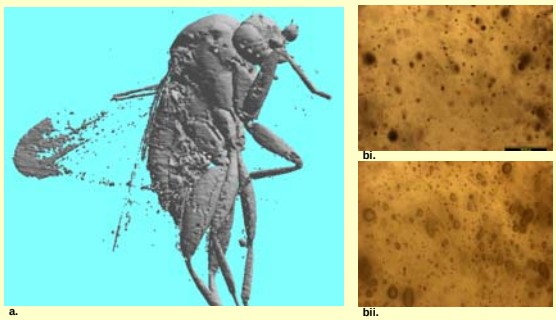


Results of cluster analysis using the near infra-red part of the spectra taken, displayed as a hierarchical tree.

Imaging

Automontage software is being pioneered by us for the study of amber, and is here reported for the first time (see b, below). This technique can splice together a number of (usually 10 – 40) images taken at different focal planes, to bring small and complex structures within the amber – such as spider's silk webbing - into a single focal plane.

X-ray tomographic (XMT) imaging of arthropods in amber is also being explored by us (see a, below, from Baltic amber).

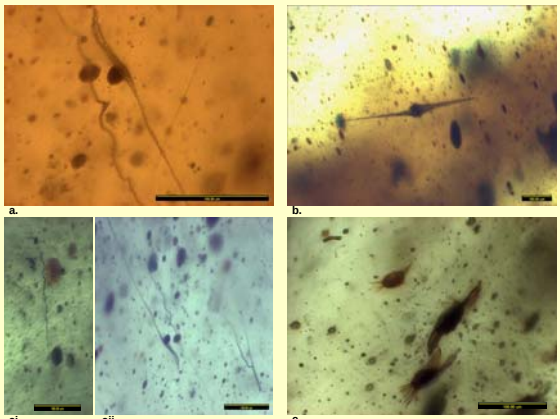


a. bi. bii.

a) 3D XMT image of fly in Baltic amber; b) Amber images created without (i) and with (ii) the use of Automontage

Inclusions

The amber is inclusion-rich, containing many infilled droplets and biological materials. The latter includes silk and possible faecal matter. Until this study, the earliest silk known was from the Lebanese amber (127-132Ma; see Zschokke, 2003), but the Sussex amber predates this by some 10 Ma. This makes it the oldest amber with arthropod trace fossils and demonstrates the potential for further arthropod discoveries.



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a-aii.) Images of the silk in Sussex amber. Note the pairing of threads, typical for spider silk; b) "Incertae sedis" - an as yet unidentified inclusion crossing the amber flow; c) Exudates or "bubbles" can misleadingly mimic biological structures such as protozoans, owing to minute fracture planes.

Conclusions

- Well-preserved geological setting. The earliest amber can now be placed into a context of forests and fossil soils situated near to lake margins.
- Links are emerging between the early evolution of amber resins and massive forest fires in the earliest Cretaceous.
- Oldest known spiders silk, revealed by Automontage, points to the potential for further exciting discoveries.
- FTIR suggests the amber is chemically most similar to the New Jersey material of Late Cretaceous age.
- FTIR shows considerable potential for further amber investigation.

Glossary

Amber- fossilised resin.
Lägerstatten- remarkable fossil deposit.
Fusain – fossilised charcoaified wood.
Rays – sheets of living cells which run horizontally through the wood of a tree.
Pits – act like valves between tracheids; if air gets into the system the pressure difference causes the valve to close.
Tracheids – tubes composed of elongate dead cells which run longitudinally through the wood.

References

Collinson, M. E., Featherstone, C., Cripps, J.A., Nichols, G.J., Scott, A.C. 1999. Charcoal-rich plant debris accumulations in the Lower Cretaceous of the Isle of Wight, England. *Acta Palaeobotanica Supp.* **2**. 93-105.

Zschokke, S. 2003. Spider-web silk from the early Cretaceous. *Nature* **424**, 636-637.

Acknowledgements

We would like to thank the discoverers, Jamie and John Hiscocks, for help with the field work and for the provision of samples. Chris Nicholas and Didier Néraudeau are thanked for providing samples for FTIR, Cedric Dicko for help with FTIR and Heather Johnstone for help with XMT imaging. Finally, many thanks to Derek Siveter who co-supervised the project.