Cold Ash, Berkshire

[SU 500 714]

Introduction

Sediments in the Reading Formation (Lambeth Group) at Cold Ash Pit near Newbury in Berkshire have yielded insect fossils along with a diverse flora from the Palaeocene–Eocene transition of early Paleogene age (*c.* 55 Ma); indeed Cold Ash is an important GCR fossil plant site (Cleal *et al.,* 2001) whose unusually well-preserved flora includes various plant elements (foliage, fruit and seeds). The combination of these elements allows the partial reconstruction of several plant species. Detailed examination of the abundant plant fossils also revealed unique evidence for plant/insect interactions. Cold Ash was first identified as a major source of palaeo-botanical material in the mid-1970s by Peter Crane and Roland Goldring (Crane and Goldring, 1991) when sand-working at the site was expanding, but by the 1980s this activity had finished and most of the pit was subsequently infilled. One of the fossil-bearing pockets of mudstones was conserved by the former English Nature and provides the continuing interest in the site.

There are some old records of occasional insect finds elsewhere in the Woolwich and Reading Beds, for instance beetles at Peckham, in London, but the Newbury pits in Berkshire provide the best potential for future finds of fossil insects of this age. In addition to the fossil arthropod importance of this site, the area is also selected for the GCR for the Tertiary Palaeobotany selection category (Cleal *et al* 2001).

Description

Sedimentary succession

The stratigraphy of the old quarry site, as exposed at its previous maximum extent, revealed a sedimentary succession dominated by unconsolidated and poorly consolidated cross-bedded sands of the Reading Formation, above a few metres of sediments forming the Upnor Formation and then the underlying Chalk (Figure 5.13). The Reading Formation represents the transitional interval between the Palaeocene and Eocene Epochs of the Palaeogene Period. The plant and insect fossils occur in lenticular bodies of silty clay within the arenaceous Reading Formation and are thought to represent abandoned channel fills or muds deposited at low water (Crane and Goldring, 1991). Fossil plants were reported from five lenses, only one of which remains after the quarrying activity but that single lens is still conserved.

Palaeontology

None of the Cold Ash insect species are known elsewhere, although some of their genera are present elsewhere. Since Palaeocene insects are uncommon worldwide, but inform us about the biotic recovery following the Cretaceous–Tertiary extinction, there is considerable palaeontological interest and importance attached to the Cold Ash entomo-fauna. Furthermore, it complements the Palaeocene-age Ardtun GCR site on Mull by preserving additional groups of insects such as Lepidoptera (moths) and Heteroptera (true bugs). These are preserved as trace and body fossils at Cold Ash.

Jarzembowski (1989a) has described the unique preservation of the leaf mines produced by both Lepidoptera and Diptera from the fossil flora of Cold Ash. Other pits at a similar stratigraphical horizon in the area have provided further unpublished information about leaf galling and possible beetle borings in wood of *Entandrophragminium lewisii* Crawley, 2001 (Meliaceae). Leaf mines and galls have also been described from the mid-Eocene age Branksome Sand Formation at Bournemouth Cliffs (Lang *et al.,* 1995): these were based purely on museum collections and the sites have been lost due to the building of amenity and sea-defence structures. The Cold Ash leaf mines are better preserved than those found at Bournemouth which are decarbonized.

The leaf mines from Cold Ash have been named by Jarzembowski (1989a) as a new species of the ichnogenus *Stigmellites,* S.? *gossi* Jarzembowski, 1989 and *S.? centennis,* both from plant bed E. The former resembles the Recent

Stigmella pomivorella (Packard) and the latter, the Recent *Nepticula hemargyrella* Kollar. The leaves are too fragmentary for detailed identification but both leaf mines are thought to have been produced by the larvae of nepticulid moths. Another leaf mine found on the leaves of *Platanus schimperi* (Heer) from plant beds C and E is less readily identifiable but is thought by Jarzembowski (1989a) to have been produced by dipteran rather than lepidopteran insect larvae and has been placed in a new monobasic ichnogenus *Foliofossor cranei* Jarzembowski, 1989.

Mining within a leaf provides small moth larvae with a source of fresh plant food and some protection from the surrounding environment which is not available to free-living caterpillars. In the early 1980s, this fossil evidence for leaf mining from Cold Ash was the earliest known in Lepidoptera but in recent decades older insect fossil leaf mines have been recovered from mid Cretaceous angiosperms and a radiation of this habit seems to relate to the early radiation of the flowering plants at this time. However, there are also even older insect leaf mines dating back to Triassic times. They are developed in ferns and predate the evolution of the Lepidoptera so that the first radiation of the mining habit was initiated by some other group of insects on a different kind of host plant. Lepidoptera appeared in Jurassic times as small species before the angiosperms so there may have been some host transfer involved. Leaf mining has arisen independently in different insect groups as shown by the fossils from Cold Ash.

The somewhat younger *c.* 34 Ma (latest Eocene), and even more abundant and diverse fossil plants from Florissant in Colorado in the USA, record an even bigger range of plant–insect interactions, such as leaf margin feeding, hole feeding, skeletal feeding, galls, leaf cutting and leaf mining. A quantitative study of insect damage on Florissant fossil leaves (Smith, 2000a,b; Meyer, 2003) shows that 23 % of the fossil leaves had insect damage, with 1.4 % of the total leaf area, of all leaves examined, having been removed by insect herbivory. Interestingly, this is much less than found in a sample of six modern forests, where 72–90 % of the leaves had been damaged and 4–10 % of the leaf area has been removed. The rare leaf mines at Florissant were excavated in leaves of the souca or piocha (*Thichilia,* a meliacean (Figure 5.15) an extant deciduous tropical subcanopy tree whose flowers have been preserved in Dominican amber of Tertiary age (Poinar and Poinar, 1999).

However, it has also been postulated that insect herbivory increases with rising temperature at any given latitude (Wilf and Labandeira, 1999). Wilf and Labandeira tested the idea using abundant fossil data from late Palaeocene-early Eocene deposits of south-western Wyoming in the USA (e.g. the Green River Basin, their, fig. 2) and did indeed find that global warming at that time was reflected by an increase in more types of insect damage (such as leaf mining) per host species and higher attack frequencies.

The diverse flora, recovered from Cold Ash, is dominated by fossils derived from angiosperm trees of the plane, katsura and walnut families. The Cold Ash flora contains type material upon which some important aspects of global palaeobiogeography have been built. It includes the only recorded example of Palaeogene *Rhododendron* from anywhere in the world and the earliest known member of the tribe Coryleae, which subsequently became specialized for animal dispersal (Collinson, 1999a,b).

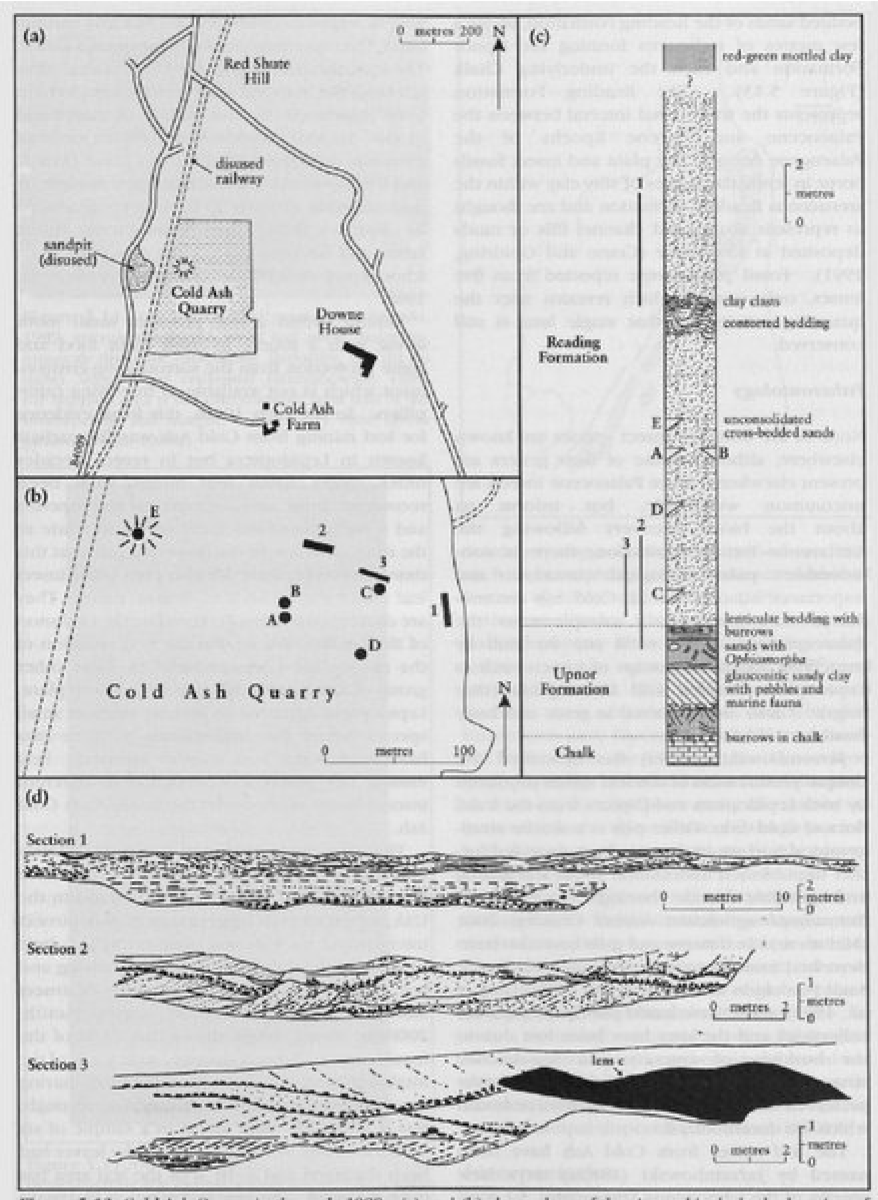
Interpretation

Much of the Cold Ash flora remains to be documented and there is potential for the collection of further material from the site. Felpham is the only other site in the Reading Formation that also has such potential. There is some floral similarity between Ardtun in the Western Isles of Scotland and Cold Ash at the family level but there are no species in common. According to Kvacek (1994) such similarities reflect the migration of high latitude elements into the paratropical forests of central Europe and are thus crucial for developing our understanding of the Tertiary vegetational history of Europe. The fossil insects of Ardtun and Cold Ash inform us about the entomofauna just prior to the Eocene climatic optimum.

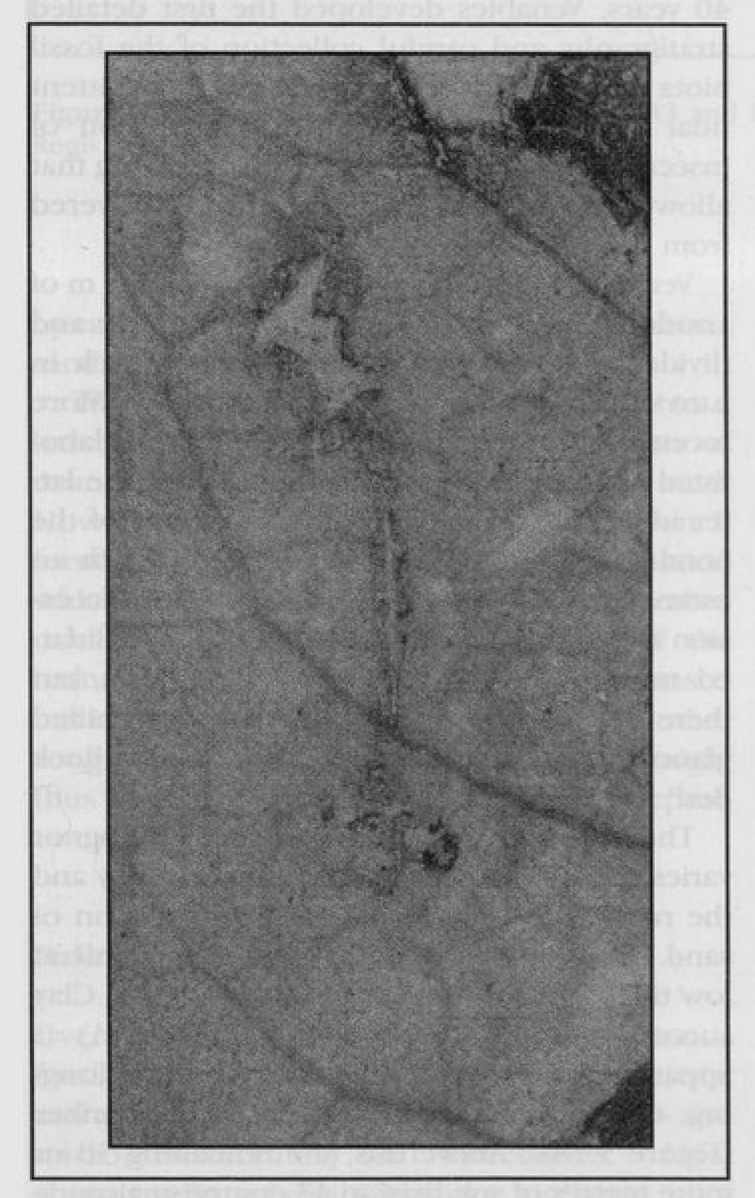
Conclusions

Cold Ash has famously yielded an internationally significant flora from the Palaeocene–Eocene transition beds (Reading Formation) of southern Britain, with an age of some 54 Ma. Preserved within the fossil flora from this site is unique evidence of insect plant co-evolution in the form of leaf mines and there is the potential for further investigation of the remaining fossiliferous deposits.

References



(Figure 5.13) Cold Ash Quarry in the early 1980s; (a) and (b) show plans of the site and include the location of the sections represented in (d). Also shown are the locations of the main plant-bearing lenses (A to E) on the composite stratigraphical section (c). (After Crane and Goldring, 1991.)



(Figure 5.15) Trichilia leaf from Florissant, Colorado, demonstrating leaf mining activity (x 6). The egg was laid at the base; the larva then tunnelled through leaf tissue, eventually making a pupation chamber — seen as the hole at the top. (From Meyer, 2003.)