Ardtun, Strathclyde

[NM 379 248]

Introduction

At the Ardtun GCR site in the Western Isles of Scotland (Figure 5.1) and (Figure 5.9) insect fossils are preserved in a geological setting that is unique amongst the Tertiary strata of Britain. Furthermore, this is the only significant Tertiary palaeoentomological site in Scotland. The entomofauna here has been known since the 19th century and the most significant collective work on the fauna was that of Zeuner (1941). Only half of the known species have been named formally (although these have mostly been commented upon by late-twentieth century workers).

The Ardtun site consists of coastal cliffs and gullies along the southern shore of Loch Scridain, a deep, fjord-like, sea loch in the southwest of the Island of Mull (Figure 5.9). Here there are exposures of the basal lavas (olivine basalts of Upper Palaeocene–Lower Eocene, *c.* 55 Ma age) of the Plateau Formation that form one of three formations making up the Mull Lava Group ((Figure 5.9) and ((Figure 5.10); Emeleus and Gyopari, 1992). Interbedded with the lavas are the sand, gravel and shaley sediments that make up the Ardtun Leaf Beds and contain the fossil insects.

The sediments were originally discovered in the early 19th century by a local man from the nearby village of Bunessan. They were first fully investigated by the then Duke of Argyll, who was well known for his interest in the natural sciences. However, the subsequent description of the sediments and their contained fossils was made by Forbes (1851). For the history of palaeobotanical investigation see Cleal *et al.* (2001, p.181). The find was of major significance in the study of the geology of the Tertiary volcanic rocks of the region because the rich fossil flora allowed the sequence to be given a relative age (early Tertiary) for the first time. This has since been confirmed by radiometric dating of the lavas (Mussett, 1986) at *c.* 5$ Ma. In addition to the fossil arthropod importance of this site, the area is also selected for the GCR for the Tertiary Igneous and Tertiary Palaeobotany selection categories (Emeleus and Gyopari, 1992, and Cleal *et al.,* 2001).

Description

Geological setting

In early Paleogene times, lithospheric thinning of the crust between Greenland and northern Britain led to intense volcanic activity along the continental margin of north-western Europe and ultimately the formation of new ocean crust around 55 Ma. Vestiges of this volcanism are preserved along the west coast of Scotland and especially on the island of Mull. Intermittent igneous activity led to the development of a lava field and interbedded sediments within the North Atlantic Tertiary Igneous Province, a belt of Palaeogene igneous rocks and intrabasaltic sediments that stretch from Rockall to Spitsbergen, ranging in age from 58.5–55 Ma.

The lavas at Ardtun belong to the Mull Plateau Lava Formation, the middle of three formations that comprise the overall architecture of the Mull Lava Field that has an overall thickness of about 1800 m. The stratiform flow sequences were dominated by subaerial lava facies, ranging in composition from alkaline olivine basalts to trachytes with some tholeiites. Eruption was from fissure systems now represented by dyke swarms and from some central vents now represented by deeply eroded central igneous complexes. Between the lavas there are a variety of pyroclastic, epiclastic and volcaniclastic deposits, including tuffs and lahars, along with fluviatile and lacustrine sediments. These were deposited in quiescent phases within the eruptive sequence during which there was weathering, erosion and landscape development with the formation of soils, vegetation and extensive drainage systems (Figure 5.10).

Stratigraphy

The sedimentary succession at Ardtun varies in thickness between 4 and 15 m and was de posited upon the upper slaggy amygdaloidal zone of a thick columnar lava flow and is covered by a second major flow. Both flows show

well-developed columnar cooling joints and the lavas are olivine basalts of the Staffa magma Type (Thompson *et al.,* 1986).

The best section through the sediments is seen in the ravine at Slochd an Uruisge and has been described in detail by Skelhorn (1969). The sediments are predominantly flint-bearing conglomerates and grits (*c.* 6 m thick) of the Ardtun Conglomerate Member that represent the first major hiatus in the volcanism of the region. The sedimentary sequence represents an alluvial debris fan deposit with three interbedded finer-grained horizons (Upper, Middle and Lower) of silty sandstone and clay that form the Ardtun Leaf Beds. These finer-grained beds have been interpreted as fluviatile and lacustrine units (Jolley, 1997) and contain an abundant fossil flora and rare fossil insects.

Palaeontology

Ardtun is the richest site in the UK for insects representing the Brito-Arctic Igneous Province (BIP) with over 16 species in at least six orders (in contrast, only solitary finds are known from the BIP in Northern Ireland). The entomofauna provides insight into the early Tertiary fauna of high northern latitudes (in contrast to the entomofauna found further south in the UK and continental Europe). Dating from the late Palaeocene at 58 Ma, the entomofauna (Figure 5.12), is found associated with a rich and significant fossil flora including the leaves of maidenhair tree (*Ginkgo*) and tree-forming angiosperms such as plane (*Platanus*), hazel (*Corylus*) and oak (*Quercus*). The plant remains are exceptionally well preserved, some being more than 30 cm in length (Cleal *et al.,* 2001).

The insects are mainly disarticulated remains found in interbasaltic, fine-grained siliciclastic sediments (Ardtun Leaf Beds). The fauna includes aquatic and terrestrial forms comprising beetles (Coleoptera, (Figure 5.12)c), flies (Diptera: 'March' and Craneflies, Krzeminski, (Figure 5.12)a), a long-horned grasshopper or bush cricket (Orthoptera), a dragonfly (Odonata), a caddisfly (Trichoptera, (Figure 5.12)f) and several kinds of bugs (Homoptera: a cicada, spittlebug and leafhopper, (Figure 5.12) b,c).

All of the species are extinct and unique to Scotland as well as many of the genera. Their affinities are mainly (but not exclusively) with modern non-European fauna, for example the cicada *Eotettigarcta scotica* (Whalley, 1983; (Figure 5.12)b) has upland south-east Asian affinities. Cicadas no longer range as far north as Scotland. Some species are the earliest representatives of their groups, for example the anostostomatid orthopteran *Zeuneroptera scotica* (Gorochov, 1995; (Figure 5.12)d) is the earliest representative of stenopelmatoids.

An accompanying sparse fauna includes molluscs (Cooper, 1979). The lowest leaf bed is underlain by a thin coal seam below, which is a 0.15–0.20 m whitish concretionary seat-earth clay containing root traces. The Ardtun flora also differs from the Reading Formation plant fossils of southern England in being dominated by deciduous species of both conifers and hamamelidids. The reason for this may partly be due to the more northerly latitudes of the site. However, despite its high latitude, the flora does not represent cold-climate vegetation, but temperate or even warm-temperate conditions that prevailed in very early Tertiary times. Also the location within a highly active volcanic region of disturbed habitats, poor soils and acid rain no doubt also played a role.

Comparison with other localities

Several sites within the region have yielded fossil plants but Ardtun is in many ways the key locality. Similar contemporaneous floras are known from comparable geological settings in County Antrim (Northern Ireland, see Watts, 1970) but without such a diversity of plants being preserved and only very rare insect fossils. Within the BIP but beyond Britain, plant macro-fossils of this age are also found in eastern Greenland and Spitsbergen. Of these localities, Spitsbergen is the only locality that matches Ardtun in diversity with 13 species of conifers and angiosperms. However, the balance of taxa is quite different and is associated with swamp forests rather than riparian vegetation as found at Ardtun.

Interpretation

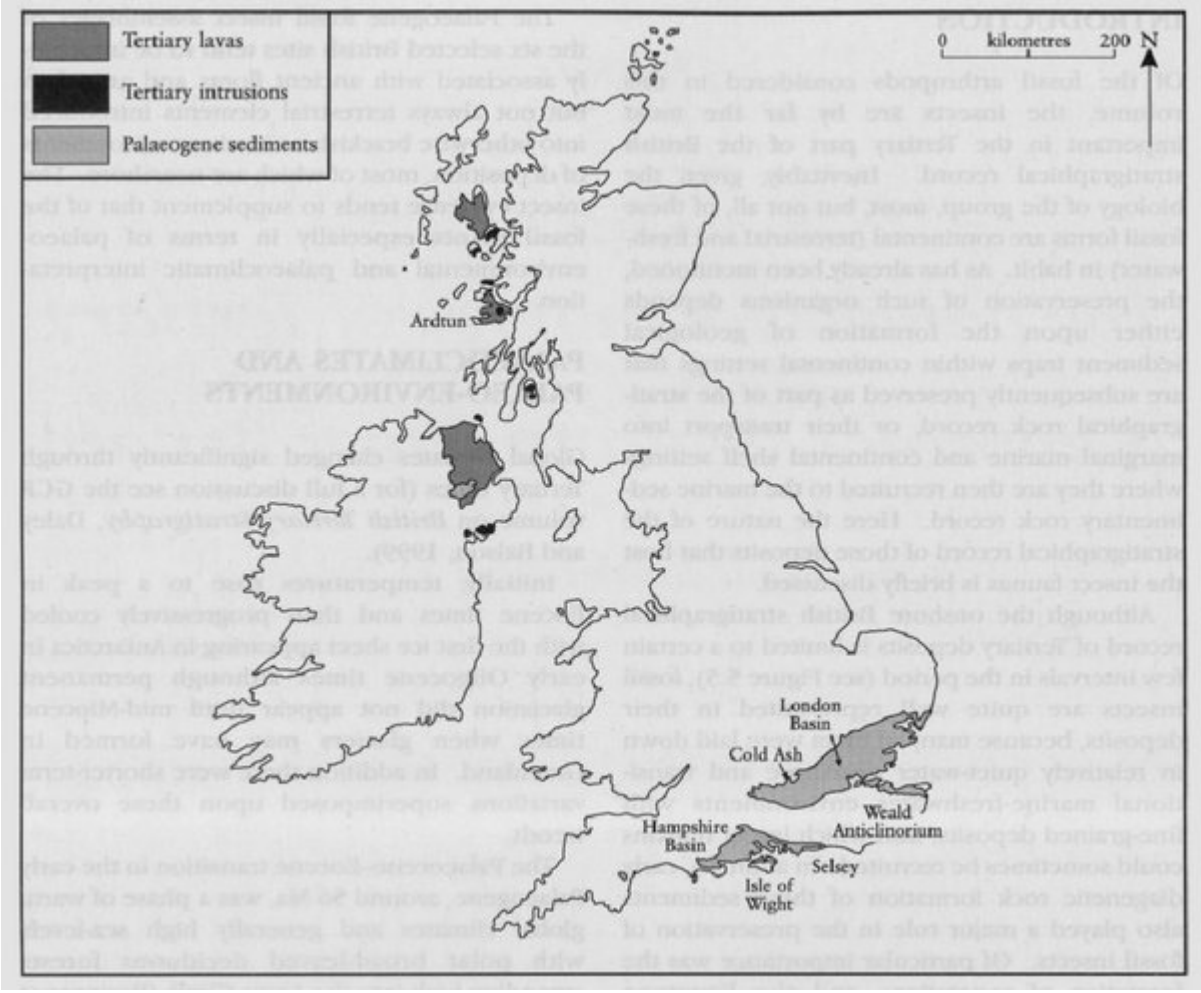
The Artun sedimentary deposits provide evidence for extended intervals of weathering and erosion of nearby landscapes and sedimentation in lake basins between phases of lava effusion from nearby fissures. The sediments and flora indicate deposition in a shallow, ephemeral and stagnant fluvio-lacustrine environment with shallow lake, swamp and marsh environments, all of which were intermittently overflowed by lavas which generated pillow structures on contact with the lake waters. The composition of the flora indicates that there was a warm temperate climate at the time and the flora has been correlated with other northern European early Tertiary fossil floras (Seward and Holtum, 1924), although the Mull flora is now considered to be the oldest at some 55 Ma and of Paleocene age.

The varied terrestrial and aquatic insect fauna includes a primitive leafhopper, the earliest stenopelmatoid bush cricket, and a primitive cicada with south-east Australian affinity constituting the most northerly record of a true cicada in the British Isles (Figure 5.12).

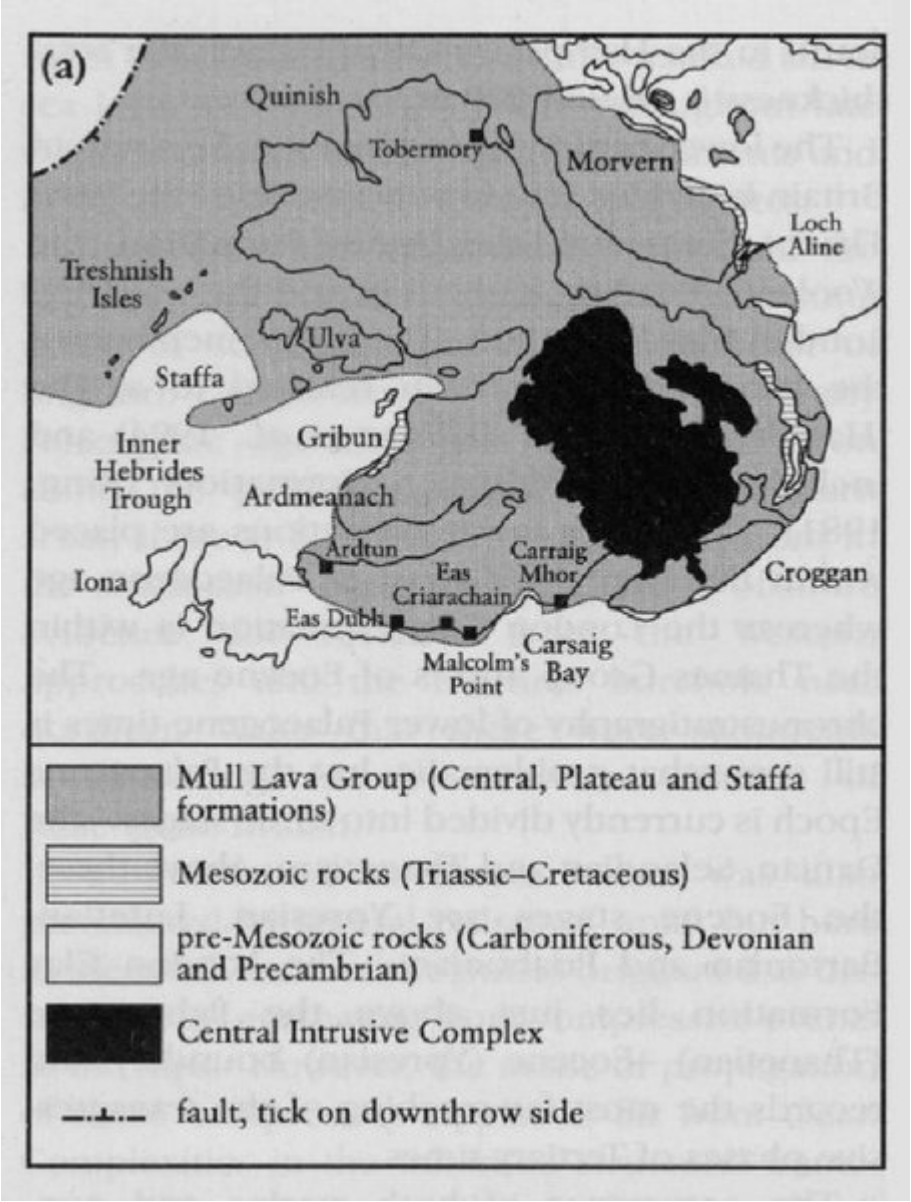
Conclusions

Situated in an active volcanic province of early Tertiary age (late Paleocene, around 55 Ma), this is a unique location in Britain and has a wider European significance. Its plant fossils are internationally famous and provide important evidence for the environments and climates of the time within which the insect fauna flourished. It provides an invaluable insight into the insect fauna of this part of Europe in early Paleogene times with northerly extension of cicadas and an early non-stridulating bush cricket.

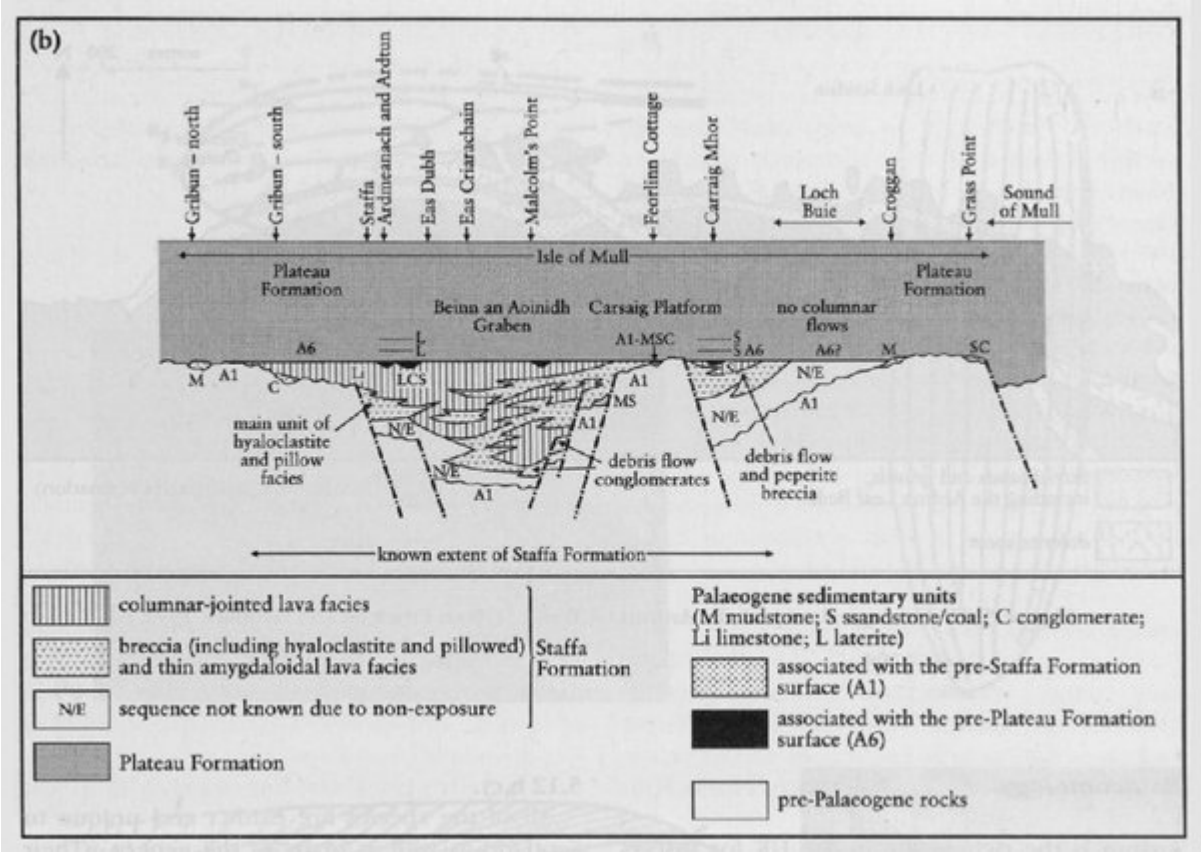
References



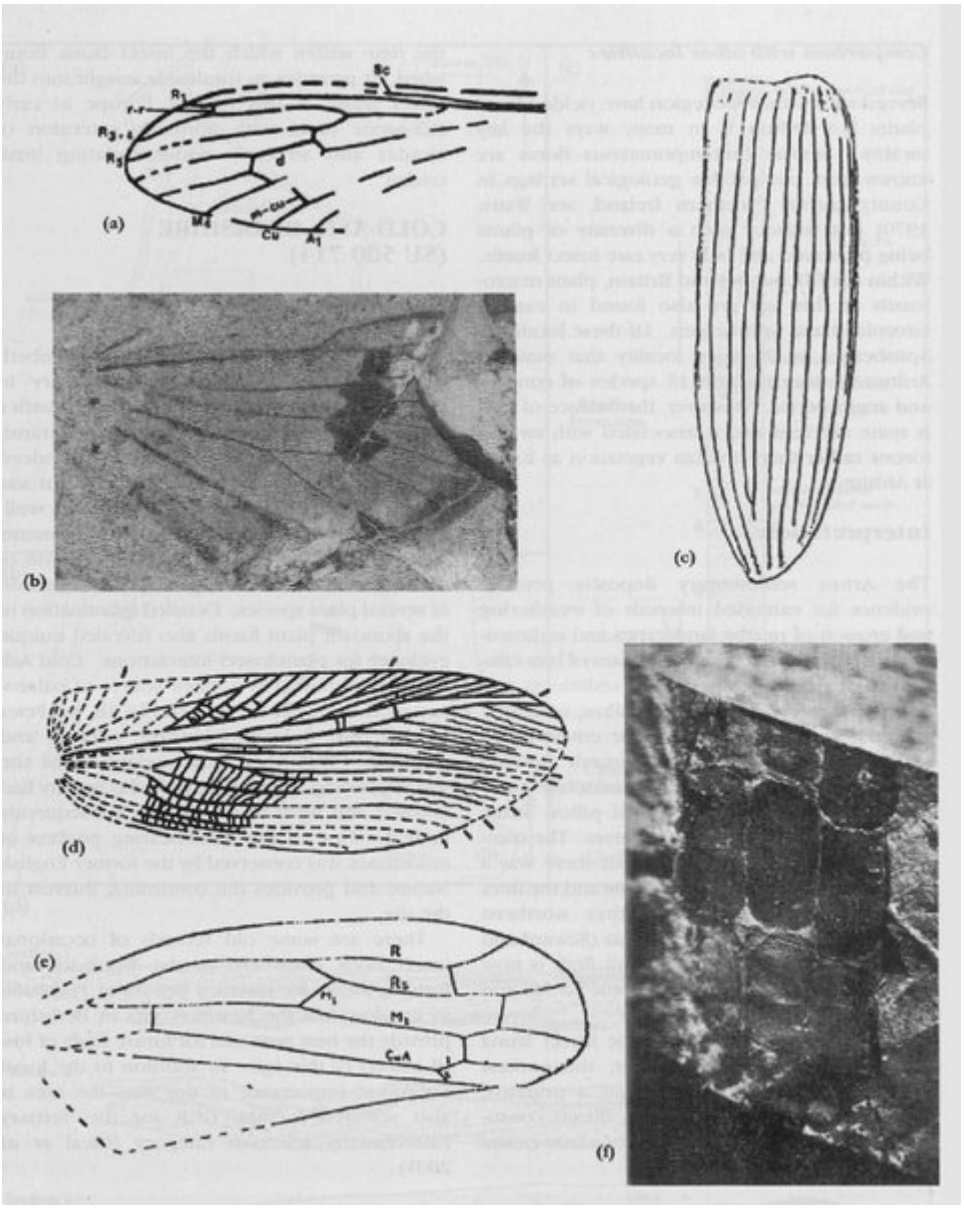
(Figure 5.1) Distribution map for Tertiary rocks. (After Benton et al., 2005.)



(Figure 5.9) Geological map of Mull with the Ardtun locality. (After Trewin, 2002.)



(Figure 5.10) Schematic cross section of the lava succession in south-west Mull, illustrating the possible relationships between the various volcanic facies and intercalated sedimentary rocks of the Staffa Formation to 'basement' structures and the succeeding Mull Plateau Lava Formation. (After Trewin, 2002.)



(Figure 5.12) Ardtun entomofauna. (a) Dicranoptycha europaea (Zeuner, 1941) (from Krzeminski, 1993). (b) Eotettigarcta scotica (Zeuner, 1944) (from Whalley, 1983). (c) Carabites scoticus, Cockerell, 1921, elytron, x 17 (from Zeuner, 1941). (d) Zeuneroptera scotica (Zeuner, 1939) (Anostostomatidae) male (?) forewing, wing fragment 27 mm long (from Gorochov in Rasnitsyn and Quicke, 2002). (e) Maleojassus primitivus Zeuner, 1941, tegmen, x 10.3 (from Zeuner, 1941). (f) Folindusia zeuneri Vyalov and Sukacheva, 1976 (loc. cit.). a, c, d, e forewings; b, hindwing; f, caddiscase. The key to venation annotations can be found in (Figure 4.23).