

# *Fossil Reptiles of Great Britain*

## *Contents*

Acknowledgements  
Access to the manuscript  
Museum abbreviations

**M.J. Benton and P.S. Spencer**

Department of Geology,  
University of Bristol,  
Bristol, UK.

GCR Editors: W.A. Wimbledon and D. Palmer



**CHAPMAN & HALL**

London · Glasgow · Weinheim · New York · Tokyo · Melbourne · Madras

---

*Chapter 3*

*British Permian fossil  
reptile sites*

---

### INTRODUCTION: PERMIAN STRATIGRAPHY AND SEDIMENTARY SETTING

British Permian time can be grouped into two broad units, an earlier phase of predominantly terrestrial deposition and a later phase characterized by greater marine influence. The Early Permian of the British Isles, and also of much of northern Europe, was mostly a time of terrestrial subaerial erosion with desiccation of newly uplifted areas that had been generated during the final phases of the Variscan Orogeny. A large number of fault-bounded sedimentary basins developed, with the creation of wide-ranging facies variations of coarse- and fine-grained sediments as well as evaporites. Later in the Early Permian, aeolian deposits and evaporites became dominant, indicating a prevailing arid climate. The sediments were deposited in a westward extension of the German-Dutch basin and are known as the Rotliegendes. By the end of the Early Permian, Britain had been reduced to a gently rolling peneplain (Smith *et al.*, 1974; Smith, 1989; Smith and Taylor, 1992), which was largely an inhospitable desert.

A major marine transgression in the Late Permian led to the development of an inland (epicontinental) sea which flooded the North Sea Basin and part of mainland Britain, leading to deposition of the thick, evaporitic Zechstein sequences. The Zechstein deposits of north-east England, the North Sea and Germany comprise five major sedimentary cycles, each commencing in shelf carbonates and grading up into evaporites. The base of each cycle is sometimes marked by widespread development of bituminous shale which passes directly into the main carbonate sequence. The earliest of these deposits contain plant remains, perhaps reflecting a temporary increase in humidity following the establishment of the Zechstein seaway. This, however, was short-lived, as the return of arid conditions led to a re-establishment of evaporite sedimentation.

Arid and semi-arid conditions continued to the end of the Permian throughout the British region, but in the isolated sedimentary basins of north-east Scotland a diverse reptilian fauna appears to have flourished in spite of the harsh conditions.

The lack of biostratigraphic indicators makes relative dating of Permian deposits in Britain very difficult (Smith *et al.*, 1974), and only parts of the succession may be dated with any degree of accuracy. The diversity of facies and their diachronous

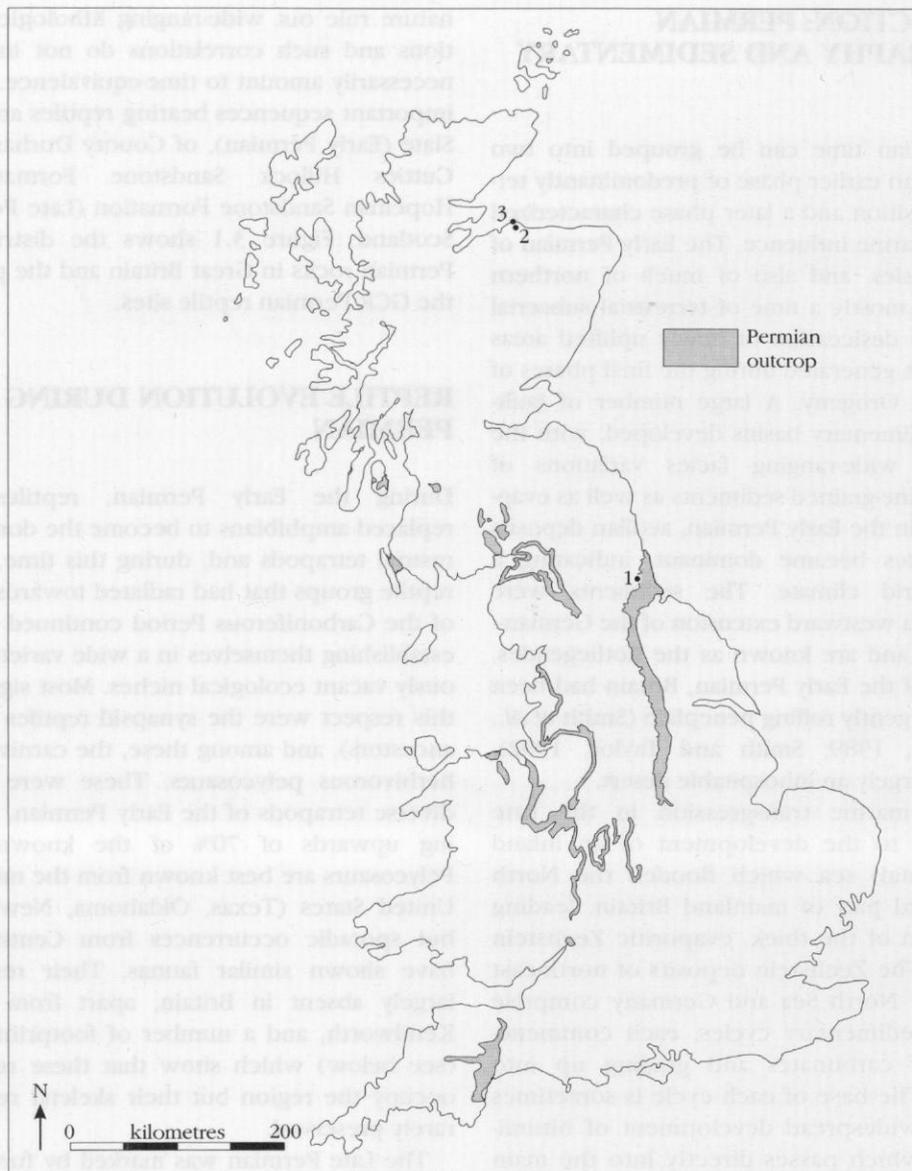
nature rule out wide-ranging lithological correlations and such correlations do not in any case necessarily amount to time-equivalence. The most important sequences bearing reptiles are the Marl Slate (Early Permian), of County Durham and the Cutties Hillock Sandstone Formation and Hopeman Sandstone Formation (Late Permian) of Scotland. Figure 3.1 shows the distribution of Permian rocks in Great Britain and the position of the GCR Permian reptile sites.

### REPTILE EVOLUTION DURING THE PERMIAN

During the Early Permian, reptiles broadly replaced amphibians to become the dominant terrestrial tetrapods and, during this time, the main reptile groups that had radiated towards the close of the Carboniferous Period continued to evolve, establishing themselves in a wide variety of previously vacant ecological niches. Most significant in this respect were the synapsid reptiles (mammal-ancestors), and among these, the carnivorous and herbivorous pelycosaurs. These were the most diverse tetrapods of the Early Permian, representing upwards of 70% of the known reptiles. Pelycosaurs are best known from the mid-western United States (Texas, Oklahoma, New Mexico), but sporadic occurrences from Central Europe have shown similar faunas. Their remains are largely absent in Britain, apart from a site at Kenilworth, and a number of footprint localities (see below) which show that these reptiles did occupy the region but their skeletal remains are rarely preserved.

The Late Permian was marked by further radiation of the synapsids, with the appearance of numerous new groups belonging to the major derived group, the therapsids. Key groups include the dicynodonts (specialized herbivorous forms with reduced numbers of teeth), the dinocephalians (an assemblage of large herbivores and carnivores) and the gorgonopsians (moderate to large-sized carnivores, many with 'sabre'-teeth). The dicynodonts, and certain other groups, survived with reduced diversity beyond the end-Permian extinctions into the Triassic, whereas the dinocephalians and gorgonopsians died out. Other important reptile groups from the Permian include the anapsids (e.g. captorhinomorphs) and primitive diapsid reptiles, whose descendants were to dominate the course of reptile evolution to the present day.

## British Permian fossil reptile sites



**Figure 3.1** Map showing the distribution of Permian rocks in Great Britain. GCR Permian reptile sites: (1) Middridge; (2) Cutties Hillock; (3) Masonshaugh.

The best information on Late Permian reptilian evolution comes from the early parts of the Beaufort Group of the Karroo Basin in South Africa, with supplementary information from Madagascar, central Europe and eastern Russia, all of which confirm the general story. The British sites illustrate parts of this story, with typical South African/Russian-style dicynodonts from Elgin, and smaller diapsid reptiles, like those of Madagascar and central Europe, from Durham.

### BRITISH PERMIAN REPTILE SITES

Early Permian fossil reptile bones have been reported from Whitemoor Brickpit, Kenilworth (SP 294717), probable source of remains of the large amphibian *Dasyceps bucklandi*, and certain source of the 'pelycosaur' mammal-like reptiles *Sphenacodon britannicus* (Huene, 1908a) (type: BGS(GSM) 22893-4) and *Haptodus grandis* Paton, 1974 (type: WARMS Gz 1071) (Huene, 1908a; Paton, 1974b; Reisz, 1986, p. 78). The

Enville Beds here contain a limited flora including the conifer *Lebachia* (= *Walchia*) dated as earliest Permian (Shotton, 1929; Smith *et al.*, 1974). A second site, 'one mile north-west of Coventry', yielded a jaw bone of *Ophiacodon* sp. in the Kenilworth Breccia (Murchison and Strickland, 1840; Paton, 1974b).

Other sites have yielded Early Permian footprints (McKeever, 1990, 1991). The key localities are in Dumfriesshire at Corncockle Muir (NY 086870), Locharbriggs (NX 907813), and Greenmills (NY 023692), all old quarries in the Locharbriggs Sandstone Formation (Brookfield, 1978a), which is the same as the Dumfries Sandstone of Smith *et al.* (1974). Footprints were reported from the 1820s onwards, these being some of the first tetrapod footprints recorded in the literature (Grierson, 1828; Harkness 1850, 1851; Hickling, 1909; Sarjeant, 1974; Delair and Sarjeant, 1985). Similar footprint faunas have been found in the Penrith Sandstone at Penrith, Cumbria (?NY 5729) (Smith, 1884; Sarjeant, 1974). None of these could be selected as a GCR site since they have all been filled to a greater or lesser extent. The main hope is that current sporadic quarrying in the Dumfries area may reveal more footprints.

Late Permian reptiles are known from the Marl Slate of the Durham area, in quarries at Eppleton, Midridge and Quarrington (Mills and Hull, 1976; Bell *et al.*, 1979; Evans and King, 1993), and from the Cutties Hillock Sandstone Formation of Cutties Hillock Quarry, near Elgin, Morayshire (Benton and Walker, 1985).

Late Permian reptile footprints have been reported from the Lower Magnesian Limestone of Rock Valley Quarry, Mansfield Nottinghamshire (SK 524613), now filled in (Hickling, 1909; Sarjeant, 1974, pp. 332-4) and from Poltimore, Devon in the Broadclyst Sandstone Member of the latest Permian Dawlish Sandstone Formation (Clayden, 1908a, 1908b; Warrington and Scrivener, 1990). Footprints are also known from Masonshaugh Quarry, and other sites, in the Hopeman Sandstone Formation of the Morayshire coast (Peacock *et al.*, 1968; Benton and Walker, 1985; McKeever, 1991). Three locations are selected as GCR sites to represent British Permian reptiles:

1. Midridge, Durham (NZ 24552535). Upper Permian (Ufimian-lowest Kazanian), Marl Slate.
2. Cutties Hillock, Grampian (NJ 185638). Upper

Permian (Tatarian), Cutties Hillock Sandstone Formation.

3. Masonshaugh, Cummingstown, Grampian (NJ 125692). Upper Permian (Tatarian), Hopeman Sandstone Formation.

### MIDDRIDGE, DURHAM (NZ 24552535)

#### Highlights

Midridge Quarry has been the source of several fossil reptile specimens from the Marl Slate. These reptiles are close to the origin of groups that became important later, such as lizards and dinosaurs. Midridge is Britain's best Upper Permian reptile locality.

#### Introduction

The Upper Permian Marl Slate exposed in a quarry and railway cutting 1 km south-south-west of Midridge, and close to East Thicklely and Thicklely Wood, has long been known (e.g. Hancock and Howse, 1870a, 1870b) for its rich fossil plant, invertebrate and vertebrate assemblages. There is another quarry, Old Towns Quarry (NZ 257246), about 1 km to the south-east, and closer to Newton Aycliffe than to Midridge. However, the reptile site is almost certainly the former, sometimes termed Thicklely Quarry. Extensive collections were made in the 19th century, and these include important specimens of the reptiles *Protorosaurus*, *Adelosaurus* and the 'amphibian' *Lepidotosaurus*. The sections of the quarry that lie near the railway line and the side of the railway cutting are now rather overgrown and the Marl Slate is no longer visible. However, a new excavation in the floor of the eastern end of the old quarry exposes a good section right through the Marl Slate and gives clear access to the fossiliferous beds (Mills and Hull, 1976, pp. 137-8; Bell *et al.*, 1979). The Marl Slate here has already produced abundant fossils which include possible reptile bones (Bell *et al.*, 1979, p. 452), and there is a good chance of further discoveries.

#### Description

Midridge Quarry and railway cutting expose sections in the lowest portion of the Upper Permian

## British Permian fossil reptile sites

which rests unconformably on Carboniferous sediments. Typical sections taken in the new pit at Middridge show the following sequence (Bell *et al.*, 1979, p. 445):

	Thickness (m)
Lower Magnesian Limestone	4+
Marl Slate	2.58-2.76
calcareous laminated siltstones and thin silty limestones	(1.47-1.60)
laminated limestone (upper invertebrate bed)	(0.02-0.03)
calcareous laminated siltstones and thin silty limestones	(1.09-1.13)
Basal Permian Breccia	
Calcareous breccia (lower invertebrate bed) with abundant <i>Lingula</i> in the top (0.02-0.03 m)	0.38-0.42
----- unconformity -----	
Lower Coal Measures	
Thin-bedded micaceous sandstones and shales	1.20

The new pit exposed the Basal Breccias (?Lower Permian) which may be equivalent to the breccias observed elsewhere in Durham, Yorkshire and North Nottinghamshire lying below the Lower Permian Yellow Sands (Smith *et al.*, 1974; Smith, 1989; Smith and Taylor, 1992). The Yellow Sands are not seen at Middridge.

The Marl Slate is well represented, compared with the thicknesses of 0-3 m elsewhere in south Durham. It comprises a succession of rusty brown-weathering, thinly laminated, calcareous siltstones and thin silty limestones rich in bituminous and other organic material. There is a thin, highly fossiliferous laminated limestone (upper invertebrate bed) just over 1 m above the base of the Marl Slate. Pyrite, galena and sphalerite occur as spherulitic aggregates, small veins and as a partial replacement of some fossils (Bell *et al.*, 1979).

Numerous fossils have been found in the Marl Slate at Middridge, in addition to the reptiles and amphibians (Pattison *et al.*, 1973; Bell *et al.*, 1979). These include 12 genera of plants (Thallophyta, Pteridophyta, Pteridospermae, Coniferales), as well as a wide selection of invertebrates (foraminifers, bryozoans, brachiopods, bivalves, nautiloids and ostracods) and fish. The fishes are represented by isolated scales and fragments, as well as by a few complete flattened specimens. Typical genera are the shark *Wodnika*, the holocephalian *Janassa*, the

palaeoniscoids *Acentrophorus*, *Acrolepis*, *Dorypterus*, *Palaeoniscum*, *Platysomus* and *Pygopterus*, and the coelacanth *Coelacanthus*. Some fish remains are found in coprolites deposited by other fishes or by tetrapod predators.

The reptile remains were found in the Marl Slate, and the amphibian just above (Hancock and Howse, 1870a, 1870b). Hancock and Howse (1870a, p. 556) state that 'it is, in the middle, or nearly so, of this yard of Marl-Slate that Mr. Duff has found . . . the remains of two species of reptiles . . .'. They then note (p. 557) that the amphibian *Lepidosaurus* was found 'at about seven feet above the Marl-Slate proper'. Hancock and Howse (1870a) were referring to a section taken at Middridge by Sedgwick (1829), and it is clear that by 'Marl-Slate proper', they refer to the lower portion of the 'Marl-Slate' of Bell *et al.* (1979). A height of 7 ft (c. 2 m) above this 'Marl-Slate proper' would appear to lie near the base of the Lower Magnesian Limestone, an assignment noted by Pattison *et al.* (1973, p. 232). However, Hancock and Howse (1870a, p. 557) state that the *Lepidosaurus* specimen was associated with the fossil invertebrates which suggests an assignment to the Marl Slate near the 'upper invertebrate bed' of Bell *et al.* (1979).

### Fauna

The amphibian and reptile remains from Middridge are:

#### ?Sarcopterygii/Amphibia

*Lepidosaurus duffii* (Hancock and Howse, 1870a)

Holotype specimen: NEWHM G.55.38

#### Diapsida *incertae sedis*

*Adelosaurus buxleyi* (Hancock and Howse, 1870b)

Holotype specimen: NEWHM G.26.49

#### Diapsida: Archosauromorpha: Prolacertiformes: Protorosauridae

*Protorosaurus speneri* Meyer, 1830 (described in Hancock and Howse, 1870b)

Holotype specimen: NEWHM G.55.46

### Interpretation

The Marl Slate is interpreted as a shallow-water marine deposit. It is generally reckoned to be the

oldest unit in the British Late Permian, and is treated as a correlatable stratigraphic marker that stretches from north Nottinghamshire, through central and east Yorkshire, south Durham, the Durham coast and into the North Sea (Smith *et al.*, 1974; Smith, 1989; Smith and Taylor, 1992). It is correlated with the Kupferschiefer of north-west Europe (Lower Zechstein).

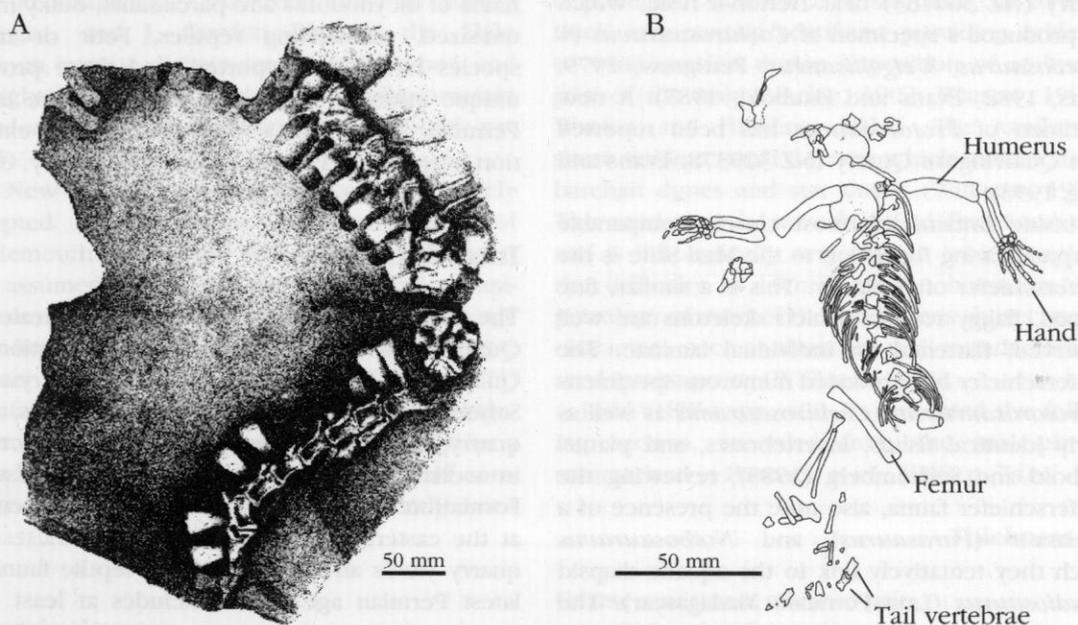
The specimen of *Lepidosaurus* shows numerous ribs, large scales and a partial skull. Hancock and Howse (1870a) were convinced that it was a labyrinthodont amphibian, but the ganoid scales, ribs and skull look more like those of a bony fish (?lung fish) than an amphibian. There has been no recent work on this specimen.

Hancock and Howse (1870b) described a specimen of a small (1 m+) reptile from Midridge (Figure 3.2A) which they assigned to *Protorosaurus speneri* (Meyer, 1830), described previously from the Kupferschiefer of Germany. Seeley (1888b) further described *P. speneri*, and made speculations on its relationships. The Durham *P. speneri* is represented by a series of 35 or 36 vertebrae and casts of vertebrae, as well as a few partial ribs and a fragment of ?pelvis. *Protorosaurus* is best characterized by its long

neck, perhaps developed in relation to a semi-aquatic mode of life.

The taxonomy of *Protorosaurus speneri* has been seen as problematic in the past, and it has been variously related to the euryapsids and diapsids. Recent cladistic analyses of diapsid relationships (e.g. Benton, 1985; Evans, 1988b) have shown that *Protorosaurus* is a basal prolacertiform, related to Triassic forms such as *Prolacerta*, *Macrocnemus* and *Tanystropheus*.

In the same paper as they described the Durham *Protorosaurus speneri*, Hancock and Howse (1870b) described a new species, *P. buxleyi*, distinguished from *P. speneri* on the basis of differences in rib structure and limb proportions. Watson (1914) confirmed differences between the skeletons of *P. buxleyi* and *P. speneri*, and erected the new genus *Adelosaurus*. The type specimen of *A. buxleyi* (Figure 3.2B) is a fairly complete skeleton exposed in ventral view. It is about 130 mm long, and shows the trunk, both forelimbs and one hindlimb; a large portion of the tail and the skull are missing. *Adelosaurus* is broadly similar to *Protorosaurus*, but differs in several respects, notably in the proportions of the humerus and cervical vertebrae, in the length of



**Figure 3.2** Reptile specimens from the Late Permian Marl Slate of Midridge Quarry, County Durham: (A) *Protorosaurus speneri* Meyer, 1830, part of the backbone (after Hancock and Howse, 1870b); (B) *Adelosaurus buxleyi* (Hancock and Howse, 1870), partial skeleton (after Evans, 1988b).

the neural spines, and in size (estimated length of skeleton 250 mm, as opposed to 1 m+ in *Protorosaurus*). *Adelosaurus* was probably a fully terrestrial form (Watson, 1914; Evans, 1988b), and it may represent an immature (?neotenus) individual (Evans, 1988b).

The taxonomic position of *Adelosaurus buxleyi* has been difficult to resolve. Vaughn (1955) was unable to establish any definite relationship between *Adelosaurus* and other early amniotes and left it *incertae sedis*, while Huene (1956) and Kuhn (1969) referred it to the Broomidae, and Romer (1966) to the Younginiformes or Protorosauridae. Haubold and Schaumberg (1985) classified *Adelosaurus* as a junior synonym of *Protorosaurus speneri*. Evans (1988b) reassigned the reptile to *Adelosaurus* and concluded that, in the absence of diagnostic features such as the ankle and skull, the taxonomic position remained equivocal. Derived diapsid features noted by Evans (1988b) include the strong humerus with poorly expanded ends, the strong sigmoidal curvature of the femur, and a triangular ilium in the pelvic girdle.

#### **Comparison with other localities**

Fossil reptiles have been found in the Marl Slate of Durham at Eppleton Quarry, or High Downs Quarry (NZ 360483) near Hetton-le-Hole, which has produced a specimen of *Coelurosauravus* (= *Gracilosaurus*, *Weigeltisaurus*; Pettigrew, 1979; Evans, 1982; Evans and Haubold, 1987). A new specimen of *Protorosaurus* has been reported from Quarrington Quarry (NZ 329378; Evans and King, 1993).

Outside Britain, the most closely comparable tetrapod-bearing formation to the Marl Slate is the Kupferschiefer of Germany. This is a similar, fine grained, flaggy rock in which skeletons are well preserved, flattened on individual laminae. The Kupferschiefer has produced numerous specimens of *Protorosaurus* and *Coelurosauravus* as well as nearly identical fishes, invertebrates, and plants. Haubold and Schaumberg (1985), reviewing the Kupferschiefer fauna, also note the presence of a pareiasaur (*Parasaurus*) and *Notbosauravus* which they tentatively link to the aquatic diapsid *Claudiosaurus* (Late Permian, Madagascar). The glider *Coelurosauravus* is also known from the Lower Sakamena Formation of Madagascar (Carroll, 1978; Evans, 1982; Evans and Haubold, 1987).

#### **Conclusions**

Middridge Quarry is the best tetrapod locality in the Marl Slate of the British Upper Permian sequence. The remains found in the last century are well preserved, are very important in themselves, and allow correlation of the Marl Slate with the German Kupferschiefer. The diapsid reptile *Protorosaurus* lies at the base of the archosauromorph branch of reptile evolution, and is a member of a group of Upper Permian diapsids important in establishing the wider ancestry of all Mesozoic and Cenozoic groups. Relatively little is known of contemporary diapsid faunas in northern Pangaea, which adds to the value of the other diapsids, *Adelosaurus* and *Coelurosauravus*.

The palaeontological importance of the fossil reptiles from here and the potential for future discoveries with re-excavation give the site considerable conservation value.

#### **CUTTIES HILLOCK, GRAMPIAN (NJ 185638)**

#### **Highlights**

Cutties Hillock Quarry is world-famous for its fauna of dicynodonts and pareiasaurs, bulky medium-sized, plant-eating reptiles. Four or more species have been reported, and these provide unique information on the reptiles of the latest Permian, just before a major global mass extinction event at the Permian/Triassic boundary.

#### **Introduction**

The main Cutties Hillock Quarry lies concealed in Quarrywood Forest, in the eastern portion of Quarry Wood, 400 m south-east of Quarrywood School, and is reached along forest roads. The quarry, now mostly overgrown, exposes sections in aeolian units of the Cutties Hillock Sandstone Formation. Some fresh rock has been broken up at the eastern end, where access is easiest. The quarry yields an important fossil reptile fauna of latest Permian age which includes at least two genera of dicynodont, a specialized pareiasaur, and a possible procolophonid, the chief references to which are: Newton (1893), Walker (1973), Rowe (1980), Benton and Walker (1985) and Maxwell (1991). Further commercial working

## Cutties Hillock

would doubtless yield more fossils in view of the number collected between 1885 and 1890.

Cutties Hillock quarry was opened for building stone in the early 19th century. Many of the buildings in Elgin, including the Town Hall, are built of sandstone from this quarry. The uniform nature of the stone also made it suitable for mill stones, and it is probable that this is the millstone quarry referred to by Harkness (1864) and others.

Fossil reptiles were collected around 1884, and displayed at the Aberdeen meeting of the British Association in 1885. Further nearly complete skeletons were obtained in 1884 and 1885 (Judd, 1885, 1886a, 1886b; Traquair, 1886) and these were described by Newton (1893) as species of the new dicynodont genera *Gordonia* and *Geikia*, and the new horned pareiasaur *Elginia*.

The Geological Survey drove test pits in the quarry in 1885, in an attempt to settle the contentious question of the true age of the Elgin reptile beds: most others had admitted their New Red (Permo-Triassic) age by that time. It was agreed by all that the reptiles had been found in the working portion of the quarry, and that a diagnostic Old Red Sandstone (Devonian) fish (*Holoptychius*) had been found 20–25 ft below in the trial pit. Judd (1886a, pp. 400–2) claimed he could identify a pebble band between two sandstone units, presumably marking the base of the New Red Sandstone. However, Linn, the Survey geologist, and J. Gordon Phillips, the Elgin Museum curator, did not see this pebble bed, and it might have been merely a local phenomenon (Gordon, 1892, p. 242; Peacock *et al.*, 1968, pp. 73–5).

A New Red, possibly Triassic, age was widely accepted by 1890 for the sandstones of Lossiemouth and Spynie which lie nearby, and it was assumed at first that the Cutties Hillock animals could be of the same age. A Permian age was, however, proposed early on (Taylor, 1894; Huene, 1902; Watson, 1909a), but Walker (1973) tentatively suggested a lowermost Triassic assignment. Benton and Walker (1985) opt firmly for a latest Permian (Tatarian) age on the basis of comparisons of the reptiles with independently dated faunas in southern Africa and Russia.

### Description

The quarries at Cutties Hillock comprise the type locality for the Cutties Hillock Sandstone Formation (*sensu* Benton and Walker, 1985, pp.

215–16). The sandstones of Cutties Hillock were formerly supposed to represent only the lower part of the Hopeman Sandstone Formation. Because of lithological similarity and tracks found near Cutties Hillock Quarry, Watson and Hickling (1914) correlated the 'Sandstones of Cutties Hillock' (Quarry Wood) and Hopeman. This has been accepted until recently by most authors (Peacock *et al.*, 1968; Williams, 1973). Benton and Walker (1985) questioned the validity of such a correlation and erected the Cutties Hillock Sandstone Formation to include the reptile-bearing beds around Cutties Hillock, and to distinguish them from the coastal series of rocks, the Hopeman Sandstone Formation.

The Cutties Hillock Sandstone Formation is a 30–45 m thick succession of coarse- to medium-grained, predominantly aeolian sandstones which outcrop as a series of isolated fault-bounded blocks in a belt stretching south-south-west from the district of Cutties Hillock. Two main units of the formation are recognized (Peacock *et al.*, 1968; Williams, 1973), comprising a lower member of up to 4 m of pebbly sandstones and an upper member, about 30 m thick, of large-scale, yellow to light-brown, cross-bedded sandstone (Figure 3.3). The base of the formation lies discordantly on Old Red Sandstone. The lower pebbly beds have been interpreted as sheet-flood deposits, but occasional pebble beds, up to 20 m thick, may contain ventifacts, providing evidence of wind erosion during deposition of at least a part of the unit (Mackie, 1902; Watson, 1909b; Watson and Hickling, 1914). The sandstones show unidirectional foresets which indicate fossil barchan dunes and star dunes (Williams, 1973). The sandstone is reworked Old Red Sandstone and is lithologically very similar, which explains the difficulty in identifying the boundary. The petrology of most of the sandstones shows aeolian characters, such as abundant well-rounded, millet-seed quartz grains (Williams, 1973).

Judd (1886a, pp. 400–2) presented the following section, recorded from the trial pit (as summarized in Peacock *et al.*, 1968, p. 74):

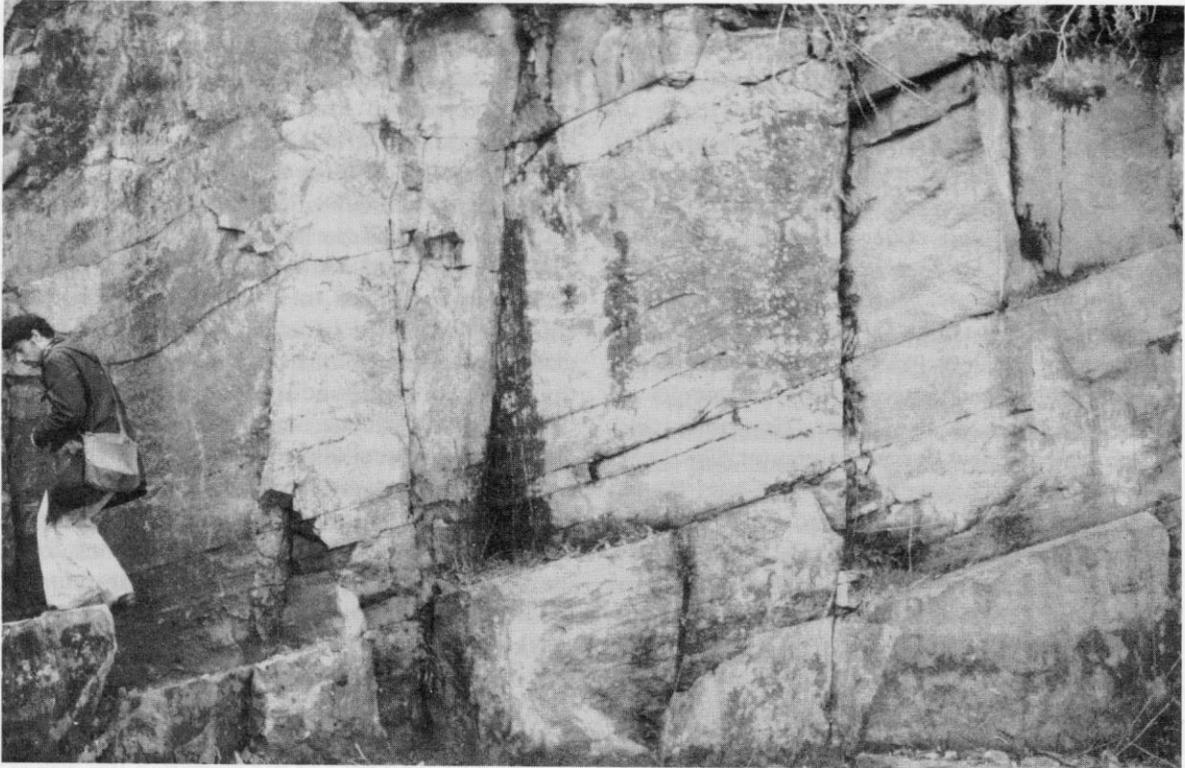
#### Thickness (ft)

Coarse sandstone, white to pale yellow, often felspathic and gritty, becoming pebbly downwards; five reptiles recovered from one horizon, and one from the course below

20

## British Permian fossil reptile sites

---



**Figure 3.3** Part of the worked face at the east end of the main quarry, Cutties Hillock, showing cross-bedding. The fossil reptile remains were recovered from the foot of the cross-bedded units. (Photo: M.J. Benton.)

	Thickness (ft)
grades into	
Conglomerate; pebbles of white and purple quartz up to fist size	c. 4
sharp contact	
Finely laminated, pink and red sandstone with much false bedding.	
Yielded at base <i>Holoptychius nobilissimus</i>	13

The Cutties Hillock Sandstone Formation broadly correlates with the Hopeman Sandstone Formation (Peacock *et al.*, 1968; Warrington *et al.*, 1980; Glennie and Buller, 1983) on the basis of striking lithological similarities and the presence of footprints that might have been formed by reptiles like those of Cutties Hillock. An associated footprint and other trackways have been discovered on Quarry Hill near the main Cutties Hillock quarries (Linn, 1886; Huene, 1913; Watson and Hickling, 1914), and A.D. Walker

(pers. comm. to M.J.B., 1990) discovered a dicynodont trackway *in situ* in the main quarry. A slab in Elgin Museum, showing footprints with a tail-drag on top of ripple marks, probably came from 'Robbies Quarry', the position of which is uncertain, but it was apparently one of the Crownhead group of quarries, on the south side of Quarry Wood Hill.

The reptiles *Elginia*, *Gordonia* and *Geikia* all came from Cutties Hillock Millstone Quarry (NI 185638), apparently from aeolian sandstones just above the pebbly sandstones. Judd (1886a, pp. 400-1) noted that 20 ft (6.2 m) of the 'Reptiliferous Sandstone' was to be seen above the pebbly layers, that the remains of five reptiles all came from one horizon and that a sixth came from the bed below. Phillips (1886) confirmed this. Gordon (1892, p. 242) referred to 'a portion of this conglomerate containing reptilian remains'. Newton (1893, pp. 462, 466) also noted that the specimens of *Gordonia juddiana* and *Geikia elegans* contained pebbles in the matrix like those of

## Cutties Hillock

the 'conglomerate' bed. Similar pebbles are also preserved in the slabs containing *Gordonia duffiana*. These respectively (ELGNM, 1978.559.1, 2) show quartz pebbles up to 20 mm and up to 7 mm in diameter.

In general, the reptile skeletons are preserved in articulation, with most elements in their natural positions. Skulls are usually in position aligned with the attitude of the rest of the anterior skeleton. However, some remains lack certain elements. The type specimen of *Elginia* (BGS(GSE)4783-8) lacks its lower jaws. A record of the natural association of parts has been lost in some specimens because of poor techniques of collection, and many blocks in museum collections are no longer associated. Most of the reptiles are preserved on their sides, although the isolated pelvis (NMS, 1966.42.3) lies horizontal to the bedding. Some elements of the skeletons, however, may pass vertically through bedding (e.g. vertebrae and limb bones in *G. duffiana*; ELGNM, 1978.559.1, 2). The alignment of skulls in relation to the bedding seems to be related to skull broadness and length; narrow long skulls are usually preserved sideways on to bedding whereas broad backed skulls, such as the skull of *Elginia*, generally lie flat.

The fossil bones are preserved in the form of natural moulds from which the bone has been removed by percolating solutions. The bone/rock interface is frequently stained with black material containing iron, manganese and cobalt (Newton, 1893, p. 425). The cavities may be deformed to the extent that opposite walls may almost touch, and skulls are often vertically compressed (Newton, 1893; Walker, 1973; Rowe, 1980). Prefossilization damage is rare, but specimens lacking certain elements (e.g. the skull of *G. duffiana*) suggests disarticulation through erosional forces or through the activities of scavengers. The open cavities permit casts to be made for study, and various synthetic, flexible, rubber-like materials (e.g. RTV silicone rubber, PVC) provide excellent representatives of the original bone morphology.

### Fauna

Anapsida: Pareiasauridae

*Elginia mirabilis* Newton, 1893

2 individuals: BGS(GSE) 4783-8, ELGNM, 1978.550

Anapsida: ?pareiasaurid

'procolophonid' of Walker, 1973, p. 179

1 individual: EM, 1978.560; ?BMNH R4807

Synapsida: Therapsida: Dicynodontia

*Gordonia traquairi* Newton, 1893

3 individuals: BGS(GSE) 4805-6, 11703, ?ELGNM, 1978.550

*Gordonia huxleyana* Newton, 1893 (?= *G. traquairi*)

2 individuals: BGS(GSE) 4799-802, 11704-5, ?ELGNM, 1978.549

*Gordonia duffiana* Newton, 1893 (?= *G. traquairi*)

1 individual: ELGNM, 1978.559

*Gordonia juddiana* Newton, 1893 (?= *G. traquairi*)

1 individual: ELGNM 1890.3

*Geikia elginensis* Newton, 1893

1 individual: BGS(GSM) 90998-1015

'dicynodonts indet.'

7 individuals: BMNH R4794, ELGNM, 1935.8, 1978.558, 886, NMS, 1956.8.3, 1966.42.1-3, 1984.20.7

### Interpretation

In the absence of any associated fossils, the reptiles provide the only means of dating the Cutties Hillock Sandstone. Comparison with similar forms from South Africa led Walker (1973) to suggest an age in either the upper *Cistecephalus* or *Daptocephalus* Zone (uppermost Permian), or more probably in the *Lystrosaurus* Zone (lowermost Triassic). Rowe (1980) showed that the close relatives of *Geikia*, the cryptodontid dicynodonts, all come from the Late Permian of South Africa or Zambia (i.e. *Daptocephalus* Zone) and implied a similar age for the Cutties Hillock Sandstone. Benton and Walker (1985) accept a latest Permian age for the Cutties Hillock Sandstones, based on the nature of the dicynodonts and the pareiasaur, known elsewhere only from the Late Permian. These reptile-defined biozones are generally (e.g. Anderson and Cruickshank, 1978) assigned to the Tatarian Stage.

*Gordonia* and *Geikia* are dicynodonts, members of a group of specialized, herbivorous mammal-like reptiles with beak-like snouts, most of which had no teeth except for a pair of 'tusks' midway along the upper jaws. *Gordonia* (Figure 3.4A) is represented by the remains of skulls and skeletons of between eight and thirteen individuals; Newton (1893) established four species (*G. traquairi*, *G. huxleyana*, *G. duffiana*, *G. juddiana*), but they are probably all synonymous, the differences being the result of individual varia-

## British Permian fossil reptile sites

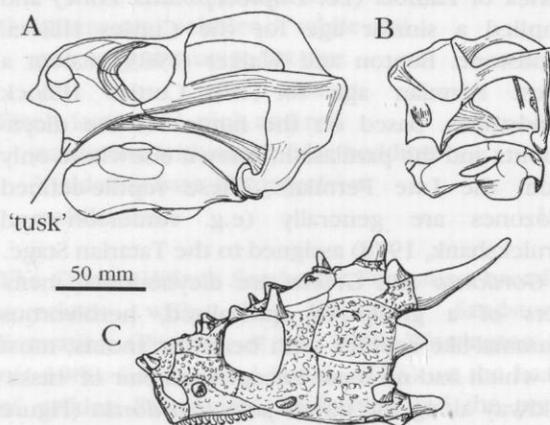
tion, age and sex differences, and the susceptibility of the Cutties Hillock fossils to early post-depositional distortion (Walker, 1973; King, 1988, p. 93). *Gordonia* has a heavy, broad skull, 100–180 mm long, modified to house a powerful musculature for mastication. *Gordonia*, the only known member of its infra-order from Europe, is a generalized dicynodont – a group of herbivorous mammal-like reptiles that have highly reduced dentition, and often only a pair of bony canine tusks. Cluver and King (1983, p. 268) stated that *Gordonia* was ‘possibly related to *Kingoria* or *Dicynodon*’, whereas King (1988, p. 93) synonymized *Gordonia* with *Dicynodon*, a genus known otherwise from the Late Permian of South Africa.

The single specimen of *Geikia* (Figure 3.4B) has no teeth at all, the skull is very short and the snout is square. The foreshortening of the skull, and its great breadth at the back, could both be connected with the development of a powerful biting mechanism to deal with tough vegetation. The foreshortening of the skull is like that of *Lystrosaurus* from Gondwanaland, but the similarity is only superficial. In *Geikia* the intertemporal area is broadened, the interorbital area broadened and depressed, and the premaxillae descend abruptly vertically. Rowe (1980) has redescribed the specimen and assigned it to the Cryptodontidae, a family otherwise known from the Late Permian of South Africa and Zambia. He also placed ‘*Dicynodon*’ *locusticeps* (Huene,

1942) from the Late Permian Lower Bone-Bearing Series of Kingori, Tanzania in the genus *Geikia* and noted that the closest relative of *Geikia* is *Pelanomodon*. Cluver and King (1983) placed *Pelanomodon* in the new family Aulacephalodontidae, a view confirmed by Cruickshank and Keyser (1984) and King (1988, pp. 88–9).

*Elginia* was a pareiasaur with a highly spinescent skull (Figure 3.4C). The 210 mm long holotype skull is broad and covered with rough pits and spines of various lengths and sizes. Other remains of *Elginia* include vertebrae and a sacrum probably belonging to the holotype, as well as an undescribed partial skeleton and skull. The teeth are leaf-shaped, indicating that *Elginia* was probably a herbivore. The ‘frill’ at the back of the skull was probably to protect the neck, and the spines are also defensive structures (compare Cretaceous ceratopsian dinosaurs). The body was also covered in spinose scutes – overall an animal highly armoured against a predator that has not yet been found, but probably a large cynodont, gorgonopsian, or therocephalian, mammal-like reptile. *Elginia* shows relationship with pareiasaurs from the *Cistecephalus* and *Daptocephalus* Zones of South Africa and Zone IV of Russia, but seemingly it is cladistically more derived (Walker, 1973, p. 181; Maxwell, 1991).

A fourth reptile from Cutties Hillock is represented by a small partial skeleton described by Newton (1893, pp. 461–2, pl. 33, fig. 5) as a tail of ?*Gordonia*. This specimen, consisting of seven dorsal vertebrae, the blades of two scapulae and the blade of an ilium, was later identified as a nearly complete postcranial skeleton and was assigned to the Procolophonidae by Walker (1973). A re-examination of the material by P.S.S. (1994), however, revealed characters, including a tall and narrow scapular blade, very wide, flattened neural arches of the dorsal vertebrae, and long laterally projecting ribs, that are shared by pareiasaurids, and hence *Elginia*. Thus, EM, 1978.560 may well represent an immature *Elginia*, and also one of the smallest pareiasaurid specimens known.



**Figure 3.4** Reptile specimens from the Late Permian Cutties Hillock Sandstone Formation of Cutties Hillock Quarry, Morayshire. Skulls of (A) *Gordonia*; (B) *Geikia*; and (C) *Elginia*, all drawn to the same scale. After Benton and Walker (1985).

### Comparison with other localities

Reptiles comparable to those from Cutties Hillock have been obtained from York Tower Hill (Knock of Alves) (NJ 162629) where, in 1953, Walker discovered parts of the skull and jaws of an unnamed dicynodont allied to *Geikia* (Walker, 1973). An unidentified bone in Forres Museum was found in

## Masonshaugh Quarry, Cummington

Crownhead Quarry (NJ 183630) on the south side of Quarry Wood Hill in sandstones of the same age. Apart from a small scrap of bone (Peacock *et al.*, 1968, p. 59), the coastal exposure of the time-equivalent Hopeman Sandstone Formation has yielded nothing except reptile tracks.

The Cutties Hillock fauna shows most similarity with uppermost Permian faunas of southern Africa, especially the *Cistecephalus* and *Daptocephalus* biozones, and Zone IV of Russia. This points to a Tatarian age. There are no comparable localities in the British Isles or in Europe.

### Conclusions

Cutties Hillock Quarry is a key Permian reptile locality because of its unique fauna (Figure 3.4) which provides clear links between the Gondwana faunas of southern Africa and the mainland Eurasian faunas of western Russia. The dicynodonts *Gordonia* and *Geikia* are well preserved, and offer much useful palaeobiological information. *Elginia* is one of the most specialized pareiasaurs, being distinguished by its excessive spinescence.

The conservation value of this quarry lies in its uniqueness in Britain, its international importance and potential for future significant finds with reworking.

### MASONSHAUGH QUARRY, CUMMINGSTOWN, GRAMPIAN (NZ 125692)

### Highlights

Masonshaugh is famous for its fossil reptile tracks. Many complete specimens of trackways were found when the quarry was operational, and these show evidence of many reptiles, small, medium and large, trotting northwards across the sands.

### Introduction

Masonshaugh Quarry, situated next to a disused railway line, comprises a 400 m long north-facing exposure on the coast. The quarry lies in aeolian units of the Hopeman Sandstone Formation, and the importance of the site lies in its abundant ich-

nofauna of tetrapod tracks. The trackways are extremely well preserved and provide almost the sole record of tetrapods from the formation. Masonshaugh Quarry was fully operational in the 1860s, when Martin (c. 1860) visited and observed tracks. It was part worked in 1912, and used as a tip in the 1930s as appears in County valuation rolls. The site is now badly weathered and much rubbish has been tipped in front of it. However, the faces are free of overgrowth, and fresh workings would doubtless yield new finds *in situ*.

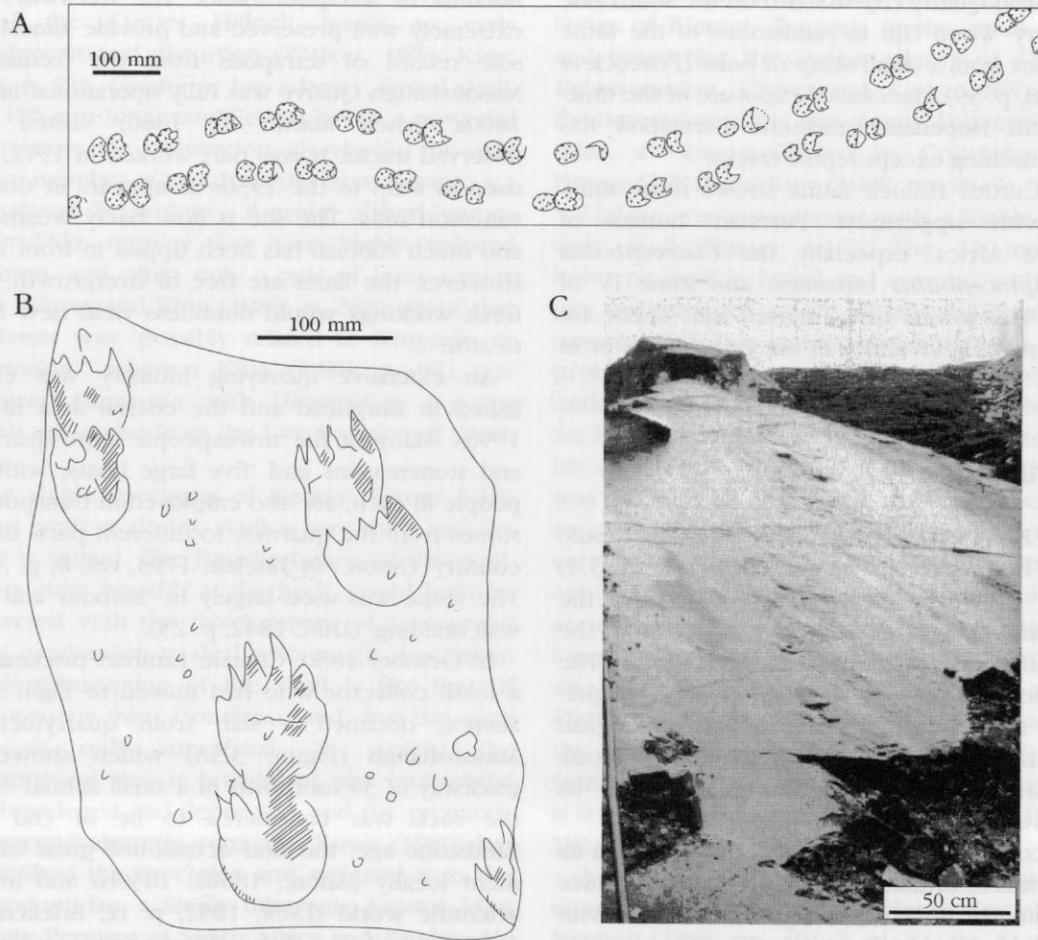
An extensive quarrying industry was established in Burghead and the coastal area in the 1790s. Many of the townspeople were quarriers and stonemasons and 'five large boats, with six people in each, are also employed in transporting stones from the quarries, to different parts of the country' (Anon., *in* Sinclair, 1793, vol. 8, p. 390). The stone was used largely in 'harbour and seawall building' (Duff, 1842, p. 25).

In October 1850, Captain Lambart Brickenden, a fossil collector who had moved to Elgin from Sussex, obtained a slab from quarrymen at Masonshaugh (Figure 3.5A) which showed a trackway of 34 footprints of a small animal. Since the rock was considered to be of Old Red Sandstone age, the find occasioned great excitement locally (Anon., 1850a, 1850b) and in the scientific world (Lyell, 1852, p. ix; Brickenden, 1852) as evidence of the oldest tetrapod, together with the *Leplopleuron* (*Telerpeton*) from Spynie (Benton, 1983c).

Numerous further slabs were collected during the 1850s (Beckles, 1859; Huxley, 1859b; Hickling, 1909). Huxley (1859b, pp. 456-9, pl. 14, figs 4, 5) described and figured footprints which were larger than those found by Brickenden. At the same time, Beckles (1859) hired workmen and carpenters and extracted many tracks from the quarry, which was supplying material for the new railway from Burghead to Hopeman on the coast.

Huxley (1877, pp. 45-52, pl. 14-16) described the 'ichnites of Cummington' further and named them *Chelichnus megacheirus* (Figure 3.5B). Hickling (1909, pp. 12-14, pl. 2, figs 6-8) compared the Elgin tracks with those from Mansfield, Notts., and Penrith, and concluded that the Cummington (*sic*) beds were Permian in age. The tracks were revised by McKeever (1990, 1991).

## British Permian fossil reptile sites



**Figure 3.5** Reptile footprints from the Late Permian Hopeman Sandstone Formation of Masonshaugh Quarry, Morayshire: (A) small prints; (B) medium prints, *Chelichnus megacheirus* Huxley, 1877; and (C) large prints. After Benton and Walker (1985).

### Description

Masonshaugh Quarry lies in the Hopeman Sandstone Formation, and is just east of the fault separating that unit from the Burghead Sandstone Formation. In the quarry, 8 m faces of orange-weathered, jointed sandstone are exposed, extensively silicified and hardened near the fault. The well-rounded sand grains and large-scale cross-bedding suggest that the sandstones of Hopeman are here of aeolian origin, although some water-laid pebbly beds were found at the west end of the outcrop near the old railway line.

The Hopeman Sandstone Formation is best observed on the coast between Cumingstown and Covesea Skerries and Haliman Skerries, where it is some 60 m thick. The coastal exposures show

large-scale cross-bedding in sandstones generally composed of well-rounded quartz grains and feldspar, often of high sphericity, with only a little mica (Peacock *et al.*, 1968, p. 59). These are features typical of aeolian deposition. Well-developed aeolian dune features have been observed along the coast, and these include complex star dunes which indicate the major wind direction from the NNE, secondary winds from the SSE, and subordinate winds from the NW (Clemmensen, 1987). Rarer lenses of coarse sandstone and well-rounded pebbles with small-scale cross-bedding, as well as contorted beds, indicate times of fluvial deposition (Peacock, 1966). Glennie and Buller (1983) interpret the contorted beds as the result of marine flooding. Williams (1973, pp. 10-11) identified four phases of barchan and seif dune formation, each cycle being followed by water-

## Masonsbaugh Quarry, Cummingstown

deposited, contorted beds and sheet-flood or playa-lake deposits.

The tracks are preserved as depressions, often 'smudged', and may be associated with ripple marks and sun-cracks on sub-horizontal flagstones. McKeever (1991) studied the nature of track preservation in the Hopeman Sandstone Formation, and argued that they were not imprinted on dry loose sandy dunes. This has bearing on a debate about track formation in aeolian situations, with some workers (e.g. Brand, 1979) arguing that dune beds bearing tracks must have been laid down entirely underwater, while others (e.g. McKeever, 1991) accept the extensive evidence for aeolian deposition, but find evidence for local and short-term flooding or rainfall. McKeever (1991) found clay minerals in the footprint-bearing levels from Early Permian track sites in Dumfriesshire, clear evidence for wetting of the particular layers. No such clay minerals were found in track-bearing horizons in the Hopeman Sandstone Formation, but other evidence for the presence of water (fluvial lenses; contortion of beds) suggests that footprints may be found where the dune faces are wetted.

The age of the Hopeman Sandstone Formation has, since 1900 at least, been assumed to be Upper Permian, largely because of comparisons with the likely track-makers from Cutties Hillcock. Indeed, closer comparisons of the tracks with comparative ichnofaunas in continental Europe and North America, confirm the Late Permian age. On the other hand, Glennie and Buller (1983) postulated an Early Permian age, since they considered that the Hopeman Sandstone Formation was laterally equivalent to the Early Permian Weissliegend (White sandstones) of Germany and the North Sea. In addition, they interpreted the heavily contorted beds in the Hopeman Sandstone Formation (Peacock, 1966) as the result of flooding by the Zechstein Sea (early Late Permian). These views were disputed by Benton and Walker (1985), and the Late Permian age confirmed by a comparison of the footprints with ichnofaunas elsewhere (McKeever, 1991).

### Fauna

At least two kinds of footprint have been identified from the Hopeman Sandstone Formation. Footprint Type A is represented by a slab collected in 1850 and is important as the first fossil from Elgin recognized as reptilian (Brickenden, 1852;

Hickling, 1909, p. 13). The footprints consist of roughly circular impressions, 30–40 mm long, with the fore and hind feet forming tracks that nearly touch. The stride length is 110–120 mm, the width of the trackway is 80–90 mm and there is no sign of toe marks.

Footprint Type B (Huxley, 1859b, pp. 456–9, pl. 14, figs 4, 5; 1877, pp. 45–52, pl. 14–16; Hickling, 1909, p. 13, pl. 2, fig. 6; Haubold, 1971, p. 37, fig. 22 (4)) was named *Chelichnus megacheirus* by Huxley (1877) and type C15 by Hickling (1909). The fore and hind feet were clearly different. The print of the fore foot (smaller print) is semicircular, about 40 mm long and 60 mm wide, with impressions of nine or five claws at the front. The sole part of the footprint is 60 mm wide, 30–40 mm long and the claws would measure 10–15 mm. The print of the 'hind foot' (larger print) is longer: 80–90 mm long and 80 mm wide, bearing five claw marks at the front 20–40 mm long. The prints overlap in pairs and show a stride length 300–400 mm, with the width of trackway (between midpoints of tracks), c. 150 mm.

There may be a third track type, like Type B, but larger. Huxley (1877, pl. 15, fig. 6) described such a track (prints 170 mm long and 140 mm broad) and with impressions of three claws. These larger tracks measure 150–250 mm long and 100–150 mm wide, and the stride length is 700–800 mm. A slab of such large prints, 100–150 mm wide, and with a stride length of 700–800 mm (Figure 3.5C), were observed *in situ* in Clashach Quarry (Benton and Walker, 1985, p. 208).

McKeever (1990, 1991) has revised the Hopeman Sandstone footprints, and notes the presence of the ichnogenera *Chelichnus*, *Laoporus*, *Herpetichnus* and *Palmichnus*. Fuller details of these determinations have yet to be published.

Footprint specimens from Masonsbaugh Quarry include: BGS(GSM) 113445 (Brickenden's 1850 specimen) and BGS(GSM) several slabs (Huxley 1859b, 1877). Undescribed material includes ELGNM (six slabs), NMS (several slabs), and other material in Forres Museum, Inverness Museum and MANCH.

### Interpretation

Brickenden (1850, 1852) thought tracks of Type A were produced by tortoises, and Huxley (1859b,

p. 459) thought the track type B might have been formed by *Stagonolepis*, but in 1877 (pp. 49–51) he could not ascribe them to any definite fossil amphibian or reptile then known. In a recent review of vertebrate tracks, Haubold (1971, p. 37) describes *C. megacheirus* (Type B) as possibly formed by a dicynodont, and indeed *Gordonia* from Cutties Hillock is the right size.

The footprints may be preserved on low-angle dune foresets, but this has only been observed in a few *in situ* occurrences. The slabs collected in the nineteenth century may include some from horizontal bedding planes. However, there is usually a mound of sand behind each print (Brickenden, 1852; Huene, 1913; Watson and Hickling, 1914), perhaps indicating that the producers of most trackways were moving uphill. These mounds are seen also behind the large footprints at Clashach.

Martin (c. 1860) gave a detailed account of the occurrence of tracks at Masonshaugh, and notes that all were heading in one direction (towards today's North Pole). He considered that the producers were moving down to the Moray Firth across the beach to find the sea! Benton and Walker (1985, p. 217), more plausibly, interpret the footprints as individual trackways probably formed by two or three species of mammal-like reptiles (?anomodonts), each displaying a range of sizes, heading across a dune-field towards the depositional basin to the north.

#### Comparison with other localities

Trackways and individual footprints similar to those from Masonshaugh have been observed in Greenbrae and Clashach Quarries. The 16 m working face in Greenbrae Quarry (NJ 137692) displays large-scale cross-bedding in fine- to medium-grained, yellow-brown sandstone. Evidence of water action includes fine lamination, small channels, ripple marks and small quartz pebbles. In addition to footprints, Peacock *et al.* (1968, p. 59) report an unidentified bone fragment from this

locality. This quarry is still worked to some extent for ornamental stone (1990).

Clashach Quarry (NJ 163702) is also still in operation to a small extent and contains stone very like that at Greenbrae. Murchison (1859, p. 429) recorded tracks from this quarry, and some poor specimens were noted by Peacock *et al.* (1968) and Walker (pers. comm., 1990). A range of tracks from small 5 mm 'lizard-like' forms to large 100 mm dicynodont prints was seen *in situ* and on nearby spoil tips at Clashach by M.J.B. (April, 1980).

A third kind of track (Type C) was described from the coastal exposure of Hopeman Sandstone by Huxley (1877) and Hickling (1909, pl. 2, figs 7 and 8), and Watson and Hickling (1914, p. 400, fig. 1) found 'one of the typical Cummingstone footprints' (i.e. Type C prints) in a quarry '300 yards WNW from the Cutties Hillock reptile quarry', from a site that cannot now be identified. Tracks of this type were also seen at Cutties Hillock Quarry in 1878 before the reptiles there were discovered (Peacock *et al.*, 1968, p. 73) and these have occasionally been seen since (Walker, pers. comm., 1981). These footprints are similar to the Type B prints from Masonshaugh, but the toes are broader. The dimensions are: print 30 mm wide, 20 mm long; toes 8 mm long, 6 mm wide. These footprints supposedly differ from Types A and B in having broader toes, but the generally poor preservation of most specimens makes such a distinction inadvisable.

#### Conclusions

The best British Late Permian tetrapod trackway site. Its importance rests on the diversity of tracks observed there, and their potential in allowing stratigraphic and palaeobiological observations.

Despite the partial degradation of the site by weathering and infill, its importance in Britain and potential for re-excavation give it significant conservation value.