Chapter 4 British Triassic fossil reptile sites

Introduction: Triassic stratigraphy and sedimentary setting

The British Triassic deposits have a broad U-shaped outcrop in the English Midlands, with a continuation south-westwards to south Wales and Devon (Figure 4.1). Smaller outcrops occur in northwest England, in Northern Ireland and in Scotland (Warrington *et al.,* 1980, figs 2 and 3). The sediments are almost wholly continental terrestrial red-beds deposited in fault-bounded basins in southern and western Britain and on the more regionally subsiding Eastern England Shelf, which formed the onshore marginal part of the Southern North Sea Basin (Audley-Charles, 1970; Holloway, 1985). In the Late Permian and Early Triassic, renewed and extensional subsidence in the Wessex Basin, Worcester Graben and the Needwood and Cheshire basins, resulted in the establishment of an axial drainage system which flowed northwards from the Variscan Highlands (Holloway, 1985). The south-to-north regional palaeoslope, and the proximal to distal depositional pattern which developed, is reflected in the diachronous nature of the Sherwood Sandstone–Mercia Mudstone Group boundary (Figure 4.2), with coarse elastics being deposited in the south, while mudstones and evaporites accumulated farther north (Warrington, 1970a, 1970b; Warrington *et al.,* 1980; Warrington and Ivimey-Cook, 1992). This general sedimentary pattern was complicated locally by the introduction of coarse-grained deposits along basin margins and the deposition of marine-intertidal sediments during Mid Triassic marine incursions. The widespread occurrence of transgressive intertidal facies of Mid Triassic age indicates extremely low relief in central England and suggests that the contemporary vertebrates were disporting themselves in lowland areas close to sea level, a suggestion first offered in 1839 by Buckland, who proposed (1844) a palaeoenvironment of intertidal sandbanks.

In the British Triassic there is a general dearth of biostratigraphically useful fossils (Figure 4.2). This, combined with rather limited vertical facies variations throughout the sequence, has led to problems of correlation across Britain and between the British Isles and abroad. The standard stages of the Triassic were defined using ammonoids in the marine sequences of southern Europe, and it has been hard to correlate the continental Triassic of Britain with these type successions. In Germany the Early to Mid Triassic Buntsandstein ('mottled sandstone') and Mid to Late Triassic Keuper ('red marl') consist of continental facies which compare superficially with parts of the British sequence.

Sedgwick (1829) recognized the British New Red Sandstone as equivalent in part to the German Triassic and considered some units equivalent to the German Buntsandstein and Keuper. Hull (1869) equated the English Bunter Sandstone with the German Buntsandstein (broadly Early Triassic in age) and the Lower Keuper Sandstone with the German Lettenkohie (latest Mid Triassic to early Late Triassic in age). He argued that a major unconformity in the British sequence corresponded to most of the Mid Triassic and represented the Muschelkalk. Warrington *et al.* (1980) advocated the abandonment of the terms 'Bunter' and 'Keuper' as applied in Britain, and established a lithostratigraphic nomenclature with correlations based on palynomorphs and other fossils where possible (Figure 4.2).

Palynological work (Warrington, 1967, 1970b; Geiger and Hopping, 1968) showed that deposits of Mid Triassic age are present in Britain (Figure 4.2), where correlatives of the Muschelkalk, including brackish-water to littoral marine facies, occur in the upper part of the Sherwood Sandstone Group and lower parts of the Mercia Mudstone Group in central and northern parts of England (Geiger and Hopping, 1968; Warrington, 1974a; Ireland *et al.,* 1978; Warrington *et al.,* 1980; Warrington and Ivimey-Cook, 1992).

The Sherwood Sandstone Group includes the former 'Bunter Sandstone' and the arenaceous (lower) parts of the former British 'Keuper'. Its boundaries are diachronous, the lower varying from Late Permian to Early Triassic and the upper from Early to Mid Triassic in age (Warrington *et al.,* 1980). The group comprises up to 1500 m of arenaceous deposits that form the lower part of British Triassic successions. The sandstones are red, yellow or brown in colour, and pebbly units occur, especially in the Midlands. Most of the deposits are of fluvial origin, but there are many aeolian units (Thompson, 1969, 1970a, 1970b).

The Mercia Mudstone Group corresponds broadly with the former 'Keuper Marl', and encompasses the dominantly argillaceous and evaporitic units that overlie the Sherwood Sandstone Group throughout much of Britain. Its lower

boundary may be sharp, but there is commonly a passage upwards from predominantly sandy to predominantly silty and muddy facies at a diachronous interface that varies regionally from Early to Mid Triassic in age. The upper boundary, associated with a marine transgression which apparently occurred approximately contemporaneously throughout much of Europe, lies within the Rhaetian Stage. The group comprises dominantly red mudstones with subordinate siltstones. Extensive developments of halite and of sulphate evaporite minerals suggest deposition in hyper-saline epeiric seas, connected to marine environments in associated sabkhas, and in playas (Warrington, 1974b).

The Penarth Group, which overlies the Mercia Mudstone Group, consists of argillaceous, calcareous and locally arenaceous formations, predominantly of marine and lagoonal origin. The topmost beds of the Penarth Group (Lilstock Formation, Langport Member), pass up into grey bituminous shales and limestones, which are lithologically indistinguishable from and continuous with the beds of the overlying Jurassic. The top of the British Triassic is placed above the Penarth Group within the Blue Lias, at the point of appearance of the first ammonite, *Psiloceras* (Cope *et al.,* 1980a; Warrington *et al.,* 1980).

In Scotland red-bed sequences assigned to the Permian and Triassic form fairly numerous, although scattered and usually small, outcrops (Judd, 1873) which represent the thin marginal expressions of extensive thicker successions, possibly of different facies, present in important offshore basins. Of these, the small occurrences of Late Triassic deposits in the Moray Firth area and in particular those in the Elgin district (Lossiemouth Sandstone Formation), are important for their datable vertebrate faunas.

Reptile evolution during the Triassic

The Triassic Period was a time of major flux among tetrapods. The earliest Triassic faunas were of low diversity by comparison with the Late Permian faunas, a consequence of the end-Permian mass extinction event. The ecological niches left vacant by removal of the old faunas were soon filled in the Early Triassic by several new tetrapod groups and by re-radiation of surviving groups from the Permian. In several parts of Gondwanaland, Early Triassic faunas were uniquely dominated by the dicynodont *Lystrosaurus,* which often comprised 95% or more of the individuals in a fauna. The remainder of these faunas consisted of small plant- and insect-eating therapsids, and some archosaurs. The archosaurs (Triassic forms are often termed 'thecodontians'), new groups of therapsids, particularly cynodonts, and the rhynchosaurs (archosauromorphs) rose to prominence during the Early and Mid Triassic.

Mid Triassic tetrapod faunas worldwide were strikingly similar (Benton, 1983a, 1983b) being dominated by rhynchosaurs or by dicynodonts as herbivores, and with associated fish-eating tem-nospondyl amphibians and a variety of prolacertiforms, small- to medium-sized insectivores, and procolophonids, modest-sized plant- and insect-eaters. These animals were preyed on by a range of cynodonts and thecodontians, some of the latter, the rauisuchians, achieving large size (up to 5 m long). These faunas continued into the early part of the Late Triassic, but were apparently decimated at the end of the Carnian (Benton, 1983a, 1983b, 1986a, 1986b, 1991, 1994a, 1994b): the rhynchosaurs and larger therapsids all died out, as well as some smaller groups.

Following this extinction event, the dinosaurs, pterosaurs, crocodilomorphs, sphenodontians (lizard relatives), and other groups radiated during the last 15–20 Ma of the Triassic, the Norian. The thecodontians, particularly the rauisuchians, ornithosuchids, fish-eating phytosaurs, and herbivorous aetosaurs dwindled during this time, and finally died out near the Triassic/Jurassic boundary, an extinction event that was also marked by major effects on marine life.

British Triassic reptile sites

The British Triassic is for the most part unfossiliferous, and tetrapod faunas occur only sporadically. However, some of these faunas are locally rich. The principal reptiliferous horizons lie within three rock units: the uppermost portion of the Sherwood Sandstone Group of south-west England and the Midlands (Anisian), the Lossiemouth Sandstone Formation (Carnian) of north-east Scotland, and the Penarth Group (Rhaetian), of central and south-west England. These provide excellent information on Mid Triassic terrestrial reptiles, rare elsewhere in the world, on Late Carnian pre-extinction faunas, and on terminal Triassic forms. Virtually all the Mid Triassic bone-bearing sites are selected as GCR sites, as are

all the Carnian localities around Elgin, and most of the fissure localities. Aust Cliff is selected as the sole Rhaetian GCR site out of dozens of other candidates, since it has yielded most specimens in the past.

Some of the most unusual British Triassic reptile faunas are the insular assemblages from fissure-fill deposits within fossilized cave systems developed in the Carboniferous Limestone of south-west England and South Wales. The deposits range in age at least from the Late Norian, possibly the Late Carnian, to the Early Jurassic and some have been correlated lithostratigraphically and biostratigraphically with the local marginal Trias (formerly the 'Dolomitic Conglomerate'). The best examples of these fis sure sites, as well as sites in the Mid Triassic of the English Midlands and Devon, the Carnian of northeast Scotland and the Penarth Group of south-west England, have been selected as GCR sites.

Reptile bones have not been reported from the British Early Triassic, but Wills and Sarjeant (1970) noted a variety of small reptilian footprints from the Bunter (=Kidderminster and Wildmoor Sandstone Formations) of a borehole at Bellington, Worcestershire. *Cheirotherium* footprints have been observed in the Wilmslow Sandstone Formation in the Wilmslow Waterworks Borehole (Thompson, pers. comm., 1993). The British record of fossil reptiles is also sporadic during Mercia Mudstone Group times: reptiles are represented by undiagnostic dissociated bones from the conglomeratic marginal Triassic of the Bristol district, and rarely from the Arden Sandstone Member of the Midlands and the Weston Mouth Sandstone Member of south-east Devon, both of which are Carnian in age. Some of the fissure deposits around Bristol and in South Wales may date from Late Carnian and Norian times, as might the footprints from Barry, South Wales (see below).

Mid Triassic of the English Midlands

Numerous localities in the English Midlands have yielded fossil reptiles of Mid Triassic age, from the upper part of the Sherwood Sandstone Group (Bromsgrove Sandstone Formation, Helsby Sandstone Formation; Figure 4.2) and the lower part of the Mercia Mudstone Group (Tarporley Siltstone Formation). These, and other neighbouring units, have also yielded significant ichnofaunas (see below).

In the Warwick area, old quarries at Guy's Cliffe, Leek Wooton, Cubbington Heath, Coten End and Leamington have yielded many fragmentary fossil reptiles, but only Guy's Cliffe and Coten End are extant. A number of localities in Leamington and Warwick (e.g. Coten End, [SP 2900 6550]; Leamington Old Quarry, [SP 325 666]) have produced remains of the reptiles *Macrocnemus* (type specimen of Owen's *Rhombopholis scutulata* (Owen, 1842a, pp. 538–41, pl. 46, figs 1–5), *Rhynchosaurus brodiei* (Benton, 1990c), *Cladeiodon lloydi* (Owen, 1841b), *Bromsgroveia walkeri* (Galton, 1985a), a possible prosauropod tooth (Murchison and Strickland, 1840, pl. 28, fig. 7a; Huene, 1908b, figs 210–11, 265), the temnospondyls *Mastodonsaurus, Cyclotosaurus pachygnathus, C. leptognathus* and the fish *Gyrolepis* (Walker, 1969, p. 472). Cubbington Heath Quarry [SP 335 694] has yielded *M. jaegeri, C. pachygnathus* and *C. leptognathus* (Huxley, 1859c; Woodward, 1908a; Wills, 1916, pp. 9–11, pl. 3). Guy's Cliffe [SP 293 667] has produced remains of the jaws of *Mastodonsaurus* sp. (=*M. jaegeri*) (Owen, 1842a, pp. 537–8, pl. 44, figs 4–6; pl. 37, figs 1–3; Miall, 1874, p. 433), probably the first find of a tetrapod to be made in the area, having been collected in 1823 (Buckland, 1837). A ?prosauropod femur and tooth have been recorded from Leek Wooton [SP 289 689], but the site of the quarry from which this specimen was collected is uncertain. Elsewhere in the Midlands good remains of *Rhynchosaurus articeps* have been obtained from a series of quarries at Grinshill, Shropshire [SJ 520 237], and a fine skull of *C. leptognathus* was collected from Stanton, near Uttoxeter, Staffs [SK 126 462] (Woodward, 1904).

Many localities in the Early and Mid Triassic of the English Midlands, especially in Cheshire, have yielded rhynchosauroid and *Cheirotherium* footprints (Tresise, 1993). The richest of these footprint localities is Storeton Quarry, Higher Bebington [SJ 303 838], source of hundreds of slabs, but now filled in (Tresise, 1989, 1991). Other localities in Cheshire and Merseyside include Rathbone Street, Liverpool; Delamere Forest; 'Mr Leach's quarry', Runcorn; Beetle Rock Quarry, Runcorn; Overhill, Iveston and Weston Point, all near Runcorn; Runcorn Hill; Flaybrick Hill, Birkenhead; Daresbury; Oxton Heath; Moorhey, near Great Crosby; Eddisbury; Warrington; Five Crosses Quarry, Frodsham; Potbrook, Mottram St Andrews; Wazards Well, Alderley Edge; Haymans Farm Borehole, Nether Alderley, all in the Helsby Sandstone Formation and Tarporley and Lymm in the Tarporley Siltstone Formation. The only Cheshire site that has recently

produced footprints is Red Brow Quarry, Daresbury [SJ 567 834] and scattered occurrences in boreholes and in field walls (Thompson, 1970a; Ireland *et al.,* 1978; Sarjeant, 1974, pp. 312–13). Localities in Shropshire include Grinshill (site of reptile finds as well — see below) and Oaken Park Farm, Albrighton (Sarjeant, 1974, pp. 316–17). Localities in Derbyshire are Weston Cliff on the River Trent and Dale Abbey, Stanton-by-Dale (Sarjeant, 1974, p. 321) and in Staffordshire, Stanton; Coven, near Brewood; Burton Bridge, Burton-on-Trent; Ashby Road, Burton-on-Trent; Hollington; Townhead Quarry, Alton; Chillington; Great Chatwell (Sarjeant, 1974, pp. 319–21; Delair and Sarjeant, 1985, pp. 131–2). Localities in Warwickshire are Birkbeck; Shrewley Common; Witley Green, near Preston Baggot; Coten End Quarry, Warwick; Rowington (Sarjeant, 1974, pp. 314–16; 1985), and in Worcestershire: Barrow Churz, Malvern (Sarjeant, 1974, p. 324). Localities in Leicestershire are Shoulder-of-Mutton Hill, Leicester; Castle Donington; and Derby Road, Kegworth, although the first two are rather uncertain (Sarjeant, 1974, pp. 317–19), and in Nottinghamshire: Colwick, Nottingham; 011erton; Sherwood district or Mapperley Park, Nottingham (Sarjeant, 1974, pp. 321–3). Unfortunately, most of these localities, listed largely from 19th century reports, are either lost or untraceable. A strong case could not be made for listing any Mid Triassic footprint locality or localities as a GCR site. A complete overview of these sites is urgently required (King, M.J. in prep.).

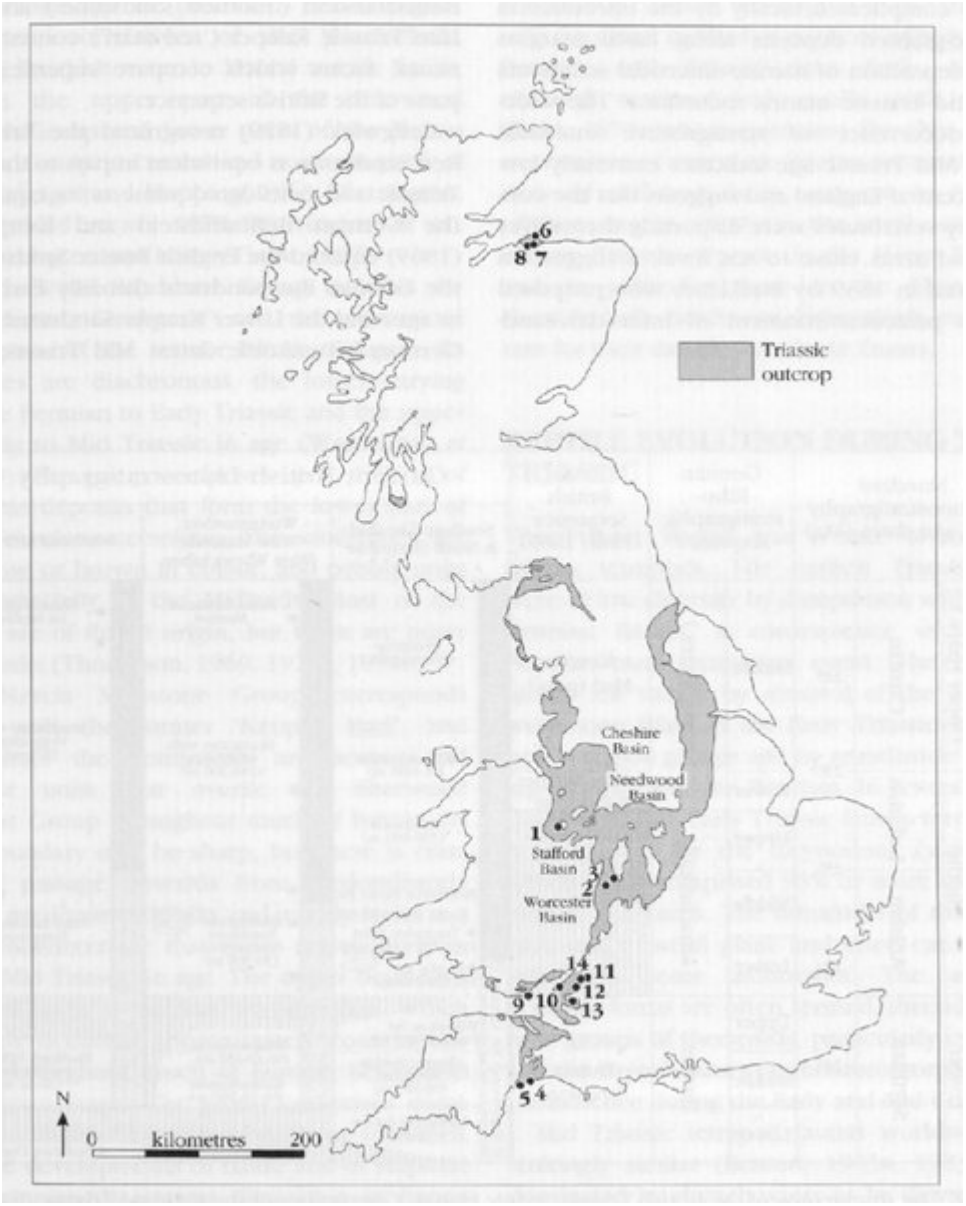
At Bromsgrove, near Birmingham, three quarries near Hilltop Hospital, on Breakback or Rock Hill [SO 948 698] are also known for their Middle Triassic tetrapods. These quarries (Wills, 1907, 1910, pp. 254–6) formerly showed good sections in the Finstall Member of the Bromsgrove Sandstone Formation (the former Building Stones and Waterstones). Wills (1907; 1908, pp. 29–32; 1910, pp. 254–6) described the succession as 15–20 m of alternating sandstone and shales, and a band of 'marl conglomerate'. Some lenticular beds are 'true marls', others are sandy shales, green, brown or red in colour. Individual units are lens-shaped, and the sandstones appear to show cross-bedding (Wills, 1907, fig. 1). The present sections are very limited, and the sites could not be recommended as GCR sites.

The Bromsgrove Sandstones at Bromsgrove (Figure 4.2) are approximately equivalent in age to the fossiliferous horizons at Warwick and Leamington (Walker, 1969; Paton, 1974a; Warrington *et al.,* 1980, pp. 38–9, table' 4). The flora and fauna from Bromsgrove is similar to those from Warwick, and from the Otter Sandstone Formation of Devon, and they assist our understanding of these GCR sites. The fauna comprises arthropods: conchostracans (*Euestheria*), scorpionid arachnids (*Mesophonus, Spongiophonus, Bromsgroviscorpio and Willsiscorpio*), annelids (*Spirorbis*), and a bivalve (*?Mytilus*). The vertebrates include the shark *Acrodus,* the perleidid *Dipteronotus* and the lungfish *Ceratodus,* as well the capitosaurid amphibians *Cyclotosaurus pachygnathus* and *Mastodonsaurus* (Wills, 1916, pp. 2–7, figs 2–4, pl. 2; Paton, 1974a), and reptiles cf. *Macrocnemus, Rhynchosaurus brodiei,* rauisuchian remains (?including *Teratosaurus, 'Cladeiodon'), Bromsgroveia walkeri,* a ?prosauropod tooth (Huene, 1908b, p. 242, figs 273a, b; Galion, 1985a; Benton, 1990c), a trilophosaur, a nothosaur (Walker, 1969) and other, undiagnostic, remains. The remains of *R. brodiei* from Bromsgrove are labelled as having come from 'Wilcox S. Quarry'. The Bromsgrove fauna is associated with a rich flora that includes sphenopsids (horsetails and relatives) and gymnosperms (cycads, cycadeoids, conifers).

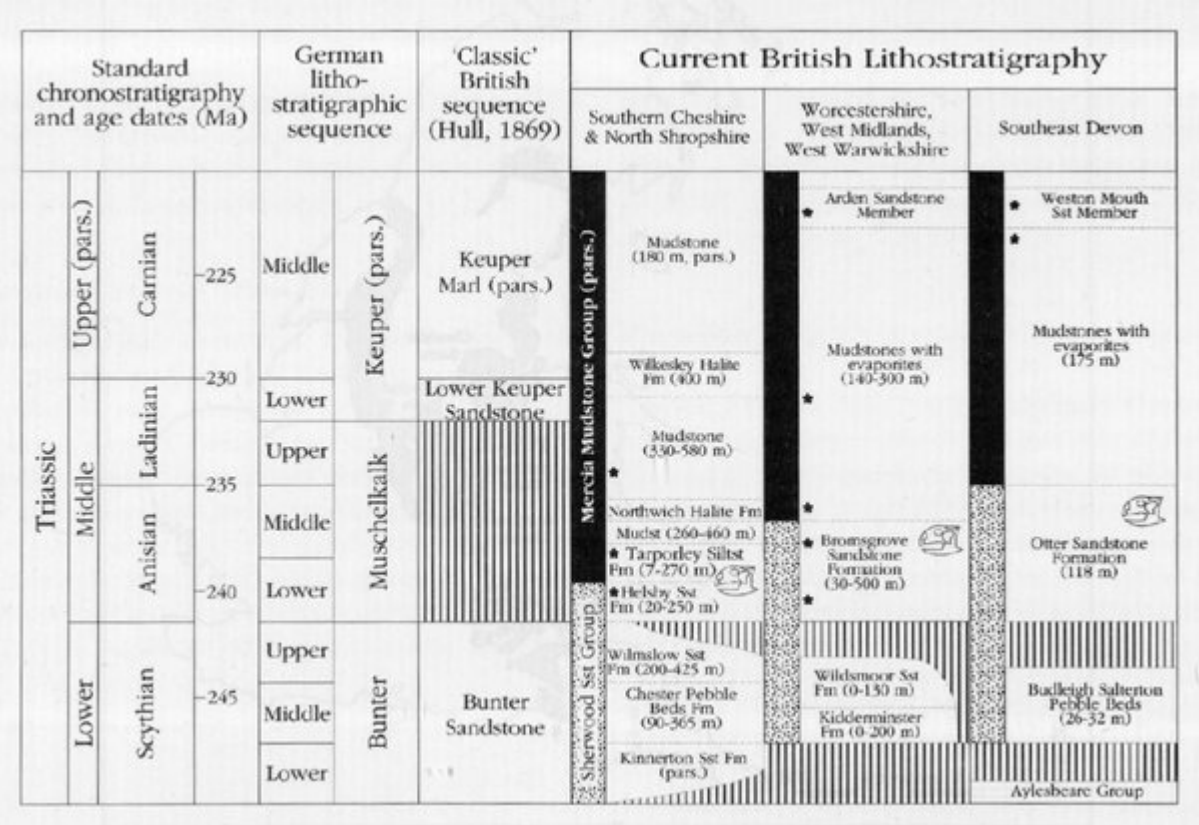
The following Midlands Mid Triassic localities are selected as GCR sites:

1. Grinshill Quarries, Shropshire [SJ 520 237]. Middle Triassic (Anisian), Helsby Sandstone and Tarporley Siltstone Formations.
2. Coten End Quarry, Warwick, Warwickshire [SP 290 655]. Middle Triassic (Anisian), Bromsgrove Sandstone Formation.
3. Guy's Cliffe, Warwick, Warwickshire [SP 293 667]. Middle Triassic (Anisian), Bromsgrove Sandstone Formation.

References



(Figure 4.1) Map showing the distribution of Triassic rocks in Great Britain. GCR Triassic reptile sites: (1) Grinshill Quarries; (2) Coten End Quarry; (3) Guy's Cliffe; (4) Sidmouth coast section; (5) Otterton Point; (6) Lossiemouth East Quarry; (7) Spynie; (8) Findrassie; (9) Bendrick Rock; (10) Aust Cliff; (11) Slickstones (Cromhall) Quarry; (12) Durdham Down; (13) Emborough Quarry; (14) Tytherington Quarry.



(Figure 4.2) The stratigraphy of the British Triassic reptile faunas. Correlations of the standard Triassic divisions and the German Triassic sequence with the British Triassic, as proposed by Hull (1869) for the 'classical' British succession, and by Warrington et al. (1980) for currently recognized lithostratigraphical units. Skull symbols indicate the levels of the main tetrapod faunas, and asterisks denote palynological evidence of relative age. Age dates (Ma ± 5) after Forster and Warrington (1985). From Benton et al. (1994).