Slickstones (Cromhall) Quarry, Avon

[ST 704 916]

Highlights

Slickstones (Cromhall) Quarry is the site of some of the richest of the fissure deposits in the Bristol–South Wales region. The Late Triassic cave fills have produced excellent specimens of more than 20 species of small reptiles: procolophonids, sphenodontids, gliding kuehneosaurs, problematic archosauromorphs, pterosaurs, crocodilomorphs, thecodontians and rare dinosaurs.

Introduction

Slickstones Quarry contains at least seven fossiliferous cavity-fill sites, the main fissures being located at [ST 7035 9155], [ST 704 916] and [ST 7040 9165]. Fissures 1 and 2 are the original sites of fossil finds described by Robinson (1957a). The quarry company (ARC Ltd) is working the Carboniferous Gully Oolite and Black Rock Limestone (Tournaisian age). The fissures noted are not in areas in which there are currently any quarrying operations; these are not likely to take place in the future, and further collecting is possible (Figure 4.23).

The vertebrate-bearing fissure deposits in Slickstones Quarry were first exposed during quarrying operations early this century and, having no commercial value, were left *in situ as* a rock promontory. They were later identified by Robinson (1957b) as representing one of the prime examples of a fossilized underground water-course fissure or cave. Robinson (1957b) recorded that F.G. Hudson discovered reptiles in the Slickstones deposits in 1938, this site being the first non-marine fissure discovery. Hudson collected specimens of a sphenodontid which was described and named as the type of *Clevosaurus hudsoni* by Swinton (1939), who did not specify the exact locality. Continued excavation and extensive collecting from the same area revealed the first remains in association, and Robinson *et al.* (1952) and Robinson (1957a) gave further details on the fauna, estimating the total number of reptile species as about nine and listing sphenodontids, squamate lizards and archosaurs. Robinson (1962) mentioned that the gliding 'lizard' *Kuehneosaurus* occurred at Slickstones. Halstead and Nicoll (1971) drew attention to dissociated material within recemented debris in the fissures, which formed the subject of all future work, and noted the occurrence of two further species, a procolophonid and a trilophosaur. Crush (1980) revised the number of species represented at Slickstones Quarry to 10, including *Kuehneosaurus latus,* a prosauropod dinosaur, two ?lizards and *Clevosaurus hudsoni.*

More recently, research by Fraser and Walkden (1983), Fraser (1985, 1994), and Walkden and Fraser (1993) has revealed the presence of six vertebrate-bearing deposits of Triassic age at Slickstones Quarry. Extensive collections were made from all these horizons and they identified six genera of lepidosaurs, including five sphenodontids, and at least four genera of archosaurs, comprising a theropod dinosaur, one or two 'thecodontians' and a possible terrestrial crocodile.

The sphenodontids were most abundant and diverse. Fraser (1982) and Fraser and Walkden (1984) described the dissociated remains of the most abundant form, a new small sphenodontid, *Planocephalosaurus robinsonae.* Specimens of *Clevosaurus* in the AUGD collections were found in five of the fissures and, although they too are mostly dissociated, some articulated remains were collected, including a partial skull and two lower jaws. A third sphenodontid, *Sigmala sigmala* (Fraser and Walkden, 1983; Fraser, 1986), was based on a maxilla, dentary and palatine, and a fourth, *Pelecymala robustus,* was based entirely on isolated jaw elements (Fraser, 1986). Fraser (1988c) described *Clevosaurus* in detail, and formally described the new species *Clevosaurus minor* and a third indeterminate species which he called *Clevosaurus* sp.

Fraser (1988a) described some rare and unusual skeletal elements, including jaw bones and a procoelous vertebra, which he suggested tentatively might represent prolacertiform, thalattosaurian and even pterosaurian remains. The remains of a rhamphorhynchoid pterosaur, the earliest known from Britain, were reported by Fraser and Unwin (1990).

Description

Fraser and Walkden (1983), Fraser *et al.* (1985) and Walkden and Fraser (1993) identified seven fissure and cavity fill sites at Slickstones, six of which yielded vertebrate remains. The seventh, a collapsed cave system, was evidently not fossiliferous and pre-dated the rest on sedimentological grounds. The fissure walls range from subhorizontal to almost vertical in relation to bedding in the Carboniferous Limestone host rock, and the fills are arranged in a linear fashion along a common axis. This alignment of the fissures is not obviously associated with any persistent joint system or with faults; it probably reflects the flow direction of an ancient water course (Fraser, 1985). The fissures have been interpreted as a series of separately filled sink-holes (dolines) and part of a small cave system. Simms (1990), however, disputes this interpretation and regards at least the western fissure as a thermal spring conduit.

The fissure material consists of Triassic land-wash laid down in the karstic fissures and cave systems in Carboniferous Limestone. A calcareous, buff-coloured matrix is lodged in Fraser's fissure 1, whereas fissures 3, 4, 5 and 7 contain marls, sandstone, bedded crinoidal limestone and soft, pale green to red mudstones. Most of the fills are nearly horizontally bedded, sometimes with sag-curvature and with some small-scale cross-bedding, and they may contain fragments of stalactites and rare cave pearls. Halstead and Nicoll (1971) mention fluting on the limestone wallrock and laminated red marls (clay grade) in the lower levels, and coarser sandy green marls higher up, the latter formed at a time when the limestone surface had been eroded to approximately the level of the water table.

In fissures 3, 4, 5 and 7 vertebrate remains occur in three principal lithologies: lenses of conglomerate with Carboniferous Limestone clasts in the mudstones enclose reptile bones and remanie fossils, paler sandy mudstones with reptile bones, and hard red calcite-cemented sandstones with the original *Clevosaurus* material and many specimens of the branchiopod crustacean *Euestheria minuta.*

The preservation of the bone is generally excellent, although few bones are complete. Some of the fossils are extremely well preserved and in a fully associated state (i.e. with bones still in position of original articulation), and complete skulls have been found; part of the skin was preserved in one specimen. However, many specimens are broken and show in addition a high degree of rounding and polishing, indicating considerable attrition during transport (Kermack *et al.,* 1973; Fraser and Walkden, 1983).

A certain degree of sedimentary sorting of elements is evident, with coarser sediments tending to contain larger bones in addition to the smallest elements. One lamina was found to contain almost exclusively dentaries of *Clevosaurus* (specimen in BRSUG). Current alignment is not uncommon in some of the beds.

The bone material is preserved as a pale yellow or white substance, but may be dark brown in colour. Unabraded elements often show fine surface detail, preserving tiny foramina and even muscle attachment points.

Fauna

Nearly twenty genera of archosaurs and lepidosaurs (Figure 4.24) have been identified from the six fissure fills, and the variety of assemblages present may represent successional ecosystems. The reptiles are mostly small, the largest, a dinosaur, being no more than one metre long. At least seven species of sphenodontids occur, and for five of these, *Clevosaurus hudsoni, C. minor, Sigmala sigmala, Pelecymala robustus* and *Planocephalosaurus robinsonae,* Slickstones is the type locality. A reconstruction of the faunas of the Bristol region in the Late Triassic, based on fossils found in fisure deposits, is shown in (Figure 4.25).

Arthropoda: Crustacea: Branchiopoda

Euestheria minuta Casts of carapaces (AUGD)

Arthropoda: Myriapoda: Diplopoda

Millipedes Several well-preserved complete and part-enrolled specimens (AUGD)

Arthropoda: Hexapoda: Insecta

Beetle elytra (AUGD)

Anapsida: Procolophonidae

Procolophonid

Abundant dissociated cranial and postcranial material (AUGD)

Lepidosauria: Sphenodontida

Clevosaurus hudsoni Swinton, 1939 Syntypes: BMNH R6100, R9249, R9251, R9252, R9253, R9255-R9260

Clevosaurus minor Fraser, 1988 Type specimen: AUGD 11377

Clevosaurus sp. Various specimens (AUGD)

Planocephalosaurus robinsonae Fraser, 1982 Type specimen: AUGD 11061

Sigmala sigmala Fraser, 1986 Type specimen: AUGD 11083

Pelecymala robustus Fraser, 1986 Type specimen: AUGD 11140

Diphydontosaurus avonis Whiteside, 1986 Reptile 'B; AUGD

Archosauromorpha: *inc. sed.*

Kuehneosaurus latus Robinson, 1962 Various specimens (AUGD)

Archosauromorpha: Prolacertiformes

Prolacertiform (?)

Premaxilla and maxilla (AUGD)

Archosauromorpha: (?)Trilophosauridae

Variodens sp. Various (AUGD)

Archosauria indet.

Pterosaur or Thalattosaurian (?) Fused premaxilla, maxilla and vertebrae (AUGD)

'Thecodontians' Numerous serrated teeth belonging to two or three genera (AUGD)

Archosaur ('Reptile G')

A single left dentary with three remaining teeth (AUGD)

(?)Scleromochlid Various (AUGD)

(?)Aetosaur Various (AUGD)

Archosauria: Crocodylomorpha

Terrestrisuchus sp. and a sphenosuchid Various (AUGD)

Archosauria: Pterosauria

Rhamphorhynchoid Metacarpals (AUGD)

Archosauria: Dinosauria: Saurischia:

Sauropodomorpha

Thecodontosaurus Various (AUGD)

Archosauria: Dinosauria: Saurischia:

Theropoda

Theropod dinosaur Various (AUGD)

Unidentified sauropsids

Interpretation

The recognition of pre-Rhaetian sediments at Slickstones Quarry has been based largely on the abundance of red and green marls of Mercia Mudstone lithology, since it has not been possible to establish direct stratigraphic relationships based on nearby bedded sequences, as has been achieved for other fissures (e.g. Robinson, 1957a). In their studies of the sediments, Fraser and Walkden (1983) note that there is nothing to suggest that the Slickstones deposits postdate the Rhaetian transgression. Walkden and Fraser (1993) argue further that the sediments at Cromhall overlying the fissures contain fish and tetrapod faunas typical of the Penarth Group (Rhaetian), and that this provides an upper constraint on the ages of the fissures. The fissures may have filled at different times, and it is not possible to provide a lower age limit.

Despite careful searching at Slickstones Quarry, no palynomorphs have so far been recognized to provide a reliable date for the sediments (e.g. Warrington, 1978). Only the vertebrate fauna is available for determination of the relative age, and on this basis the Slickstones deposits have been assigned a Late Triassic age (Robinson, 1957a) and specifically Late Norian for *Clevosaurus* (Robinson, 1973). Benton (1994a, 1994b) noted that certain elements of the Lossiemouth Sandstone Formation (Late Carnian), such as *Leptopleuron, Brachyrhinodon* and *Scleromochlus,* are very similar to elements of the Cromhall fauna, and *Terrestrisuchus* is very like *Saltoposuchus* from the Mid Norian Stubensandstein of Germany.

Marshall and Whiteside (1980) noted *Clevosaurus* ((Figure 4.24)A from fissures at Tytherington, and identified a marine palynomorph assemblage which they regarded as Rhaetian. However, the Slickstone fissures contain faunal elements (e.g. *Kuehneosaurus*) not known from Tytherington, and these indicate a broad age range of Late Carnian to earliest Rhaetian, which accords with similar non-fissure faunas, such as those of the Newark Supergroup of eastern North America.

The most abundant remains at Slickstones Quarry are those of sphenodontids, of which the commonest is *Clevosaurus.* Four species of *Clevosaurus* seem to be present, based on dentitions and distinctive patterns of tooth wear (Fraser and Walkden, 1983; Fraser, 1988c): *C. minor* Fraser, 1988 is the smallest form, intermediate in size between *Planocephalosaurus* and *C. hudsoni; C. hudsoni* is the largest; a third and possible fourth species are as yet unnamed.

Clevosaurus hudsoni is one of the largest lepidosaurs in the deposit, averaging 150–200 mm in length, with a maximum of approximately 250 mm (Fraser, 1988c). It was superficially like a modern lizard with a slender body, long limbs and (probably) a long tail. The skull was strongly built. It has been suggested that *C. hudsoni* may have been a facultative herbivore (Fraser and Walkden, 1983), 'raking food together with its beak-like front teeth, and chopping it further back in the mouth'. However, in the adult *Clevosaurus* the jaws and worn dentition formed a powerful shearing mechanism fully capable of crushing the chitin exoskeleton of large insects, and the possibility of an omnivorous or fully insectivorous diet

cannot be ruled out. Young *Clevosaurus* specimens almost certainly fed on small insects and soft-bodied invertebrates such as worms, the immature jaw bones possessing sharp pointed teeth. *Clevosaurus* is known elsewhere, at Tytherington and at Durdham Down, but other localities in the Bristol Channel area have recently also been found to contain material assignable to the genus: Pant-y-ffynon (Crush, 1980, fig. 1 a), Highcroft (Fraser, 1986), and Holwell (Fraser, pers. comm., 1993).

The remains of *Diphydontosaurus* (Whiteside, 1986), a primitive sphenodontid, best known from Tytherington Quarry, are also present at Slickstones, and at Durdham Down. 'Reptile B' of Tytherington is also present in the Slickstones fauna.

Planocephalosaurus robinsonae (Fraser, 1982) usually exhibits an incomplete lower temporal bar suggesting that this character, formerly thought unique to the squamates, is more widespread in the Lepidosauria as a whole. The genus appears to have close affinities with *Clevosaurus* and *Sphenodon.* The jaw action of *P. robinsonae* is slightly propalinal (back and forth movement), and the dentition (Fraser and Walkden, 1983) indicates that it may have been primarily insectivorous, although possibly capable of taking newly hatched sphenodontids, if the opportunity arose. The genus has been found elsewhere in the fissures at Tytherington and Ruthin Quarry, South Wales, where a sphenodontid maxilla has been found very similar in shape and size to the Slickstones form (Fraser, 1982). Fraser and Walkden (1983) noted subtle differences in the adult *Planocephalosaurus* material obtained from Tytherington and Slickstones quarries: the Slickstones variety was generally larger in size, exhibiting more robust skull elements. The range of *Planocephalosaurus* from the Norian into the Rhaetian may help explain these slight differences in morphology (Fraser and Walkden, 1983).

The rare sphenodontid *Sigmala sigmala* differs from *Planocephalosaurus* in bearing a high coronoid process and in possessing a somewhat deeper dentary bone. Well-defined facets on the teeth match precisely in opposing jaws and indicate the lack of any propalinal movement for this species. In a review of sphenodontid relationships, Fraser and Benton (1989) found that *Diphydontosaurus* and *Planocephalosaurus* were basal taxa, while *Clevosaurus* fell in a crown group containing mainly Jurassic and Cretaceous forms, as well as the living *Sphenodon.* The other Slickstones taxa are too incompletely known to be used in cladistic analysis.

The procolophonid (Halstead and Nicoll, 1971; Fraser, 1985) shows affinities with *Tricuspisaurus* of Ruthin Quarry, but appears most similar to *Leptopleuron lacertinum,* an advanced form from the Late Carnian Lossiemouth Sandstone Formation of Elgin (Fraser, pers. comm., 1991). The Slickstones procolophonid and *Leptopleuron* share certain affinities with *Hypsognathus* from the Rhaetian of the Newark Supergroup of the eastern USA.

The gliding diapsid reptile *Kuehneosaurus* ((Figure 4.24)D; Robinson, 1962) is comparable with *Icarosaurus* from the Late Carnian Lockatong Formation of New Jersey, USA. The other discoveries at Slickstones include several archosaurs: an articulated partial skeleton of a terrestrial crocodilomorph, a partial skull of an undescribed thecodontian and other thecodontian remains (a possible scleromochlid and a possible aetosaur) and a procolophonid jaw. Terrestrial crocodilomorphs of comparable age to the Slickstones form include *Terrestrisuchus gracilis* ((Figure 4.24)B from fissures in Old Pant-y-ffynon Quarry, South Glamorgan (Crush, 1984). Ruthin Quarry also yielded a terrestrial crocodile (*?Terrestrisuchus*) (Crush, 1984), and other reptiles in the Ruthin sediments include a few jaw fragments of a small archosaur, probably a thecodontian similar to the Slickstones forms (Fraser and Walkden, 1983; Fraser, 1985). Terrestrial crocodilomorphs and aetosaurs are also known from several Late Carnian to Rhaetian localities elsewhere in the world, but scleromochlids hitherto have only been reported from the Lossiemouth Sandstone Formation of Lossiemouth (see above). The trilophosaur/procolophonid specimen figured by Halstead and Nicoll (1971) is closest to *Variodens* from Emborough. The Slickstones fauna shares elements with many of the other fissure sites, but the greatest faunal affinity is with Tytherington, at least six reptiles being common to both localities.

The pterosaurs (Fraser and Unwin, 1990) belong to the Rhamphorhynchoidea and represent the earliest such remains from Britain. The material consists of two specimens of a metacarpal IV (from level K of site 4; Fraser, 1985). Triassic pterosaurs are rare, but well preserved material has been reported from Norian limestones of Cene, near Bergamo, Italy (*Eudimorphodon, Peteinosaurus*) and the Norian of Friuli, Italy (*Preondactylus*) (Wild, 1978a, 1983).

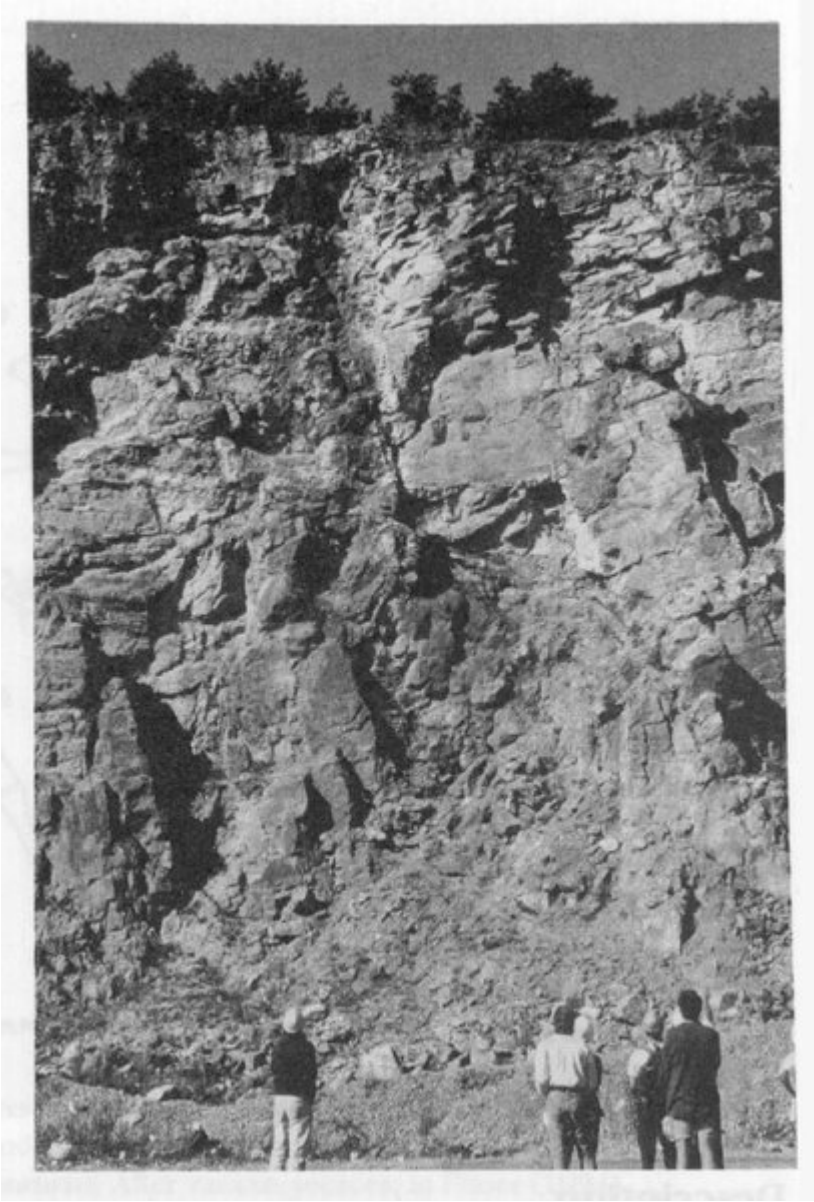
The only invertebrates present in the Slickstones fissures are the crustacean *Euestheria minuta,* and rare diplopod (millepede), and insect remains. An invertebrate fauna is unknown in most of the other fissure fillings of a comparable

age, but carapaces of *Euestheria* are recorded from Tytherington.

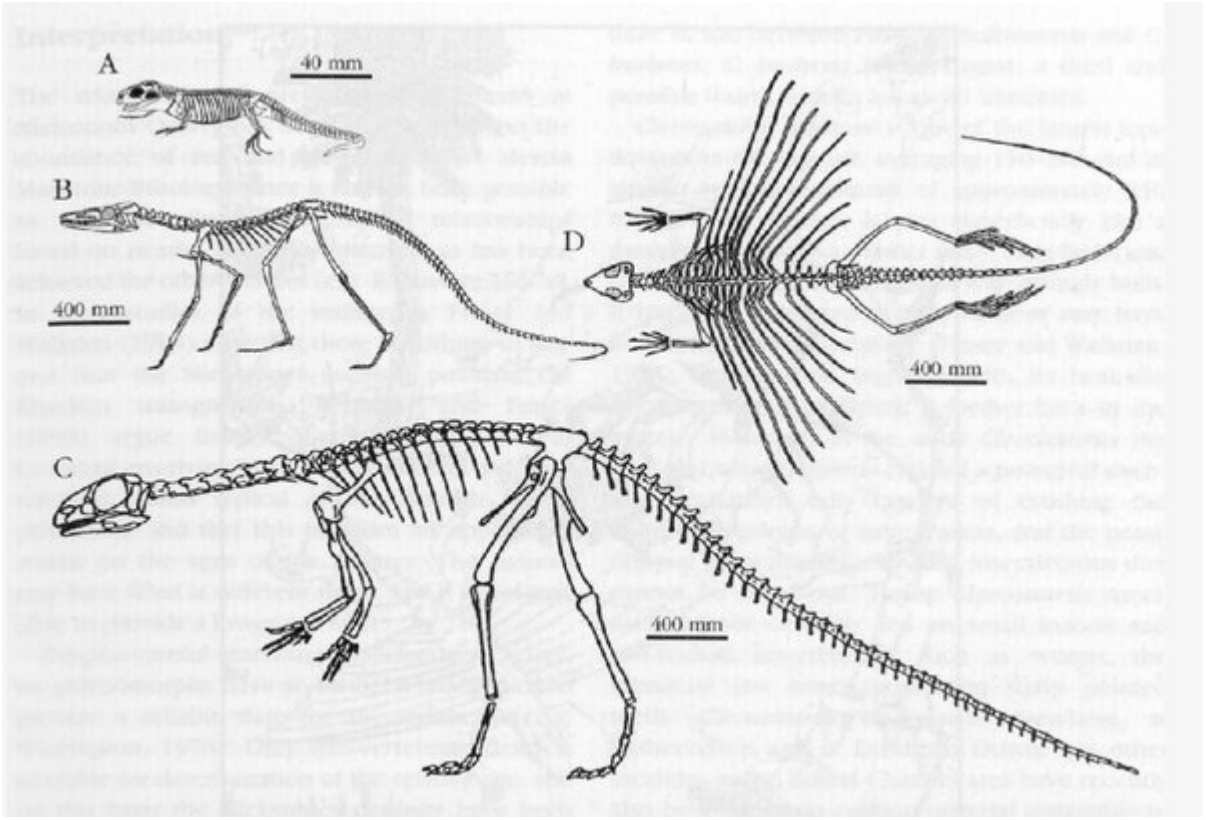
Conclusions

Slickstones is the richest fissure deposit: nearly twenty reptile taxa have been recognized, and it is the type locality for five species of sphenodontids. The diversity of lepidosaurs at Slickstones is unmatched by any other Triassic locality in the world, and this is the only fissure locality to have produced articulated remains of sphenodontid reptiles. The pterosaur remains are the oldest from Britain, and the only Triassic pterosaurs known outside Italy. This palaeontological importance and the potential for future finds give the site its conservation value.

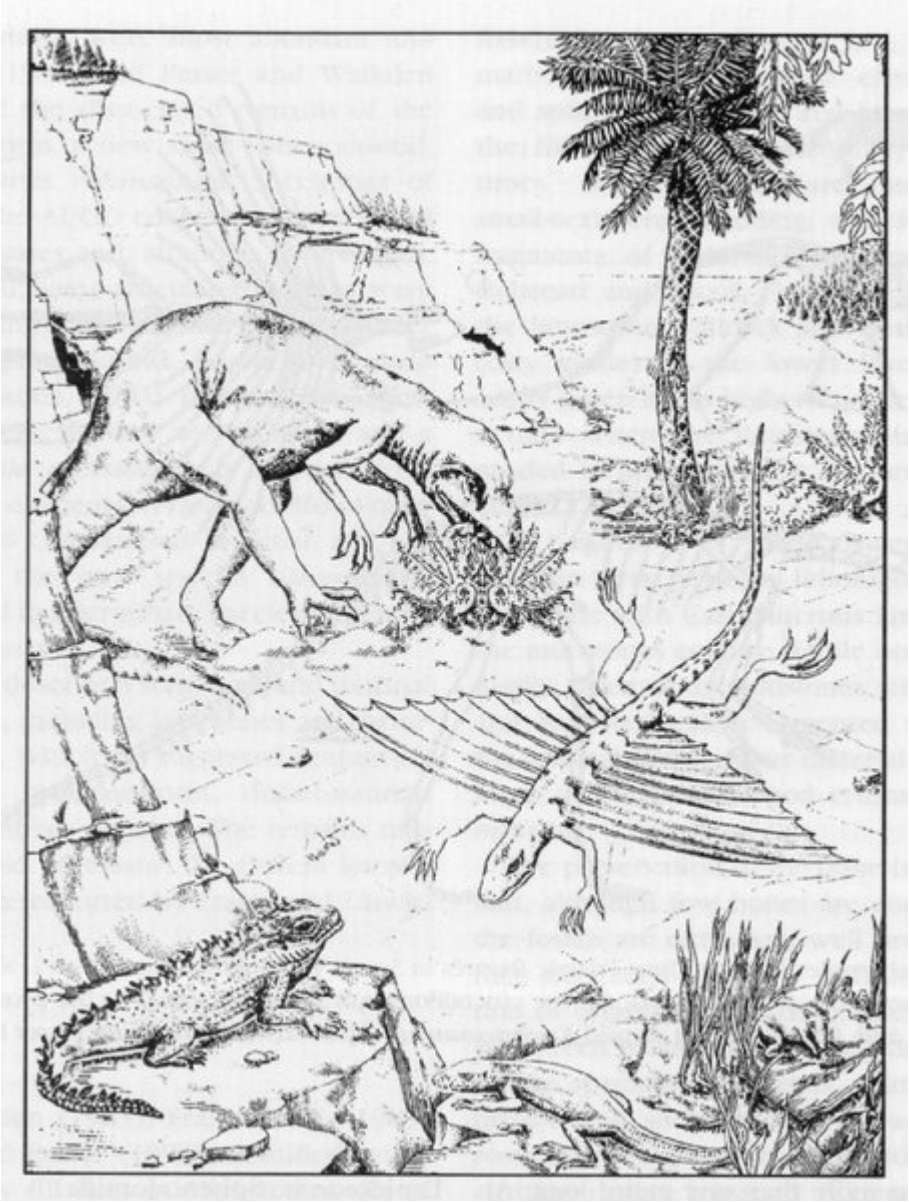
References



(Figure 4.23) Slickstones (Cromhall) Quarry: view of the north face, at the uppermost level, of this working site. A bone-bearing fissure is seen extending down the middle of the photograph. The fissure fills are late Triassic in age, and they occupy caves dissolved into uplifted Carboniferous marine limestones. (Photo: M.J. Benton.)



(Figure 4.24) Typical reptiles from the Late Triassic fissures in South Wales and around Bristol. Skeletal reconstructions of (A) the sphenodontid Clevosaurus; (B) the crocodilomorph Saltoposuchus; (C) the prosauropod dinosaur Thecodontosaurus; and, (D) the gliding diapsid Kuehneosaurus. After various sources; in Fraser (1994).



(Figure 4.25) Reconstruction of the faunas of the Bristol region in the late Triassic, based on fossil remains found in several fissure deposits. The prosauropod dinosaur Thecodontosaurus stands in the background, while the gliding diapsid Kuehneosaurus passes over a sphenodontid (bottom left), the possibly lizard-like Variodens (bottom middle), and the early mammal Haramiya (bottom right). After Duff, McKirdy and Harley (1985).