Lossiemouth East Quarry

[NJ 236 707]

Highlights

Lossiemouth East Quarry is one of the richest Late Triassic reptile sites in Britain, the source of superb specimens of six species of archosaur, one procolophonid and a sphenodontid. Four of the reptiles have been found nowhere else. The reptiles from this site are important in making palaeobiogeographical interpretations for the Late Triassic: the most similar faunas elsewhere are in India and South America.

Introduction

The Lossiemouth Sandstone Formation is seen in a 450 m long raised cliff between Lossiemouth and Branderburgh (Figure 4.12), running from School Brae to the old railway station, bounded above by Prospect Terrace and below by Quarry Road. Lossiemouth West Quarry, which is located on the west side of School Brae [NJ 231 704], was once more important for reptile finds, but is now largely filled in. Lossiemouth East Quarry, although partly filled in and surrounded by new housing, shows up to 3 m of orange or grey weathering, jointed sandstone in its eastern part (Figure 4.13) and partially to the west. Fossils could still probably be collected at the lower level of the East Quarry, which seems to have been the location of the reptile band. Neville Hollingworth obtained pieces of bone and a good skull of *Leptopleuron,* from the nearby beach in 1979.

Building stone was quarried in Lossiemouth as early as 1790, where two hills 'abound with excellent quarries in white and yellow free-stone, which is not to be found anywhere else in the Moray Firth. About 20 masons, including apprentices, and nearly double that number of labourers, are constantly employed in quarrying and dressing stones, to supply the demand for that article from this and neighbouring counties' (Lewis Gordon in Sinclair, 1793, vol. 4, p. 78). The West Quarry had ceased to work by 1912, but the larger East Quarry continued in operation until 1936 or later (according to County valuation rolls).

In 1844 a workman named Anderson collected a slab bearing casts of 31 scales, or scutes, at Lossiemouth. These he passed to the Elgin town clerk and geologist, Patrick Duff, who tried without success to have them identified in Edinburgh. Eventually, he sent drawings to the Swiss palaeontologist, Louis Agassiz, who identified them as belonging to an Old Red Sandstone (ORS) fish related to the large ganoid *Gyrolepis.* He named it *Stagonolepis robertsoni* after Alex Robertson, a local geologist (Agassiz, 1844, p. 139, pl. 31, figs 13 and 14). On the basis of this find, it seemed clear to Agassiz that the age of the Lossiemouth beds was Devonian, as had been previously assumed largely on the basis of lithological similarity with neighbouring sediments of undoubted Old Red Sandstone age.

In 1858 Mr Martin, schoolmaster in Elgin, 'detected… a bone, possibly the scapula of a reptile… It was near the same place that Mr Duff's specimen… of *Stagonolepis robertsoni* was found' (Gordon, 1859, p. 46). This bone was collected in sandstone beds behind the houses of Lossiemouth (Murchison, 1859, pp. 427–8), thus the East Quarry. Murchison collected further remains of limb bones in September, 1858, in company with George Gordon, minister of Birnie and naturalist. These remains were shown (Huxley, 1859a, 1859b) to be associated with the scutes of *Stagonolepis robertsoni* and proved that it was a reptile and, in particular, an ancestral crocodile according to Huxley (1875, 1877).

Some poorly preserved remains of another reptile were found at Lossiemouth by Gordon in April and May, 1859. These were interpreted as a rhynchosaur (Huxley, 1869) and named *Hyperodapedon gordoni* (Huxley, 1859a). The presence of an animal clearly closely related to the English *Rhynchosaurus* (from rocks of known Triassic age), and of the specialized *Stagonolepis* convinced Huxley that the Elgin reptiles were Triassic in age, and not Devonian. Murchison and other geologists continued to argue for an ORS age since there was no obvious structural or lithological break between true Old Red Sandstone of the Elgin district and the reptiliferous sandstone. However, Murchison admitted that his belief was shaken by the find of *Hyperodapedon* (Murchison, 1859, p. 436).

During the 1860s several geologists claimed to have found structural evidence to separate the Elgin ORS and Triassic, and further finds of *Hyperodapedon, Rhynchosaurus* and a rhynchosaur in the Triassic Maleri Formation of India (Huxley, 1869) were enough to convert Murchison and with him most other geologists: 'To such fossil evidence as this the field geologist must bow, I willingly adopt the view established by fossil evidence, and consider that these overlying sandstones and limestones are of Upper Triassic age' (Murchison, 1867, p. 267).

Further material of *Hyperodapedon* was described by Huxley (1887), Burckhardt (1900), Boulenger (1903) and Huene (1929a, 1938, 1939). Boulenger (1903) erected a new genus, *Stenometopon,* based on a specimen that supposedly differed from *Hyperodapedon,* but Which is merely a distorted example (Benton, 1983d).

A well-preserved skeleton of *Leptopleuron lacertinum (Telerpeton elginense*) was collected by James Grant, a Lossiemouth schoolmaster, in 1866 and described by Huxley (1867a). This was the second specimen collected, the first having been found at Spynie in 1851 (see below). Further bones of *Stagonolepis* were also collected in the 1860s (Anon., 1864) which provided materials for detailed monographs by Huxley (1875, 1877).

In the early 1890s Grant discovered a small skull and partial skeleton built into a breakwater at Lossiemouth, probably originating from one of the Lossiemouth quarries; it was named *Erpetosuchus granti* by Newton (1894b). Between 1895 and 1920 William Taylor, a retired chemist and naturalist, collected extensively in both East and West Quarries at Lossiemouth. He supplied materials for further descriptions of *Hyperodapedon* (Boulenger, 1903), *Ornithosuchus* (originally collected at Spynie; Boulenger, 1903; Watson, 1909a; Huene, 1914), *Leptopleuron* (Boulenger, 1904a; Huene, 1912a, 1920), and type specimens of the new genera and species *Scleromochlus taylori* (Woodward, 1907b; Huene, 1914), *Saltopus elginensis* (Huene, 1910a) and *Brachyrhinodon taylori* (Huene, 1910b, 1912b). Recent redescriptions of much of this material have been published (Walker, 1961, 1964; Benton, 1983d; Benton and Walker, 1985; Fraser and Benton, 1989; (Figure 4.14)) and others are in preparation by M.J.B. and P.S.S.

Description

Lossiemouth West Quarry showed '30 ft of hard, white, fine-grained, laminated and even-grained sandstone… with about 5 ft of till on top. The rock is close jointed with a dominant west-northwest-trending set and a subordinate north-north-east set, both sets dipping nearly vertically. The former is composite (i.e. two joint directions with an angle of about 20 degrees between them) and the joints often carry fillings of barytes and brown fluorspar, such fillings being filled over an inch across in some places' (Peacock *et al.,* 1968, p. 67). There is probably a small NE–SW trending fault below School Brae since the floor of the East Quarry is rather higher than that of the West.

Lossiemouth East Quarry is located in a sea cliff which was extensively quarried, and still exposes sections showing up to 20 m of hard to friable, yellow and grey sandstone, weathering orange, and jointed in the eastern part. The sandstones may be finely laminated, but more usually they show large-scale cross-beds on well-weathered surfaces. An isolated 3 m high sea stack at the eastern end shows white dune-bedded sandstone. Further west in the quarry, near a footpath up the slope, various sections show purple ORS and mudstone at the base, surmounted by yellow or white, soft, thinly-bedded Triassic sandstone. A block of 'cherty rock' that overlies the reptile beds at Spynie and north of Lossiemouth is also seen here.

Details of cross-bedding and petrography of the Lossiemouth sandstones are given by Williams (1973). The section in the East Quarry that he gives is:

	Depositional environment	**Thickness (m)**
(Cherry Rock)	altered caliche	
Sago Pudding Sandstone	water-lain, reworked aeolian	1–2
Lossiemouth Sandstone Formation	aeolian	18
Burghead Sandstone Formation	fluviatile	*c.* 4
Upper Old Red Sandstone		

Most of the reptiles were apparently collected in the West Quarry, but only the East Quarry is now exposed to any extent. Murchison (1859, p. 428) stated that the bones found then were collected 'in the lowest part' of the freestones being quarried at Lossiemouth which were 'underlain by red strata' (?ORS). Gordon (1859, p. 46) confirmed this, stating that the lowest beds at Lossiemouth were red clay (i.e. within the ORS?), succeeded by yellowish soft sandstone and then harder sandstone. The red clay may be equivalent to that reported by Peacock *et al.* (1968, p. 65) as 'micaceous siltstone', the yellowish soft sandstone may be the 'Burghead beds equivalent', and the harder sandstone is probably the Lossiemouth Sandstone. The bones were found 'immediately under this hard siliceous sandstone, in a quarry half-way to the new harbour from Rockhouse, and in the face of the wall of rock that overhangs the houses fronting the old harbour.' This probably refers to the east end of Lossiemouth East Quarry [NJ 237 707]. Judd (1873, p. 137) stated that the reptiles were found '100 ft below the top of the sandstones', which would imply at about the base of the Lossiemouth Sandstone Formation, if its complete thickness is taken into account. Judd (1886a, pp. 397, 403) added that the reptile remains all came from 'a single band of soft rock'. Further, Gordon (1892, p. 245) states that most of the fossils were found at the level of the platform made by the quarrymen in the base of the quarry where the sandstone became 'softish and rubbly'. Williams (1973, p. 130) notes that 'the quarry floor approximates to the contact of the aeolian sandstones with the floodplain deposits' (the water-laid Burghead Beds), and the reptiles seem to have been found near to this transition. The remains of reptiles are normally well preserved in articulation and only a few show disturbance, possibly through scavenging. Individual bones, particularly the smaller ones, show few signs of crushing or compression. The larger limb bones, however, appear to have been more susceptible to crushing and distortion and may show damage even when in association with other unaffected elements. The bone material is usually in a corroded state and may be partly leached out, but in a few specimens where the original material is present, internal structure may be clear, with cavities marked by replacement minerals. These minerals, which include iron oxide (goethite) and fluorite, sometimes overgrow bone margins adhering with the surrounding matrix, and in such cases are hard to remove. Most commonly, however, the Lossiemouth reptiles are preserved as external moulds in very well cemented sandstone, and details of bone form are best obtained from casts taken from the cleared natural rock moulds. Various methods that involve use of flexible synthetic 'rubbers' (e.g. RTV silicone rubber, PVC) have been employed in order to preserve the rock moulds and produce highly detailed copies of the bone (Walker, 1961, 1964, 1973; Benton and Walker, 1981).

Fauna

Anapsida: Procolophonidae

Leptopleuron lacertinum Owen, 1851 (=*Telerpeton elginense* Mantell, 1852) *c.* 26 individuals: BMNH, NMS, EGNM

Lepidosauria: Sphenodontida

Brachyrhinodon taylori Huene, 1910 *c.* 10 individuals: BMNH, NMS, ELGNM

Archosauromorpha: Rhynchosauridae

Hyperodapedon gordoni Huxley, 1859 *c.* 29 individuals: BMNH, BGS(GSM), NMS, MANCH

Archosauria: Crurotarsi: Pseudosuchia:

Stagonolepididae

Stagonolepis robertsoni Agassiz, 1844 6 large individuals: BMNH, AUZD, ELGNM, BGS(GSM); 11 small individuals: BMNH, AUZD, AUGD, NMS, ELGNM, BGS(GSM)

Archosauria: Crurotarsi: Ornithosuchidae

Ornithosuchus longidens (Huxley, 1877) 7 individuals: BMNH

Archosauria: Crurotarsi: *incertae sedis*

Erpetosuchus granti Newton, 1894 1 individual: BMNH

Scleromochlus taylori Woodward, 1907 5 individuals: BMNH

'Thecodontian' 1 individual: MANCH

Archosauria: Dinosauria: *incertae sedis*

Saltopus elginensis Huene, 1910 1 individual: BMNH

Interpretation

The Lossiemouth Sandstone Formation at Lossiemouth, Spynie and Findrassie is of the same age since it contains the same reptiles and is lithologically similar. It is placed in the Late Triassic on the basis of its varied reptile fauna (Walker, 1961; Benton, 1983d, 1986b, 1991, 1994a, 1994b). *Hyperodapedon* is represented in the Maleri Formation of central India and *Stagonolepis (= Calyptosuchus*) is reported in the lower part of the Petrified Forest Member of the Chinle Formation of Arizona (Hunt and Lucas, 1991b). The latter unit is dated palynologically as uppermost Carnian and the shared phytosaur *Paleorhinus* ties the lower part of the Petrified Forest Member to the Maleri Formation, and also to the Blasensandstein in Germany, and the marine Opponitzer Schichten of Austria, which are dated by ammonoids (Hunt and Lucas, 1991a, 1991b). On the evidence of these two reptile genera, the Lossiemouth Sandstone Formation is dated firmly as latest Carnian (Late Tuvalian palynological zone; *macrolobatus* ammonoid zone).

Lossiemouth has yielded specimens of all eight Late Triassic Elgin reptiles (Figure 4.14) and (Figure 4.15), so they will be discussed here. Each of the eight reptiles is unique to the Elgin area and some, in fact, have been placed in separate monogeneric families. Some of the reptiles (rhynchosaur, ornithosuchid) compare best with Gondwanaland faunas of similar age, such as those of the Maleri Formation in India, the Santa Maria Formation of Brazil and the Ischigualasto Formation of Argentina. Other elements (aetosaur, procolophonid, sphenodontid) are shared with the lower units in the North American Chinle Formation and Dockum Group, and with some parts of the Keuper of Germany. However, the links with these northern faunas are surprisingly weak, despite their close proximity to Elgin in the Late Triassic: Elgin lacks the temnospondyl amphibians and phytosaurs which are so important in North America and Germany.

Leptopleuron lacertinum was a specialized procolophonid, about 175 mm in length, and may have resembled the present-day North American desert horned lizard (*Phrynosoma*). It had a triangular skull, when viewed from above, which bore spines, and the *eye* sockets were exceptionally elongated. *Leptopleuron* may have been a herbivore, but more probably it was an omnivore capable of feeding on a variety of food items; its deep jaws and row of transversely broadened molariform teeth would have made an efficient grinding mechanism. *Leptopleuron* was identified as a lizard by Owen (1851a), a batrachian (amphibian) by Mantell (1852) and a lacertilian (lizard) by Huxley (1867a). However, Boulenger (1904a) noted the affinities of *Leptopleuron* with *Procolophon* from South Africa, and reclassified these as Procolophonia in the Order Cotylosauria, the so-called 'stem reptiles'. *Leptopleuron is* most similar to an undescribed procolophonid from Fraser's (1985, 1988b) 'Site 1', a productive fissure fill locality at Slickstones Quarry (Cromhall Quarry), Avon, and both of these forms share affinities with the larger *Hypsognathus* from the Upper Triassic Newark Group of New Jersey, USA (Upper Triassic to Lower Jurassic: Olsen and Galton, 1977) and *Paotedon,* from Triassic rocks in Lin-Che-Yu, Pao-Te, north-western Shansi, China. P.S.S. is currently redescribing *Leptopleuron.*

The tiny sphenodontid *Brachyrhinodon* has acrodont teeth on the jaw margins and on the palate, and a very short snout (hence the name). The narial region is unusual as it overrides the pre-maxillary teeth. It probably lived a cryptic existence feeding on insects or fruit (Fraser and Benton, 1989). Walker (1966) suggested that *Brachyrhinodon* may be congeneric with *Polysphenodon* from the Middle Keuper of Hanover, but Fraser and Benton (1989) found that, in a cladistic analysis of sphenodontid relationships, the two were rather different.

Hyperodapedon was a bulky, 1.3 m long, terrestrial quadruped with strong limbs. The 100–200 mm long skull was very broad at the back — there was an anterior premaxillary 'beak' and the teeth were arranged in multiple rows on the maxilla. The dentary had a sharp edge and it cut into a groove on the maxillary tooth-plate. *Hyperodapedon* probably cut up tough plant material with a powerful precision shear bite. The massive, laterally flattened claws of the foot and the construction of the hind limb strongly suggest their use for scratch digging (Benton, 1983b, 1983d, 1984). *Hyperodapedon* was classified from the start with the English *Rhynchosaurus* and they were regarded as relatives of the living tuatara, *Sphenodon* (Huxley, 1869, 1887; Burckhardt, 1900; Boulenger, 1903; Huene, 1929a). *Hyperodapedon* is a typical Upper Triassic rhynchosaur, its closest relatives being *Hyperodapedon (Paradapedon) huxleyi* from the Maleri Formation of India, and *Scaphonyx* from the Santa Maria Formation of Brazil and Ischigualasto Formation of Argentina, all Late Carnian in age (Benton, 1983d, 1990c).

The aetosaur *Stagonolepis* has a roughly crocodile-like skull and peg-like teeth. The snout had a curious blunt end, probably for digging. Its body was well armoured with large scutes and it had powerful digging limbs (Walker, 1961). *Stagonolepis* was thought of as a 'ganoid' fish by Agassiz (1844) and as a crocodile by Huxley (1859b, 1875, 1877). Huene (1942) classed the genus as a pseudosuchian thecodontian, and Walker (1961) recognized its close affinities with *Aetosaurus* from the Stubensandstein (middle Norian: Anderson and Cruickshank, 1978; Tucker and Benton, 1982; Benton, 1986b, 1994a, 1994b) of Germany. Murry and Long (1989) and Hunt and Lucas (1991b) report *Stagonolepis wellesi* from the lower part of the Petrified Forest Member of the Chinle Formation of Arizona. This taxon was established as a new genus (*Calyptosuchus wellesi* Long and Ballew, 1985) and was assigned to *Stagonolepis* by Murry and Long (1979, pp. 32–3), but without full justification.

The ornithosuchid *Ornithosuchus* is a small- to medium-sized carnivore with two locomotory modes — bipedal for running, quadrapedal for walking. It is one of the best known thecodontians and the fossils show a broad size range. The forelimb was adapted for grasping, and *Ornithosuchus,* when fully grown, probably preyed on *Hyperodapedon* and *Stagonolepis,* and on the smaller reptiles when younger (Walker, 1964). *Ornithosuchus* was classed provisionally as a dinosaur by Newton (1894b), a parasuchian by Boulenger (1903), a pseudosuchian by Broom (1913) and Huene (1914), and an ancestral carnosaur by Walker (1964). More recent finds in South America have suggested that *Ornithosuchus* is, in fact, a 'thecodontian' closely allied to *Riojasuchus* of the Los Colorados Formation (Norian) of Argentina (Bonaparte, 1969, 1978). The species *O. woodwardi* Newton (1894) and *O. taylori* Broom (1913) are the same as a *longidens* (Huxley, 1877). The ornithosuchids were placed on the dinosaur/pterosaur branch of archosaur evolution by Gauthier (1986), Benton and Clark (1988) and others, but Sereno and Arcucci (1990) and Sereno (1991b) argue that they fall on the crocodilian side of the Crurotarsi.

Erpetosuchus, another crurotarsal archosaur, has a narrow 75 mm long skull with a huge antorbital fenestra and a broad 'square' posterior skull roof. The carnivorous and/or insectivorous dentition is peculiar, with long sharp recurved teeth at the front of the jaws and toothless longtitudinal ridges behind which may have been used for crushing prey or for masticating the food to an extent prior to swallowing. The need to masticate food may also connect with the presence of an incipient secondary palate. *Erpetosuchus* was classed as a parasuchian by Newton (1894b) and as a pseudosuchian by Broom (1913), Huene (1914) and Walker (1970b). The nearest relations of *Erpetosuchus* are probably *Parringtonia* from the Manda Formation (Mid Triassic) of Tanzania, and possibly *Dyoplax* from the Upper Schilfsandstein (Late Carnian) of Baden-Württemberg.

Scleromochlus, represented by five specimens, has a relatively huge skull, nearly as long as the trunk, short forelimbs, but long hindlimbs and a long tail. The long hindlimbs have been interpreted (Woodward, 1907b; Huene, 1914) as adaptations for jumping and it may have sought food on the dunes in which it is preserved using a saltating mode of locomotion. Some authors (e.g. Huene, 1914) have speculated that it could glide from tree to tree, assuming that it had membranes on the side of the body. *Scleromochlus* has been placed in the 'Dinosauria' (Woodward, 1907b) and Pseudosuchia (Broom, 1913; Huene, 1914). It is presently classified in a family on its own and its nearest relation is uncertain (Walker, 1970b, p. 361). However, its skull specializations suggest a relationship to the aetosaurs (Walker, 1970b, p. 361; Krebs, 1976, p. 90) or to the pterosaurs (Padian, 1984).

A saltating mode of locomotion was also proposed for the 'dinosaur' *Saltopus* (Huene, 1910a), represented by a partial skeleton of the hind quarters. However, *Saltopus* was probably a slender running scavenger with a very long tail for balance in rapid manoeuvring. *Saltopus* was described as a dinosaur (Huene, 1910a), but more study is required to determine whether this is correct: if it is, it would be one of the oldest known dinosaurs in the world.

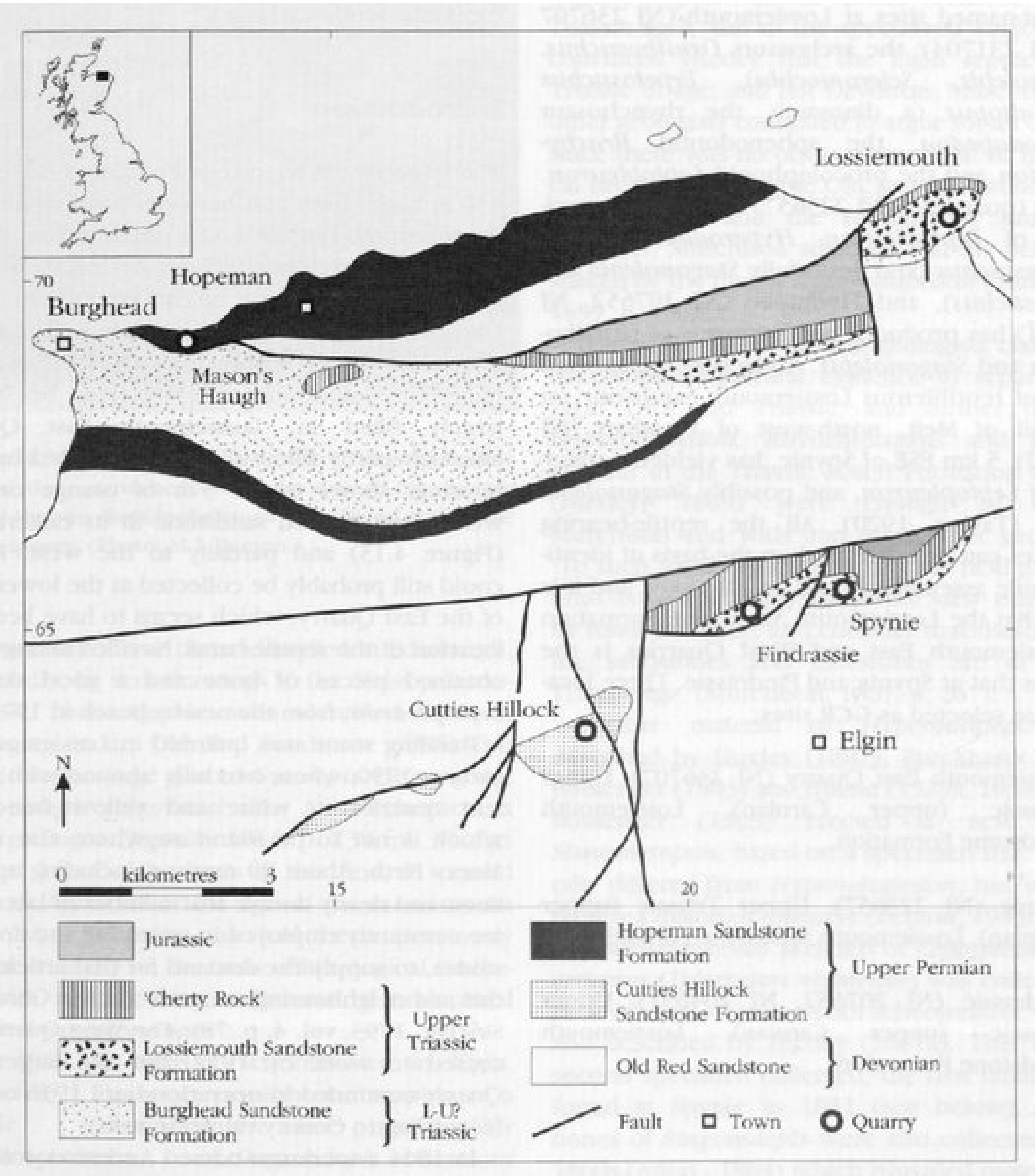
The Elgin archosaurs (e.g. *Stagonolepis, Ornithosuchus, Scleromochlus, Erpetosuchus*) have forced major changes in the classification of the order (e.g. Broom, 1913; Huene, 1914; Bonaparte, 1969; Krebs, 1976; Gauthier, 1986; Benton and Clark, 1988; Sereno and Arcucci, 1990; Sereno, 1991b). The very difficulty experienced in classifying many of these reptiles has demanded detailed redefinitions of the various families and, in particular, reappraisal of their relations to the dinosaurs and crocodiles.

Conclusions

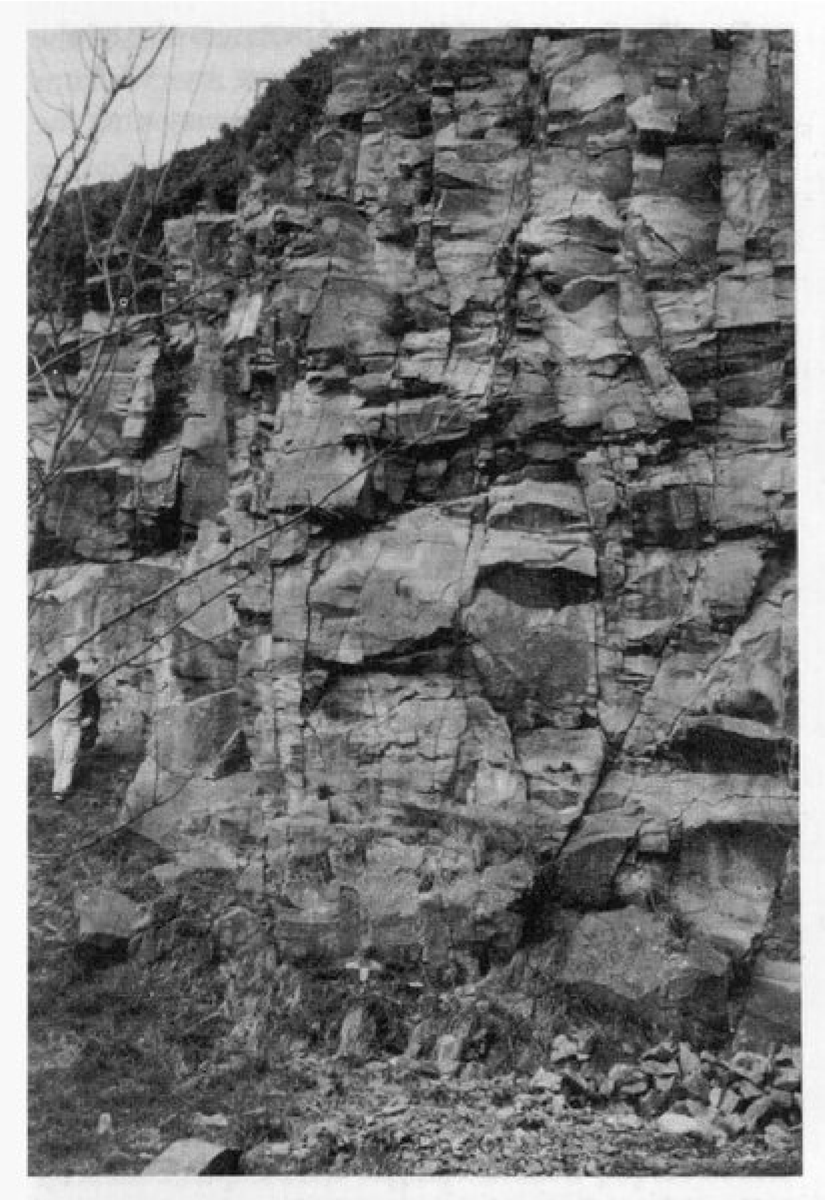
The site is important for its distinctive reptiles of Late Carnian age, which include four genera of archosaurs, a sphenodontid and a procolophonid; four of the genera occur nowhere else. The fauna is unusual in showing close affinities with those of southern continents (India, South America), as well as with those of the rest of western Europe and North America and, in that the remains are preserved in aeolian deposits, clearly not the natural habitat of the majority of the animals. In evolutionary terms, many of the genera are unique, or belong to rare groups (e.g. *Scleromochlus, Erpetosuchus, Brachyrhinodon*).

The conservation value of the site lies mainly in the richness and uniqueness of the fossil reptile fauna that has been obtained here and, to an extent, in its potential for future fords.

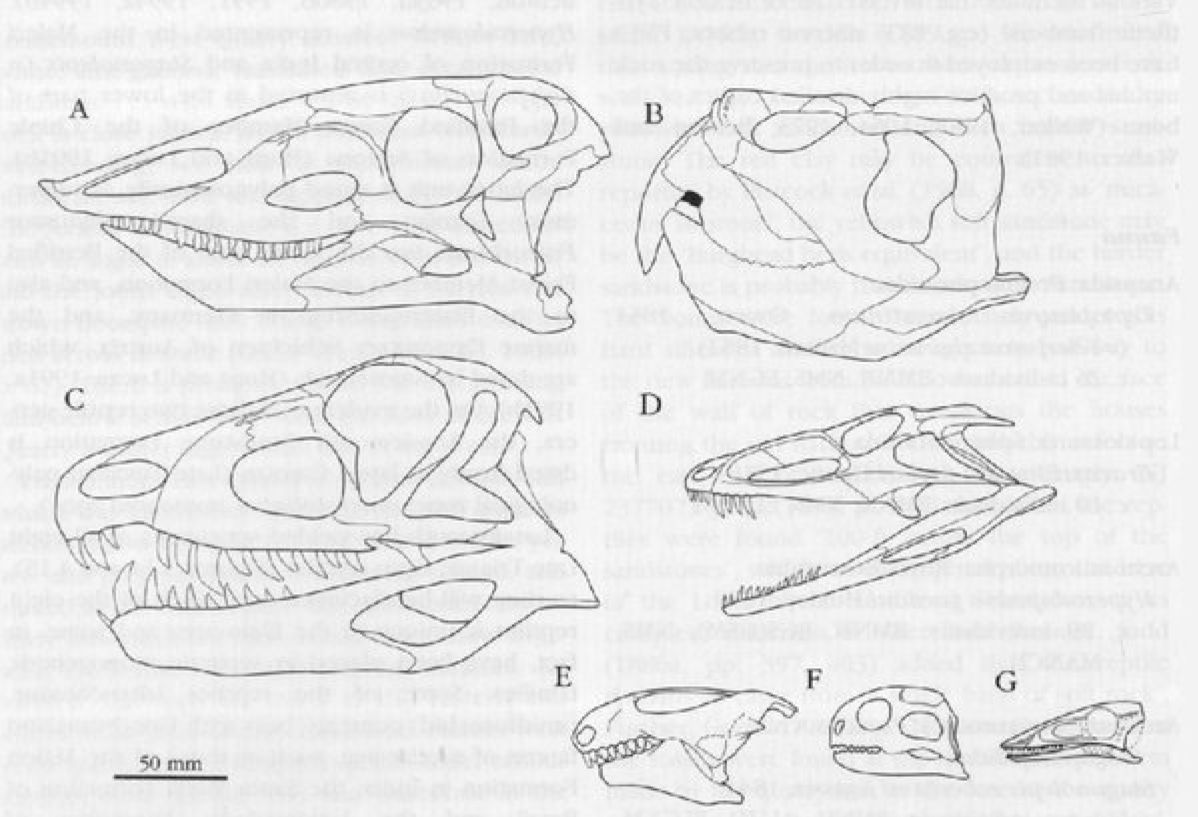
[References](#)



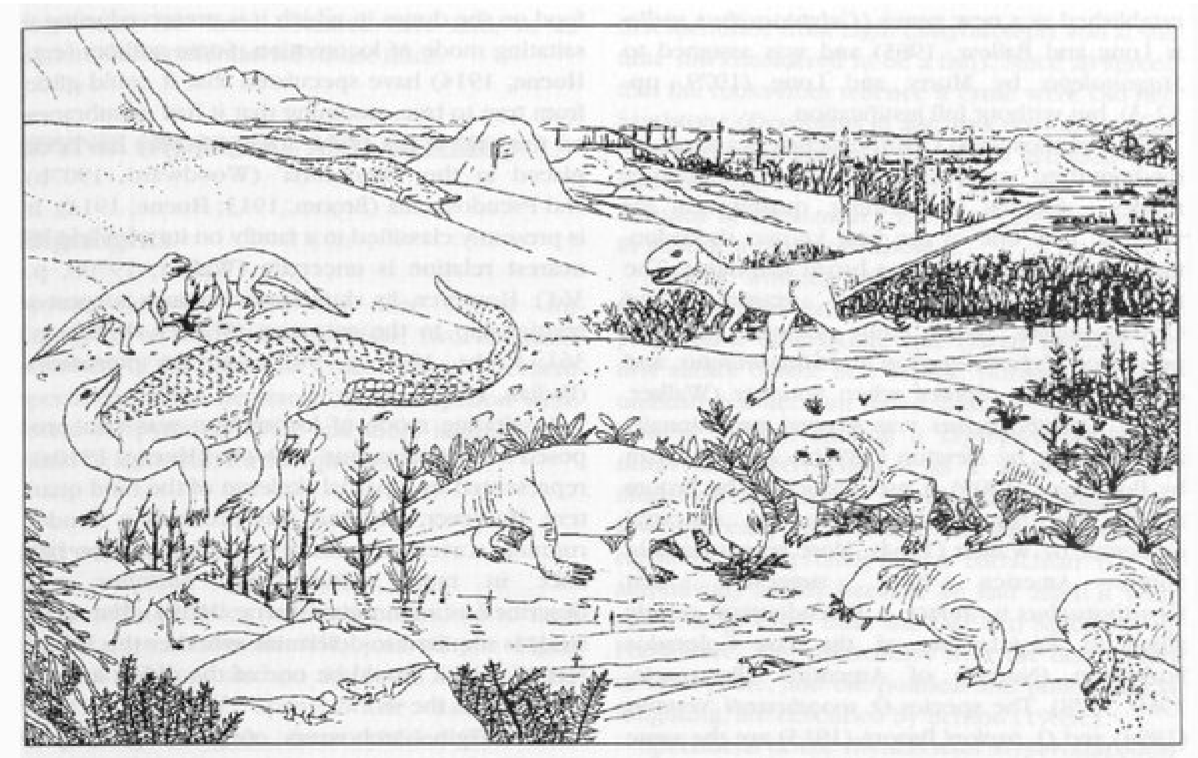
(Figure 4.12) The distribution of the Permo-Triassic beds around Elgin, Morayshire. The formations are indicated by shading, and the main reptile and footprint localities are named. From Benton and Walker (1985).



(Figure 4.13) Lossiemouth East Quarry: view of heavily jointed dune cross-bedded sandstones at the eastern end of the site. Reptile skeletons were found at the base of the quarry. (Photo: M.J. Benton.)



(Figure 4.14) The reptiles of the Late Triassic Lossiemouth Sandstone Formation, near Elgin, Morayshire. Skulls of (A) Stagonolepis; (B) Hyperodapedon; (C) Ornithosuchus; (D) Erpetosuchus; (E) Leptopleuron; (F) Brachyrhinodon; (G) Scleromochlus. From Benton and Walker (1985).



(Figure 4.15) Imaginary scene at Elgin, Morayshire, in Late Triassic times, showing reconstructions of reptiles with typical Late Triassic plants. Three Hyperodapedon feed on seed-ferns in the foreground. Behind them, an Ornithosuchus runs towards the armoured Stagonolepis which is looking over its shoulder. Behind Stagonolepis, two Erpetosuchus feed on a small carcass. On the rocks in the left foreground are two Leptopleuron, a tiny Brachyrhinodon and a small bipedal dinosaur, Saltopus. To the right of the rocks is the tiny Scleromochlus at the side of the pond. In and around the pond there are horsetails, cycads and ferns, and there are tall lycopods in the distance. Based on a colour painting by Jenny Halstead. From Benton and Walker (1985).