Masonshaugh Quarries, Morayshire

[NJ 122 691]–[NJ 133 692]

Introduction

The disused quarries at Masonshaugh and coastal sections to the east and west provide excellent exposures of the Hopeman Sandstone Formation. The sandstones show large-scale cross-bedding and other features that indicate sediment transport by wind in a desert. Abundant footprints found in the quarry in the 19th century provide age and environmental evidence. The faulted contact with the younger Burghead Sandstone Formation, at the western end of this part of the site, is associated with barite, fluorspar, and silica mineralization, and these minerals locally act as a cement. This is an important site for the interpretation of Late Permian palaeoenvironments and sedimentology, and the effects of faulting.

The sediments and trace fossils of the Hopeman Sandstone Formation were first described by Huxley (1859b, 1877). Recent descriptions of the locality and surrounding area are included in Clemmensen (1987), Gillen (1987), and Edwards *et al.* (1993). The vertebrate tracks and body fossils preserved in the Hopeman Sandstone Formation have been described more recently by Benton and Walker (1985), McKeever (1991, 1994), and McKeever and Haubold (1996). See also Clark (1999) and Hopkins (1999).

Description

The Masonshaugh GCR site is part of the Burghead–Masonshaugh coastal Site of Special Scientific Interest (SSSI), and is in continuity with another GCR site selected for coverage of the Triassic Burghead Sandstone Formation (see Chapter 3). The Masonshaugh section has also been selected for the GCR independently for its fossil reptiles (Benton and Spencer, 1995).

Sedimentology

The Hopeman Sandstone Formation, which crops out along the southern margin of the Moray Firth, is well exposed at Masonshaugh Quarry. The sediments consist predominantly of yellow and white, strongly cemented sandstones with well-rounded, often spherical quartz grains and with some feldspar and scarce mica (Watson and Hickling, 1914; Gillen, 1987). On the coast, the formation is typically less well-cemented, and is brownish-yellow in colour.

The sandstones preserve excellent examples of cross-bedded units, whose foresets dip southwest, and in places contain lenses of coarser-grained sandstones and pebbles. Watson (1909) recorded cross-bedding foresets with an apparent dip of 40° to the south-west, but the true angle of dip is probably only a few degrees, and is highly variable. The cross-bedding takes two forms; trough cross-bedding in large-scale sets, 1 to 10 m thick, and giant sets more than 10 m thick; and large- and giant-scale bi-modally dipping overlapping sets (Clemmensen, 1987).

In places the sediments are flaggy, and contain a relatively high proportion of clay minerals in lenses that contain some crude small-scale cross-bedding and slump structures (Peacock *et al.,* 1968), sometimes associated with ripple marks and mud cracks (Judd, 1873). Vertebrate tracks are preserved on the bedding planes of these flaggy beds (Watson, 1909).

A substantial E–W-trending fault, the Splay Fault (Figure 2.5), part of the major Lossiemouth Fault Zone (see (Figure 1.8)), brings the Hopeman Sandstone Formation into contact with the stratigraphically younger Burghead Sandstone Formation (Peacock *et al.,* 1968). Minerals such as galena and fluorite, both occurring as cubic crystals, are found close to the fault planes (Watson, 1909; Watson and Hickling, 1914). Edwards *et al.* (1993) mapped zones of mineralized cements in the Hopeman Sandstone Formation beside the Lossiemouth Fault (Figure 2.5). Barite is the dominant cement for 1 km to the east of the fault, then fluorspar for the next 1 km, and silica east of that, around Covesea. Close to the major fault, and around all minor faults, there is a zone of hard, splintery, strongly cemented sandstone, which weathers more slowly than the remaining sandstone (Figure 2.6). The main fault is associated with numerous, complex deformation zones through the Hopeman Sandstone Formation, and these affected the nature of mineralization. Deformation zones decrease in frequency away from the major faults.

Palaeontology

Four distinct forms of footprints have been described from the Hopeman Sandstone Formation at Masonshaugh Quarries (McKeever, 1994; McKeever and Haubold, 1996; Hopkins, 1999), although only a small and a large form had been distinguished previously (Brickenden, 1852; Huxley, 1859b, 1877; Benton and Walker, 1985). The smaller form, *Chelichnus bucklandi,* is seen in a trackway approximately 145 mm long. The prints are generally between 30 and 40 mm long, are roughly circular in outline, and show no sign of toe prints. The faint traces of tail drag marks are seen between some of the prints.

The larger prints show clearly defined impressions of toes. The fore prints are semicircular in outline, 40 mm long and 60 mm wide, with four or five claw marks at the front. The hind prints are 90 mm long and 80 mm wide, with five claws. A mound of sediment is preserved behind each print, suggesting that the animals were walking up a slope (Benton and Walker, 1985). McKeever and Haubold (1996) assigned these larger prints to the ichnotaxa *Chelichnus duncani, C. gigas,* and *C. titan.*

Interpretation

The sandstones and pebbly sandstones at Masonshaugh Quarry have been interpreted as deposits of a complex environment dominated by aeolian deposition, but which also experienced periods of heavy rainfall and localized flooding. The sediments accumulated in a half-graben, associated with tectonic activity along the Great Glen Fault (Frostick *et al.,* 1988).

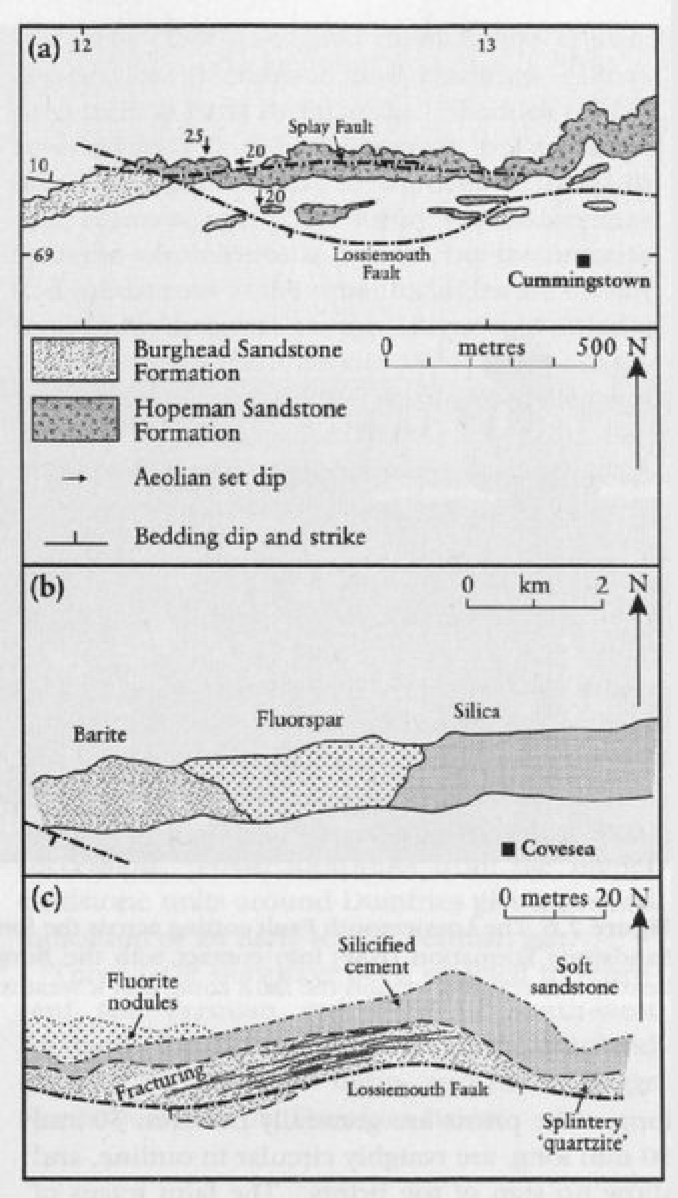
The well-sorted, cross-bedded sandstones of the Hopeman Sandstone Formation are indicative of aeolian deposition. The sedimentary geometry of this stratigraphical unit has been extensively studied by Clemmensen (1987), who interpreted the structures as complex star dunes and crescentic barchans. An analysis of the foreset orientations of these dunes indicates that the dominant wind directions were from the NNE, although there were subordinate, but significant, winds blowing from the SSE and northwest. The second type of aeolian deposits, characterized by large- and giant-scale, bi-modally dipping, overlapping sets, are interpreted as the arms of large star dunes that were orientated parallel to the dominant wind directions. The coarser-grained, pebbly sandstones were deposited during flash flood events (Williams, 1973).

The deformation zones at Masonshaugh indicate major tectonic activity, dominated by extension (Edwards *et al.,* 1993). The Burghead Sandstone Formation, on the west side of the fault was less affected since it has a less even grain-size distribution than the Hopeman Sandstone Formation. The faults initially acted as conduits to mineral-bearing fluids that penetrated the porous sandstones and precipitated cements in the deformation zones. Sandstones outside the deformation zones are less heavily cemented.

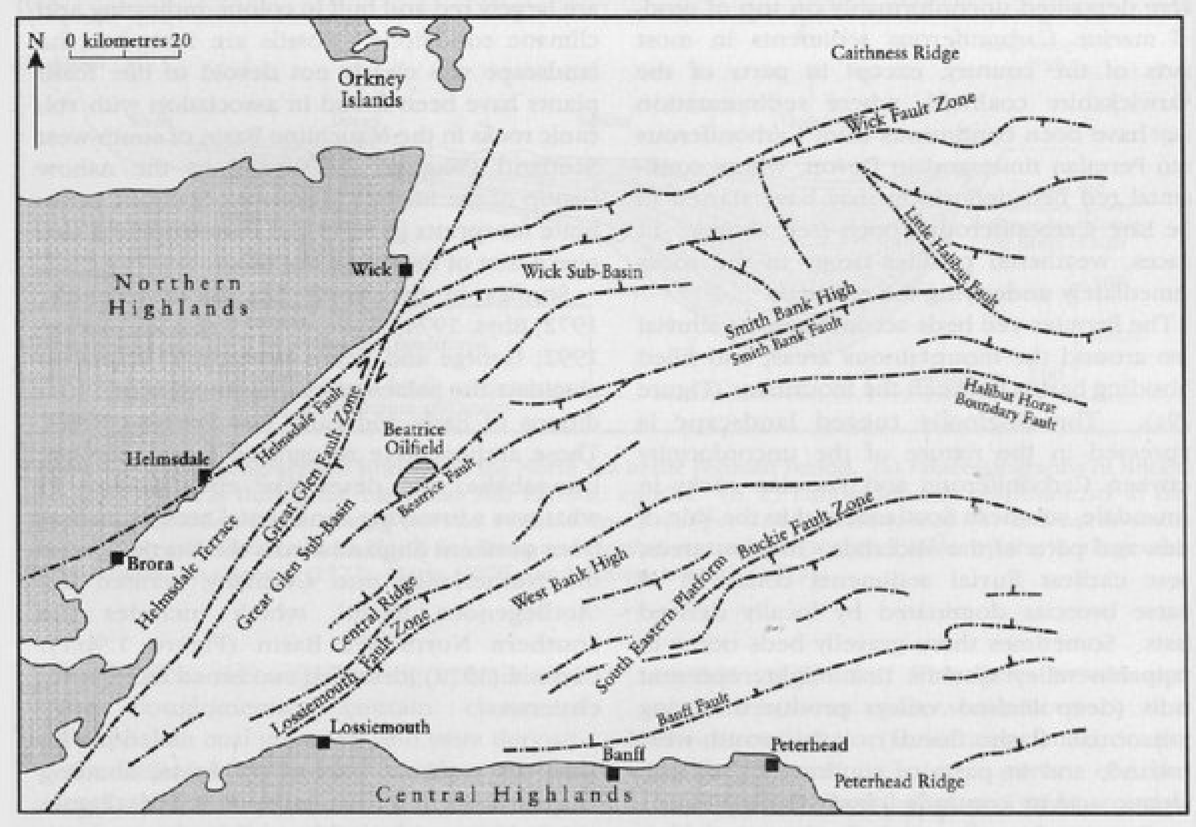
Conclusions

The sandstones of the Hopeman Sandstone Formation were deposited in a large desert, dominantly in large star- and crescent-shaped aeolian sand dunes. Interbedded with these deposits are thin beds of pebbles, deposited during flash floods. The sandstones exposed at Masonshaugh Quarry preserve many fine examples of vertebrate tracks. The Masonshaugh site is complementary to the Covesea–Clashach GCR site because it shows the rare fluviatile and flash-flood deposits better, and displays the unusual mineralization associated with the faulted western contact with the Burghead Sandstone Formation.

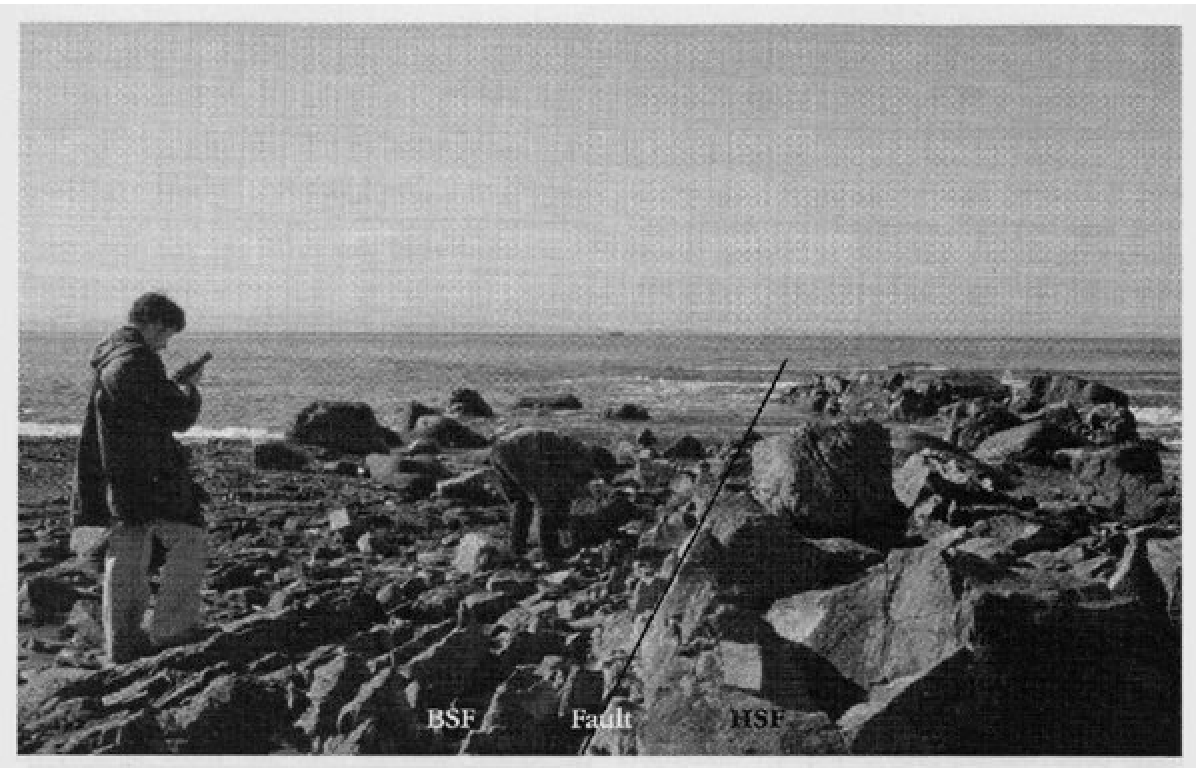
References



(Figure 2.5) The Hopeman Sandstone Formation at Masonshaugh. (a) Detail of the faulted contact between the Burghead Sandstone Formation (Triassic in age) and the Hopeman Sandstone Formation (Permian), showing the major fault zone, western termination of the Lossiemouth Fault. (b) The regional zonation of barite, fluorspar, and silica cements in the Hopeman Sandstone Formation along the north coast of Morayshire. (c) Details of the cement zone around the Lossiemouth Fault as it cuts across the beach at Masonshaugh at [NJ 131 693], showing zones of fluorite and silicified cements in the sandstone. (After Edwards et al., 1993.)



(Figure 1.8) The major tectonic elements of the Inner Moray Firth Basin. (After Andrews et al., 1990.)



(Figure 2.6) The Lossiemouth Fault cutting across the foreshore at Masonshaugh Quarry, bringing the Hopeman Sandstone Formation (HSF) into contact with the Burghead Sandstone Formation (BSF). The sandstone is heavily mineralized around the fault zone, and it weathers slowly. (Photo: M. J. Benton.)