7 Carboniferous rocks of the Howick shore section

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Purpose

The excursion will examine rocks of the Carboniferous Limestone Groups and the Whin Sill on the Northumberland coast near Howick, from Longhoughton Steel in the south to Cullernose Point in the north.

Logistics

The rocks are described from south to north. Park near Low Stead Farm [NU 262 157], 2 km east-northeast of Longhoughton. Parking is also available 3 km farther north along the road near Cullernose Point [NU 259 182]. Although some exposures can still be seen at high tide, it is best to visit the coast from mid to low tide.

Maps

O.S. 1:50 000 Sheet 81, Alnwick & Morpeth; B.G.S. 1:50 000 Sheet 6 Alnwick (solid and drift editions).

Geological background

Carboniferous sediments of northern England were deposited in the east-northeast–west-southwest-trending Northumberland Trough, a broad half-graben structure divided into the Northumberland, Solway and Tweed basins. To the north was located the emergent Southern Uplands Block, and to the south, across the Ninety Fathom-Stublick Fault system, the more slowly subsiding Alston Block. The early Dinantian, basin-fill sediments were deposited at a time of extension when the southern boundary fault system was active. Later sediments (Namurian and Westphalian) were deposited more uniformly over the whole northern England area as a result of regional subsidence. The deposits of the Northumberland Trough consist chiefly of sandstones and mudrocks with subordinate limestones and coals. Palaeocurrent and provenance studies indicate that on a broad scale the siliciclastic sediments were sourced from a large catchment area to the north and east, whereas more open-marine environments were located to the south and west.

The Carboniferous succession of eastern Northumberland is divided into eight stratigraphic units: the Cementstone Group, Fell Sandstone Group, Scremerston Coal Group, Lower, Middle and Upper Limestone Groups, Millstone Grit and Coal Measures. The sediments of the Limestone Groups (up to 1000 m thick) are markedly rhythmic, consisting of some 25 'Yoredale' cycles, ranging from 20–100 m in thickness. Typically these begin with a thin, dark, marine shale below a muddy, micritic bioclastic limestone which may reach several metres in thickness. The latter is overlain by dark shales which coarsen up into rippled and cross-bedded sandstones. In some cycles there is a channelized sandstone up to to m thick, cutting down into the coarsening-upward siliciclastic unit. The cycle is capped by a variety of palaeosols, including seatearths, ganisters and thick coals. Much thinner coarsening-upward siliciclastic units on the scale of a few metres or less, capped by a thin palaeosol, may occur above the main coarsening-upward cycle before the black shale and limestone of the succeeding cycle. Each cycle is generally named after the limestone at its base.

These 'Yoredale' cycles are interpreted as the product of flooding of a delta plain (deposition of the thin marine shale) where the palaeosols were developing (thicker coals), followed by carbonate deposition in an open-marine environment, before the gradual advance of a deltaic shoreline and the deposition of the major coarsening-upward siliciclastic unit. The channelized sandstone represents the fluvial distributary which supplied the sediment to the delta front. The small-scale coarsening-upward units at the top of a cycle represent local flooding of the lower delta plain and the infilling of interdistributary bays, lagoons and lakes.

Sediments of the Namurian Upper Limestone Group are exposed from Howdiemont Bay in the south to Howick Bay in the north (Figure 7.1), (Figure 7.2). There is a major east–west fault in Howick Bay to the north of which are sediments of the Lower Carboniferous (Dinantian) Middle Limestone Group. Some 200 m of intervening strata, including the Great Limestone, are not exposed (Farmer and Jones, 1969). The regional dip is at a low angle to the east, reflecting the broad concentric pattern of Carboniferous rocks in Northumberland dipping away from the Devonian lavas and granite of the Cheviot Hills. Locally there are variations in this pattern and small folds are kpresent.

Excursion details

Locality 1 [NU 265 156]

From the cliff-top car park near Low Stead Farm walk eastwards along the beach to the foreshore outcrops at Longhoughton Steel. These are sediments of the 'Millstone Grit' of Namurian (Kinderscoutian) age: coarse pebbly sandstones with well-developed cross-bedding separated from the underlying finer-grained sandstones of the Upper Limestone Group by a sharp erosion surface. The 'Millstone Grit' represents a major fluvial system transporting coarse elastic sediments towards the south/southwest.

Locality 2 [NU 262 158]

Walk northwestwards across the sands of Howdiemont Bay, which cover easily eroded mudrocks of the Foxton Limestone cycles, although the thin limestones can occasionally be seen. Note that moving northwards along the coast the succession is getting older. After 500 m, outcrops of pale yellow/brown sandstones occur towards the top of the Sugar Sands Limestone cycle. They are notable for well-developed examples of both planar and trough cross-bedding. The exposures are 3-dimensional so that the difference between the two is immediately apparent, especially on bedding planes (parallel straight lines versus curved nested lines). The palaeocurrent direction is towards the southeast and deposition took place in a relatively high-energy mouth bar/distributary channel environment. In the sandstones exposed 20 m farther north (i.e. a few metres lower in the succession), the bedding is contorted into fold structures and locally the sandstone is massive. These features are the result of dewatering and liquefaction of the sand soon after deposition, perhaps induced by seismic shock caused by earthquakes.

Locality 3 [NU 260 161]

Continue northwestwards across Sugar Sands Bay, also underlain by mudrocks, to the northwest corner. Here the Sugar Sands Limestone is exposed, distinctive for the presence of large gigantoproductid brachiopods, up to 15 cm across and mainly in their life position, i.e. concave upwards. The trace fossil *Zoophycos* is also present on bedding planes of the limestone, looking like brush marks, 15–30 cm across. Immediately beneath the limestone, and only exposed when the tide is halfway out, is a thin (20 cm) dark grey sandstone, containing brachiopods and many burrows, some going down into the underlying white sandstone. In thin section of this dark sandstone, fish scales and bone fragments are common. The underlying distinctive pale grey to white sandstone, with polygonal structures on the bedding planes and thin dark streaks permeating the rock, is a palaeosol. The cracks are the result of expansion and contraction of the soil and the black streaks are the remains of rootlets. The succession at this locality is the top of one cycle (the palaeosol) and the beginning of the next (the thin dark sandstone and the limestone). After deposition of the white sandstone, perhaps by a river or delta distributary, it was colonized by plants and a soil developed. There was then a transgression, and the sea flooded across the coastal plain, reworking the soil to deposit the dark fossiliferous sandstone. Relative sea-level continued to rise and the sea became deeper and clearer enabling the Sugar Sands Limestone to be deposited, in around 20–40 m of water.

Locality 4 [NU 259 162]

Continue north down the succession through finer grained sediments into mudrocks. Below black shales in the cliff the Iron Scars Limestone is exposed on the foreshore. This limestone has numerous trace fossils on the bedding planes, mostly burrow structures, and there are many crinoid ossicles, fragments of coral, bryozoans and brachiopods. Below the limestone, a few metres to the north, are black fossiliferous shales and in the cliff, below the shales, a thin coal seam and then a seatearth, crowded with black rootlets, including *Stigmaria* and with nodules of siderite present i m below the coal. This is another cycle boundary. In this case however, a peat developed on top of a soil (the seatearth) so that a coal seam was eventually produced. The initial deposits of the next cycle were black muds before the limestone was deposited.

Locality 5 [NU 259 163]

Immediately south of Howick Burn the sediments are part of the Howick Limestone cycle. In the north-facing cliff are two thin coarsening-upward cycles, each 1.5 m thick. Dark mudrock gradually passes up into sandy mudrock, muddy sandstone and then into sandstone. These minor cycles represent the infilling of small bays or lagoons along the coast of a deltaic shoreline. Erosion of the beach sand here may reveal the Howick Limestone, about 5 m from the end of the southern bridge abutment.

Locality 6 [NU 262 168]

Walk northwards across the foreshore and join a cliff-top path to reach Howick Haven. Here a west-facing cliff shows a classic coarsening-upward succession. On the beach, 3 m from the cliff, the Howick Limestone crops out as a thin (30 cm), dark fossiliferous limestone with bryozoans, gastropods, brachiopods and crinoids. At the cliff base, 1 m of dark mudrock with siderite nodules passes up into r m of sandy mudrock with isolated ripples and flaser bedding, then 3 m of sandstone with cross-lamination and small-scale cross-bedding. The whole package represents a shallowing of the environment, recording the approach of a sandy shoreline.

In the upper part of the cliff, there is a large erosion surface with angular blocks of sandstone above it. This channel and its infill are the product of recent glaciation and have nothing to do with the Carboniferous sediments, deposited some 320–340 Ma ago.

Locality 7 [NU 263 172]

Walk north along the cliff path to Rumbling Kern, a small sandy bay surrounded by cliffs of sandstone, formerly quarried. In this little bay, towards the bottom of the cliff, above a metre of shale, the Howick Limestone is exposed as large discontinuous pillow-shaped nodules, a metre or more across. At the very base of the cliff, a thin (15 cm) coal seam above some 20 cm of pale-grey seatearth again represents the end of one cycle of deposition and the beginning of the next. However, of particular note here is that above the Howick Limestone and t m of mudrock with siderite nodules (as at Howick Haven), a prominent coarse sandstone is developed. Its base is sharp and erosive, and there are large rafts of plant and peat (now coal) in the lower part. Around this bay and to the north and south for several hundred metres, the sandstone shows spectacular large scale cross-bedding, mostly directed to the east. This sandstone, reaching 8 m in thickness, was deposited in a major fluvial braided channel transporting sand from the west/northwest to a delta plain/delta front probably located a considerable distance to the east/southeast.

Locality 8 [NU 260 179]

Walk northwards along the cliff-top path past the Bathing House, seeing Dunstanburgh Castle in the far distance. The low cliffs here are of the channel sandstone with conspicuous cross-bedding. From above Howick Bay there is a fine view towards Cullernose Point, streaked white by the nesting birds. In the near distance about 200 m ahead, the Howick Fault runs east–west across the foreshore. The main feature seen from this viewpoint is the northern end of the major fluvial channel (Figure 7.2), (Figure 7.3). At low tide, look down and seawards across the foreshore exposures to see the basal erosion surface of the channel rise stratigraphically towards the north. There is a conspicuous bed of sandstone (a seatearth) at the top of the channel infill which can be followed south and then southeastwards out to sea as a result of a small synclinal structure. The sandstone within the channel shows bedding surfaces dipping gently towards the south, the result of lateral accretion of the channel margin. Again the channel cuts down to within a metre of the Howick Limestone (which crops out along the far side of a small inlet). A little farther north, the same succession as at Howick Haven can be seen, where the channel sandstone is absent. Overall, this and the last two localities together clearly demonstrate the discrete, localized nature of a major downcutting channel into the marine shales above the Howick Limestone. It suggests that there was a major change in base-level, which may have been the result of a large fall in relative sea-level.

Locality 9 [NU 259 179].

Descend to the southeast corner of Howick Bay where the remains of amphibian footprints can be seen on the hummocky surface of a sandstone bed 20 cm below a prominent thin coal seam at the base of the east–west running cliff (Scarboro & Tucker 1995). These footprints, averaging 18 cm in length and 14 cm in width, are now poorly preserved, but it should be possible to discern a trackway of 6 prints, 3 each side, with a central groove where the body was dragged through the sand. In the better preserved footprints, 5 digits could be distinguished and some have a mud rim. The sand became vegetated and penetrated by numerous rootlets and *Stigmaria* which disturbed the footprint surface and account for its hummocky nature. The footprints, probably formed by a temnospondyl amphibian crawling out onto damp sand from a nearby embayment or lake, were preserved by the deposition of a thin sheet of sand over the surface, probably from the flooding of a small channel. They are some of the oldest footprints in Britain.

In the north–south running cliff in the corner of the bay, two channel structures show lateral accretion (Figure 7.4). In the cliff on the right (to the north) a 1.5 m thick mudrock to fine sandstone coarsening upward unit can be seen which, in the central part of the cliff, is cut by a shallow channel filled with sandstone showing inclined bedding to the south. These dipping surfaces are produced by lateral accretion (meandering) of the channel. This small channel is then cut into by a larger channel to the left (Figure 7.4). This arrangement has been interpreted as levee sediments (the coarsening-upward unit) cut into by a crevasse channel, and then the main distributary channel taking the path of the crevasse channel (Elliott, 1976).

Above the channel infill sediments, a thin coal seam represents abandonment of the channels and the growth of peat in a swamp environment. An overlying 2.5 m thick mudrock to sandstone coarsening upward package (the footprint surface is towards the top of this) with another thin coal seam (Figure 7.2), (Figure 7.4) represents a small delta prograding into a shallow bay or lagoon along the delta front. These sediments, towards the top of the Cushat Limestone cycle, are all coastal plain/delta plain deposits and the rapid lateral and vertical changes in facies represent the local variation in these depositional environments.

Locality 10 [NU 259 180]

Continue northwards on the foreshore to the Howick Fault, a major east–west structure which cuts out some 200 m of strata (Figure 7.1), (Figure 7.2). On the south side of the fault the Howick/ Cushat Limestone cycle sediments (lower part of the Upper Carboniferous) are much affected by small-scale faulting and deformed into a broad hanging-wall anticline. On the north side is the Acre Limestone (upper part of the Lower Carboniferous), consisting of fossiliferous limestone beds and calcareous mudrocks. The main Howick Fault dips 40° southwards. Along the fault line dolerite of Whin Sill type has been intruded, best seen at mid to low tide in the mid-foreshore area.

Locality 11 [NU 258 183]

Farther north on the foreshore, crinoids, brachiopods and corals, as well as calcite-filled tension gashes, can be seen in the Acre Limestone. The limestone passes up into dark shales, locally with pyrite and calcareous nodules. In the cliff, these mudrocks pass up into sandy shales, muddy sandstones and then pale grey sandstones in a clear coarsening-upward package. The sandstones here show excellent examples of hummocky cross-stratification (Reynolds, 1992) on the scale 0.5–1 m in wavelength; there are also thin, graded and cross-laminated sandstone beds. Burrows and nodules are also present. These sedimentary structures are typical of storm waves and storm currents, and indicate deposition in the transition zone of a storm-dominated sandy shoreline.

Locality 12 [NU 260 186]

Northwards on the foreshore, the sandstones with storm structures give way to cross-bedded and planar-bedded white sandstone with a range of burrow structures. One of these, *Eione moniliforme,* has a very distinctive beaded appearance.

These sediments were deposited in shallower water, in the shoreface and foreshore environments. At the small cliff running out to sea, the top of this Acre Limestone cycle is well exposed, and the white sandstone is now massive and hard with black streaks. This is almost a ganister: a very clean, quartzitic seatearth. A very narrow recess in the cliff, 20 cm wide, is the position of a thin coal seam. This Acre Limestone cycle is distinctive in that it is not the result of delta progradation, but of beach-shoreface progradation. The top part of the small cliff is the Sandbanks Limestone, marking the beginning of the next cycle.

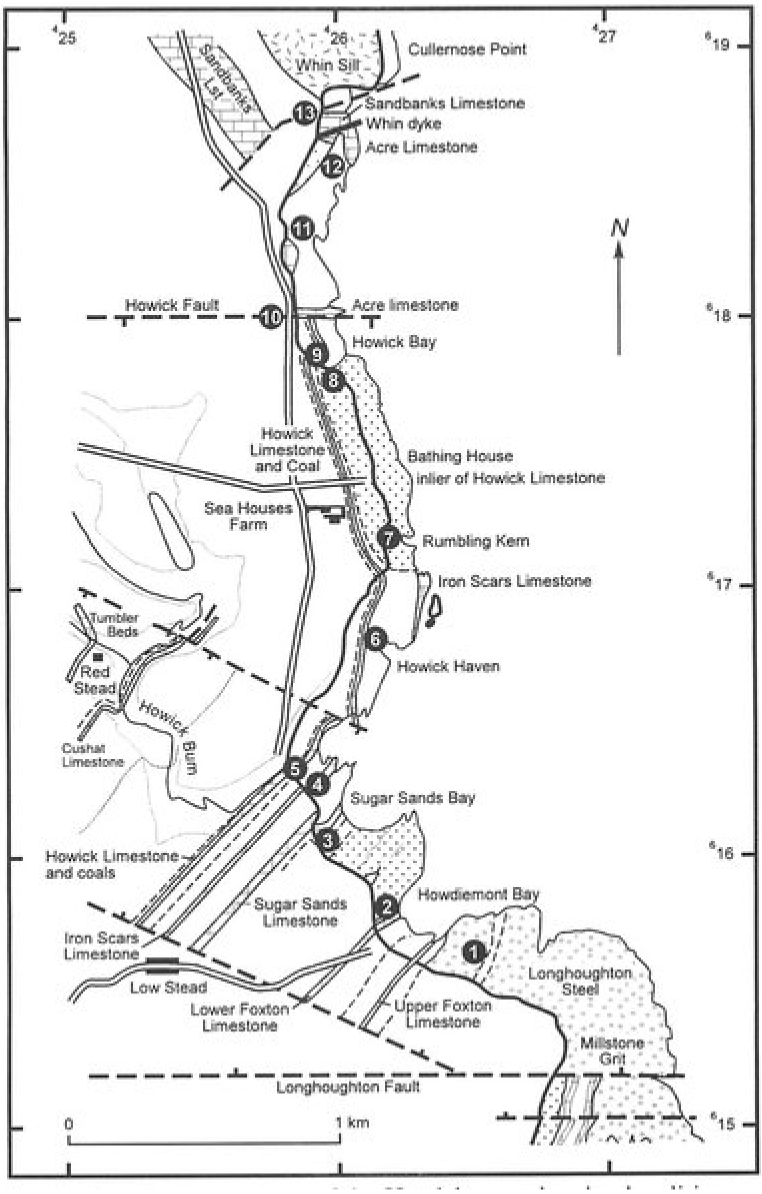
Also of interest here, just south of the small cliff crossing the foreshore, is a narrow dyke of Whin Sill material. This dyke is classic in form: it stands up as a metre-high wall, with a narrow zone of hardened sandstone adjacent to the dolerite.

Locality 13 [NU 260 187]

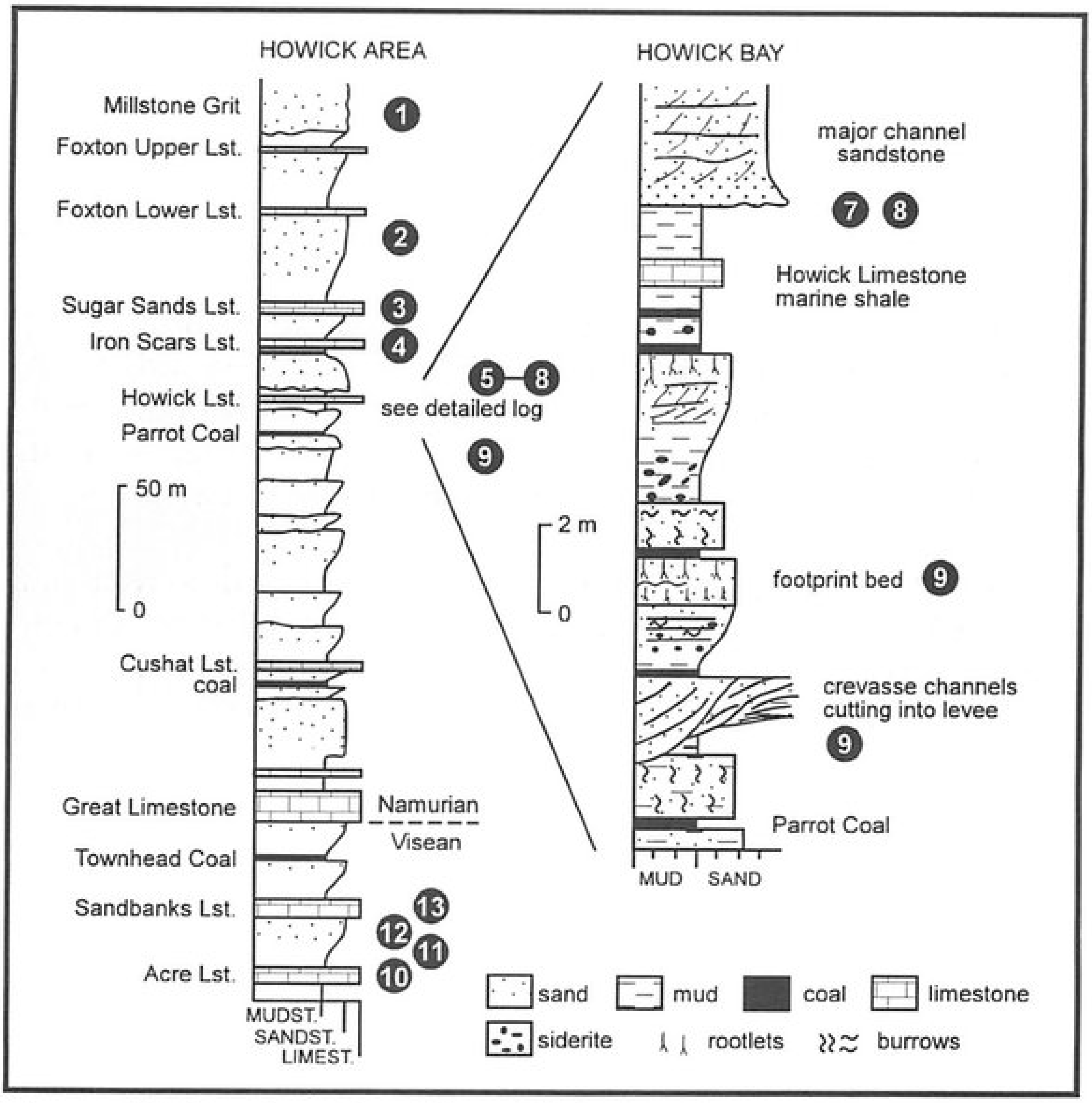
Climb over the small cliff on to the extensive bedding surface of the Sandbanks Limestone. This limestone, like the others, contains fossil crinoids, brachiopods and corals, and from a small outcrop of the overlying shale by the path up from the beach, fragments of trilobites can be found. The Sandbanks Limestone here shows some fine 'whaleback' folds on the lower foreshore. The fold axes are oriented north–south and the folds are asymmetric, with steeper limbs on their western side. There is a major fault in the northwest corner of the bay here, and it is possible that the folds are related to horizontal movement on this fault, which would then be showing dextral strike-slip movement.

Ahead is Cullernose Point, composed of the dolerite of the Whin Sill. The cliff shows well-developed columnar jointing, vertical in the central part of the cliff then dipping at a lower angle towards the seaward end of the cliff. This may be the result of the Whin Sill changing its stratigraphic horizon.

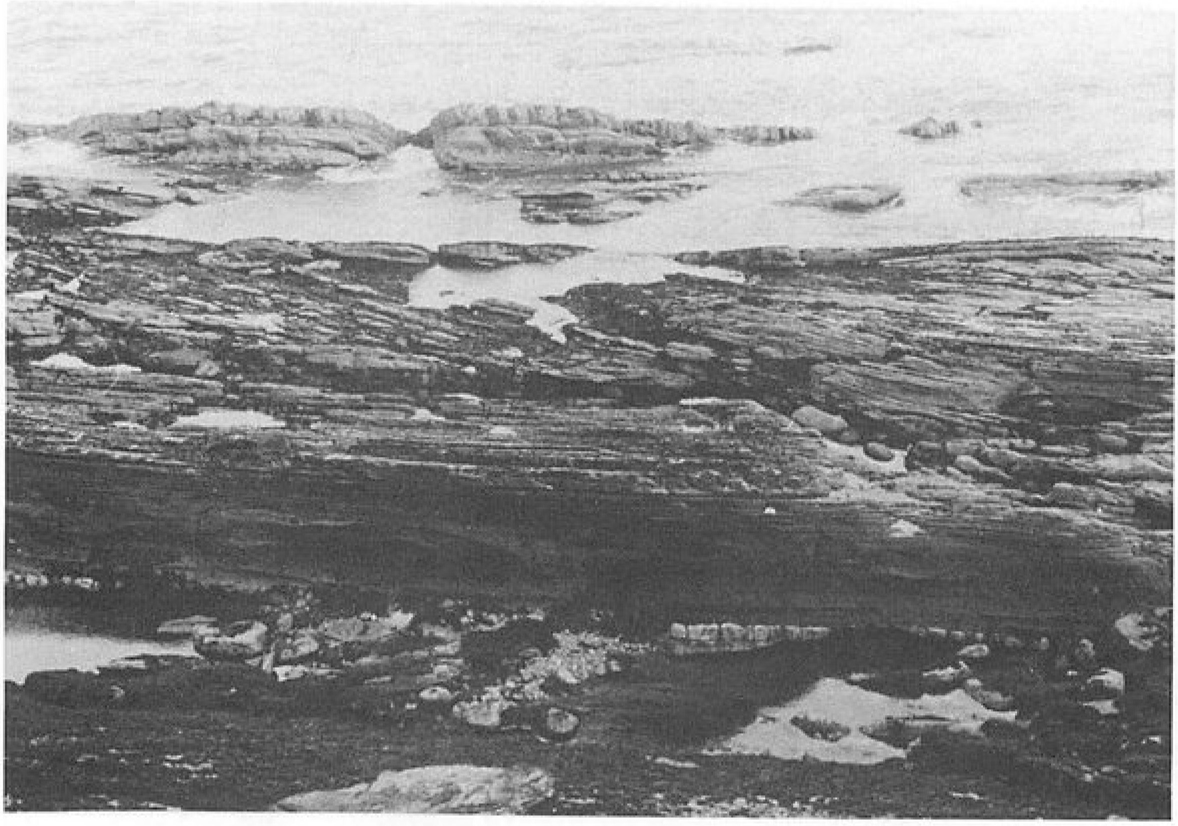
Bibliography



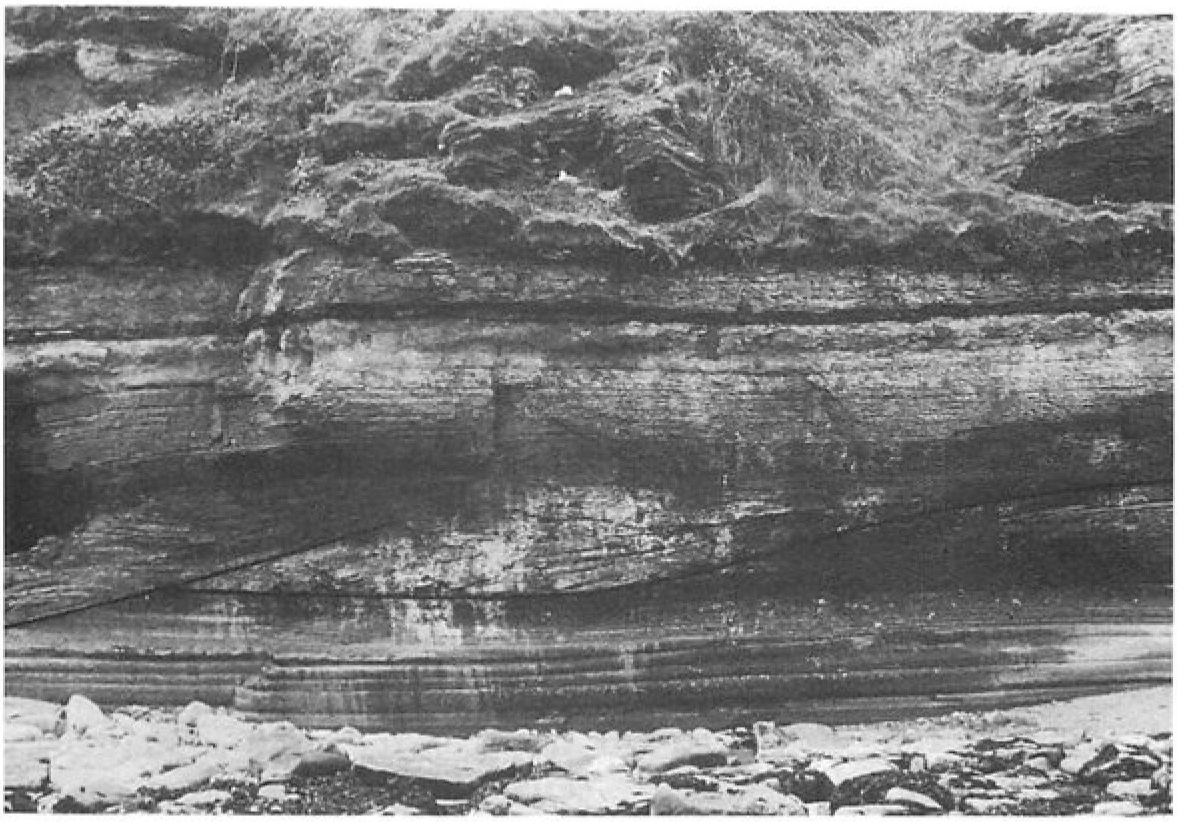
(Figure 7.1) Geological map of the Howick area showing localities mentioned in the text.



(Figure 7.2) Stratigraphy of the mid-Carboniferous of the Howick area, Northumberland, with a detailed log of the Upper Limestone Group sediments in the southern part of Howick Bay.



(Figure 7.3) The northern end of the major channel within the Howick Limestone cycle. Locality 8, southern part of Howick Bay. Photo: M. E. Tucker.



(Figure 7.4) Two channel sandstones (bases outlined) showing lateral accretion from right to left. The level of the amphibian footprints (arrow) is overlain by a thin coal seam. Locality 9, southwest corner of Howick Bay. Nesting fulmars near cliff top provide scale. Photo: M. E. Tucker.