8 The Carboniferous and Permian rocks between Tynemouth and Seaton Sluice

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Purpose

To examine the stratigraphy and sedimentology of Westphalian B Coal Measures and Permian rocks along the southern margin of the Northumberland Basin.

Logistics

The excursion can be completed in one full day depending on tides. Cars and minibuses can be parked close to all the localities, but car parks charge a fee from May to September. There is also easy access by public transport. The excursion is not recommended for large parties. Although access to all localities is relatively easy, care must be taken on the slippery seaweed-covered foreshore rocks. Hard hats and wellingtons are essential; stay clear of unstable overhanging ledges when examining cliff faces, especially between Hartley Bay and Collywell Bay where several cliff falls have occurred recently.

Maps

O.S. 1:50 000 Sheet 88 Tyneside & Durham; B.G.S. 1:50 000 Sheet 15 Tynemouth (solid).

Geological background

The area between Tynemouth and Seaton Sluice (Figure 8.1) lies at the southern end of the Northumberland coastal plain. It is an area of low, relatively flat ground covered by a veneer of glacial till, modified by late glacial and post-glacial solifluction. As a result, the underlying solid rocks of Upper Carboniferous and Permian age are exposed only in quarries, cliff faces, rocky headlands and on wave cut platforms.

This stretch of coast provides one of the best exposed sequences of Westphalian B Coal Measures anywhere in Britain. The succession consists of about 115 m of shale, mudstone, siltstone and sandstone arranged in vertically stacked coarsening-upward sequences capped by a seatearth and coal seam, interbedded with a number of prominent channel and distributary mouthbar sandbodies, each one named after their outcrop locality (Figure 8.2). Typical coarsening-upward coal-bearing facies sequences consist of (from bottom to top): (1) black shale containing fish and plant debris plus fresh-water bivalves; (2) rhythmically banded dark grey mudstone and siltstone, passing upwards into fine-grained sheet sandstone, containing burrows, ripple cross-lamination and some small-scale trough cross-bedding; (3) ironstone-bearing seatearth with small rootlets and scattered *Stigmaria;* and (4) coal. Trace fossils and plant fragments are common, but body fossils are generally confined to the fresh-water mussel bands above coal seams. Ironstone bands and nodules occur in the shales and mudstones, some of them showing cone-in-cone structure.

The coarsening-upward coal-bearing facies sequences result from the gradual infilling of shallow interdistributary bays and lakes by shoal-water lacustrine delta complexes originating from overbank flooding and crevassing along numerous distributary channels which drained a southerly sloping, low relief coastal alluvial plain remote from open marine influences. The black fossiliferous shales were deposited on the anoxic bottom of unstratified fresh to brackish water lakes, followed by mudstones, siltstones and fine sandstones as the crevasse-splay delta system prograded into the lakes. As the lakes filled with sediment the surface was colonized by vegetation, giving rise to peat swamps and ultimately, *in situ* coal, following compactional subsidence, transgression (mussel bands) and burial. The presence of faults and soft, weak shales and mudstones has caused extensive collapse of cliff faces, and the rapid retreat of the coastline due to marine erosion.

At the end of the Carboniferous Period the newly-deposited strata were uplifted and gently folded and faulted during the Variscan earth movements and were subjected to perhaps 40 Ma of subaerial erosion as the region gradually drifted northwards out of the equatorial belt into the tropics. At least 400 m of Coal Measures were eroded from southeast Northumberland during this phase and a mature desert peneplain was established before the oldest Permian deposits — the 260–255 Ma wind-blown Yellow Sands — were preserved in westsouthwest–east-northeast ridges or draa. The desert was flooded and the ridges inundated some 255 Ma ago when the almost landlocked Zechstein Sea was formed; this sea was subsequently filled with a thick cyclic sequence of marine carbonate sediments and evaporites during the last 5–7 Ma of the Permian Period. These cyclic rocks form a continuous cover in coastal districts south of the Tyne (Figure 1) and in the undersea area off the Northumbrian coast, but are preserved on land in southeast Northumberland in only a few isolated outliers in each of which the sequence is thin and incomplete. Two of these outliers, at Tynemouth and Cullercoats, are included in this excursion.

Excursion details

Locality 1, Tynemouth Cliff [NZ 374 694]

Tynemouth Cliff [NZ 374 694], not at high tide nor for the infirm; binoculars helpful. Park in ticket car park [NZ 371 694] opposite The Gibralter Rock, and take narrow road and paved footpath south and east for c.550 m to the landward end of North Pier; steps here afford access northwards to the boulder-strewn and very uneven rock platform, which can be followed (with care) around the headland and back to the car park via Short Sands and a paved and stepped path up the bay head. The round trip takes up to 2½ hours.

The spectacular coarse dark red mottling of the otherwise buff-coloured Carboniferous (Coal Measures) sandstone that forms the rock platform and lower part of the cliff immediately north of North Pier, was caused by desert weathering in early Permian time. The scattered boulders of Scandinavian schist and gneiss are thought to have been brought to Tynemouth by ice during the Pleistocene Period. Many of the other boulders are ships' ballast. The 3–4 m wide west–east subvertical basaltic Tynemouth Dyke cuts the sandstone of the shore platform (Figure 8.3) and is a member of the 58 Ma (Palaeocene) Mull Swarm. Conspicuously cross-bedded Yellow Sands (c.9 m) unconformably overlie the Coal Measures sandstone in the adjoining cliff. Continue northwards c.130 m past the buttresses and pipe, pausing at intervals thereafter to examine a markedly scoured erosion surface that divides the Coal Measures sandstone into two unequal parts (Figure 8.1, bottom left inset). The upper of these locally contains, at its base, a striking variegated breccia of angular to subrounded fragments of red and purple mudstone, siltstone and ironstone in a mainly buff-coloured sandstone matrix; this breccia is thought to be the remains of muddy sediments that were formerly associated with the Metal (= ?Top Grey or Top Five-Quarter) Coal and were ripped up and redeposited by turbulent floodwaters. An exceptionally complex large pouch of mauve and red, fine-grained, laminated sandstone at the cliff foot north of the pipe may be a load cast, caused by liquefaction of the sand (causing 'quick' conditions) soon after it was deposited; a sand volcano may have existed here but was later eroded away.

North of the buttresses the full succession in the cliff is visible, and comprises late Permian Magnesian Limestone in addition to the Yellow Sands and Coal Measures; most of the sequence is inaccessible or dangerously steep and scaling should not be attempted. The upper part of the sequence here is similar to that at the equivalent but more accessible exposure at Trow Point (Excursion 13, Locality 1), 3 km to the south-southeast, but the disturbed (resedimented) beds at the top of the Raisby Formation are here represented partly by a highly unusual debris-flow. This deposit passes southwards in about 30 m from the northeast corner of the headland into a rock composed of tabular to subrounded clasts of Raisby Formation dolostone in a 30–50% matrix of wind-abraded coarse quartz grains and, after a further 30 m, into a conglomerate-like vuggy rock composed mainly of Raisby Formation dolostone clasts in a sparse sand matrix; look for large fallen blocks to examine in detail. Clues to the origin of these unusual rocks come from Claxheugh Rock and Downhill Quarry, both in western Sunderland, where massive downslope submarine slides at the end of Raisby Formation time created canyons that in both places (and presumably others too) cut down through the Marl Slate into the Yellow Sands. Most of the Permian units may be traced westwards along the north face of the headland as they rise very gently to crop across the Castle foreditch; in spring and summer the niches marking the positions of the Marl Slate and the residue of the Hartlepool Anhydrite furnish favoured nesting sites for seabirds, especially kittiwakes.

Locality 2, Cullercoats Bay [NZ 365 714]

Access is by slipway off the promenade road at each end of the bay. The point at the southern end of Cullercoats Bay lies immediately north of the Ninety Fathom Fault (Figure 8.1) which is part of a major east–west trending fault system defining the southern margin of the Northumberland Basin; this is an asymmetric, extensional half-graben that became filled with over 4 km of sediment during Carboniferous time. The Ninety Fathom Fault is best exposed on the south side of the point where it downthrows strata to the north by about 150 m, bringing Upper Carboniferous Coal Measure shales and mudstones associated with the Hutton Coal seam against Permian Yellow Sands. Mineralized fractures and joints in the Yellow Sands, close to the fault, bind the rock together, enabling it to resist erosion by the sea; the unmineralized sandstone between the joints has been eroded by the sea to form caves, good examples of which can be seen at the base of the cliff at the back of the bay. The fault plane at the surface dips about 35° northwards. On its south side several small folds, with their axes perpendicular to the fault plane, together with the northerly dip of the beds, have created basin and dome structures in the centre of which is the Top Hutton seam and overlying sandstone. North of the fault a faulted syncline plunges seawards. Some 30 m of Permian Yellow Sands, of probable late Lower Permian age, are well exposed at the back of the bay where the structural and sedimentological features of the unit can be examined in detail except at high tide.

The Yellow Sands contain mainly medium to coarse, well rounded and well sorted grains, poorly cemented by a patchy calcite cement, except near the Ninety Fathom Fault where it was locally firmly cemented by baryte derived from fluids moving up along the fault plane in the underlying Coal Measures. The sandstone is rather friable at outcrop and contains small calcite-rich nodules, and cataclastic veinlets of granular quartz close to the Ninety Fathom Fault. At depth the sandstone is grey owing to the presence of pyrite which oxidizes near the surface to limonite, giving the sands their distinctive yellow colour. The Yellow Sands are interpreted as a formation of sinuous-crested dunes superimposed on about eleven parallel ridges of sand, trending west-southwest to east-northeast. The ridges were deposited on an easterly sloping peneplain of Coal Measure rocks, separated and underlain by thin discontinuous interdune breccias. The preserved parts of the dunes contain large-scale tabular and wedge shaped cross-bedding deposited by bidirectional seasonal winds blowing towards the south and northwest.

The Yellow Sands are sharply overlain by the Marl Slate which is a dark grey, laminated, bituminous dolomitic shale or shaley dolomite up to 1.5 m thick. This is well exposed at low tide on the foreshore just inside the south pier where it occurs in the nose of a syncline. The Marl Slate, which at Cullercoats has yielded an extensive fish fauna of early Upper Permian age and rarer land-derived plants, passes seawards beneath the pier under a ledge of pale yellow bedded dolomite that forms the centre of the syncline. The Marl Slate is overlain by the Raisby Formation which consists of a lower part of limestone and an upper part of predominantly dolomitized limestone. Disturbance of strata at the top of the Raisby Formation, seen on the foreshore at Cullercoats, is attributed to the effects of submarine slumping and sliding that took place on an easterly facing basin margin slope at the end of Raisby Formation time.

The Marl Slate was deposited in a stratified, partly anoxic sea up to 200 m deep soon after the initial transgression of the Upper Permian Zechstein Sea. Evidence of thinning and wedging out of the Marl Slate against Lower Permian sand dunes, suggests the development of shallow water conditions and ?interdunal lagoons. The Zechstein Sea quickly submerged the desert landscape concomitant with a change to more open marine conditions, and the Raisby Formation here was deposited under moderate water depths on an easterly facing carbonate ramp.

Locality 3, Table Rocks [NZ 364 722]

From Cullercoats, park just beyond a sharp left-hand bend after the coast road rejoins the cliff top. The most extensively exposed sandstone in the Westphalian B succession is the Table Rocks Sandstone which is about 16 m thick at this, its type locality (Figure 8.1). The lower part of the sandstone is exposed at low tide between the foreshore and the sea wall; the upper part is exposed in a cliff, 5–15 m high, that can be traced laterally for some 600 m northwest–southeast below the promenade at the top of the seawall. Stratigraphically the sandstone lies between the Durham Low Main (= Five-Quarter) and Bensham coal seams, where it forms part of a coarsening-upward progradational sequence overlying organic-rich interdistributary bay and peat swamp deposits. The sandstone has a lobate subsurface plan geometry, a medium to coarse grain-size and radial palaeocurrent trend, all of which suggests that it was deposited as a mouthbar sandbody forming the proximal part of a crevasse-splay delta system that prograded eastwards across the local and regional palaeoslope into a fresh to brackish water interdistributary bay lake. Well bedded flaggy sandstone, containing abundant low angle, lenticular cross-beds with tangentially based foresets, represents the main axial part of the delta mouth bar. Massive, erosively-based sandstone with large-scale lenticular cross-bedding, and large diagenetic ironstone concretions up to 2 m diameter, formed in a subaqueous distributary channel seen at the northern and southern end of the outcrop. A lithologically more variable cross-bedded sandstone, containing sandy mudstone and carbonaceous mudstone, was deposited at the margins of the mouth bar. Mudstone exposed at low tide below the seawall where it is transitional into the overlying flaggy sandstone represents the distal mouth bar fringe. All these lithological components of the Table Rocks sandbody are characteristically lenticular in shape (Figure 8.4) on several scales, producing a series of lens-shaped packages.

Locality 4, Curry's Point [NZ 350 754] and St Mary's Island [NZ 353 755]

Turn off the A193 coast road [NZ 346 747] and follow the signs to St Mary's Island; park in the large car park just before the concrete causeway to the island. The succession here consists of the St Mary's Island Sandstone overlain by up to five vertically stacked, coarsening-upward coal-bearing facies sequences, each up to 5 m thick. These are exposed in a number of fault blocks between St Mary's Island and Hartley Bay (Figure 8.1), a distance of just over 500 m. The St Mary's Island Sandstone is a predominantly cross-bedded channel sandbody deposited by currents flowing to the south. It is the lowest bed exposed along this stretch of coastline, although the base of the sandstone is not seen. It is a well jointed sandstone, cut by small faults on the south side; on the north side it is terminated by the Brierdene Fault. Note the sub-Permian reddening of the sandstone, especially down joints. At low tide, small rounded pieces of pale green apatite, can be found in the rock pools on the north side of the causeway. The apatite is the remains of the cargo of the 'City of Gothenburg' which was wrecked on the rocks here in 1891, whilst sailing from Montreal to South Shields. In the small bay immediately north of Curry's Point black shales containing large brown ironstone nodules can be seen. The nodules, which weather out from the softer shales, contain a fresh-water mussel band and well developed cone-in-cone structures. To the north the shales are overlain by a thin rippled cross-laminated sandstone, containing prominent, funnel-shaped bivalve escape structures, that forms a conspicuous ledge at the edge of a small wave cut platform. Bedding surfaces on top of the sandstone show prominent intersecting joint sets and large diagenetic ironstone nodules. In the low cliff above the sandstone, a seatearth with plant rootlets and *Stigmaria* is overlain by the Bottom Hutton Coal seam. The higher part of the cliff is a soft till, containing exotic clasts of various lithologies such as Whin Sill dolerite and Lower Carboniferous limestone. It was deposited 15–17 000 years ago during the last (Devensian) glaciation to have affected the area prior to the present interglacial period. A break in the cliff immediately to the north marks the position of the Brierdene Fault.

At low tide the next locality, Hartley Bay, can be reached by walking along the foreshore if time permits, but the cliff top path is quicker and easier.

Locally 5, Hartley Bay [NZ 344 758]

As an alternative to the cliff top path between St Mary's Island and Collywell Bay, limited parking is available above Hartley Bay by the caravan club park at Old Hartley.

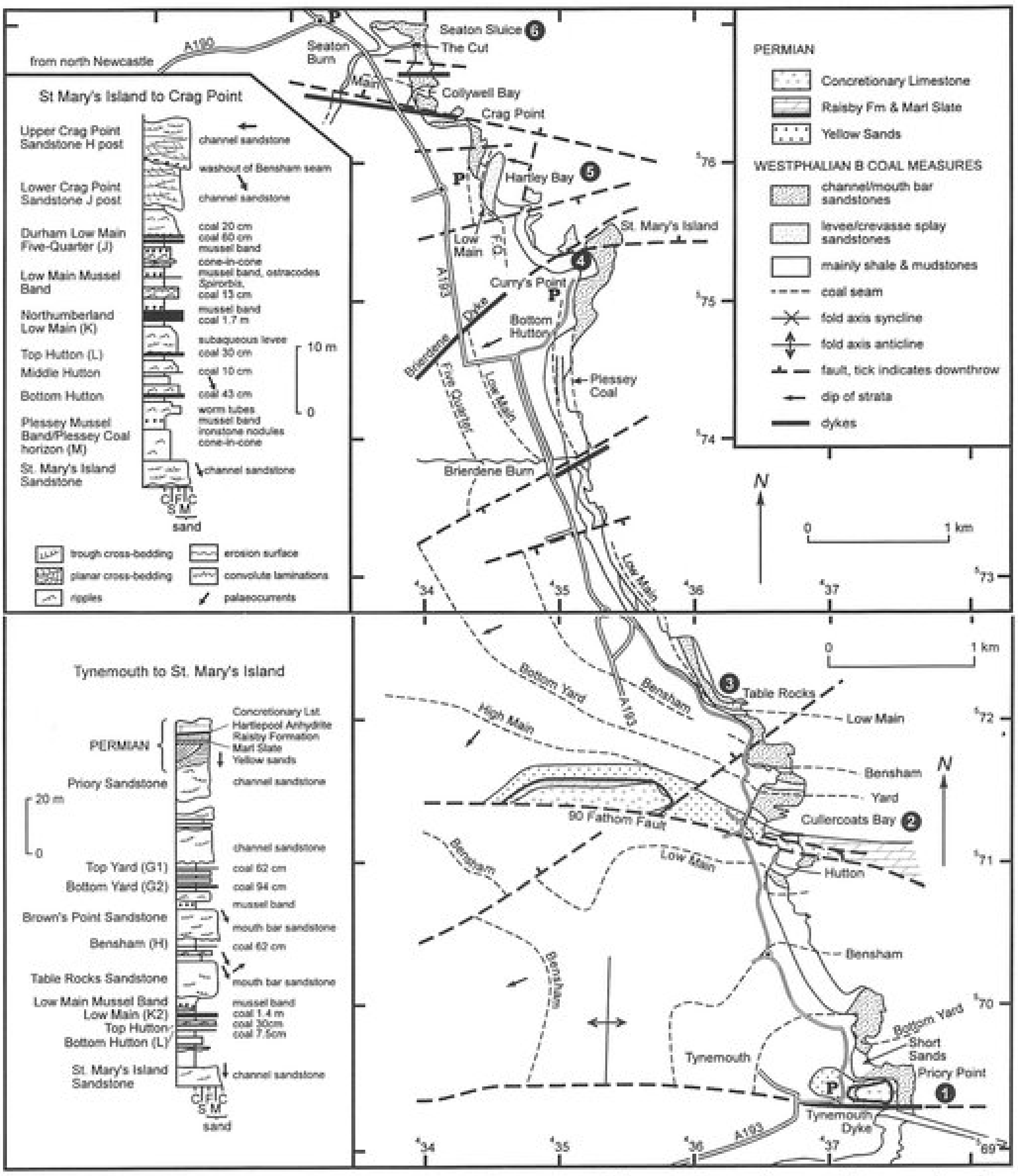
Steps lead down to the beach at the southern end of the bay. The exposures in Hartley Bay have been relatively unaffected by faulting and include all the strata between the 1.7 m thick Northumberland Low Main Coal seam and the t m thick Five-Quarter seam (Figure 8.2). The Northumberland Low Main seam can be seen below the steps, and by the concrete support wall at the bottom of the steps where it is partly covered by cliff fall material. The seam can be traced at intervals along the base of the cliff where it is underlain by a pyrite-bearing seatearth and fine-grained sandstone. The sandstone contains ripple cross-lamination, with scattered burrows, bioturbation and shallow scour features. Rippled bedding surfaces and plant fossils occur in some of the fallen sandstone blocks at the foot of the cliff; the cliff face itself provides excellent exposures of two typical coarsening-upward coal-bearing sequences. These gradually decline to foreshore level approaching Crag Point, at the northern end of Hartley Bay, due to the shallow northeasterly dip. A 13 cm thick coal seam at the cliff base on the promontory immediately north of the steps in Hartley Bay, is overlain by a mussel band containing ostracodes and *Spirorbis* (worm tubes). About i m below the coal seam is a thin sandstone characterized by convolute laminations, attributed to reactivation of the nearby Ninety Fathom Fault.

Continuing northwards along the foreshore toward Crag Point the wave cut sandstone platform contains some rectangular hollows about 1 m deep, now partially filled by wave reworked pebbles, cobbles and boulders. These hollows are thought to be the bottom of old bell-pits, dug from the cliff top during Napoleonic times to mine the thick Northumberland Low Main Coal seam beneath the sandstone. The cliff top must then have extended much further seaward. At the back of the bay a small sandbody about halfway up the cliff face contains well developed southerly dipping lateral accretion surfaces indicative of point bar deposition within a small meandering channel. Evidence of faulting can be seen in the lower part of the cliff approaching the northernmost end of Hartley Bay which is defined by the prominent, but unstable cliffs at Crag Point (Figure 8.1). The sharp contrast between sandstone and shale here is due to the Crag Point Fault, which downthrows strata 15 m to the north. The cliffs consist of two channel sandstones: a lower fine-grained sandstone characterized by wedge and trough cross-bedding with ripple cross-lamination and horizontal laminations, and an upper coarse-grained, predominantly planar cross-bedded sandstone (Figure 8.2) parts of which have collapsed making access around the point difficult. The contact between the sandstones is a well defined erosion surface overlain by a conglomerate containing small quartz pebbles, coal clasts and plant material.

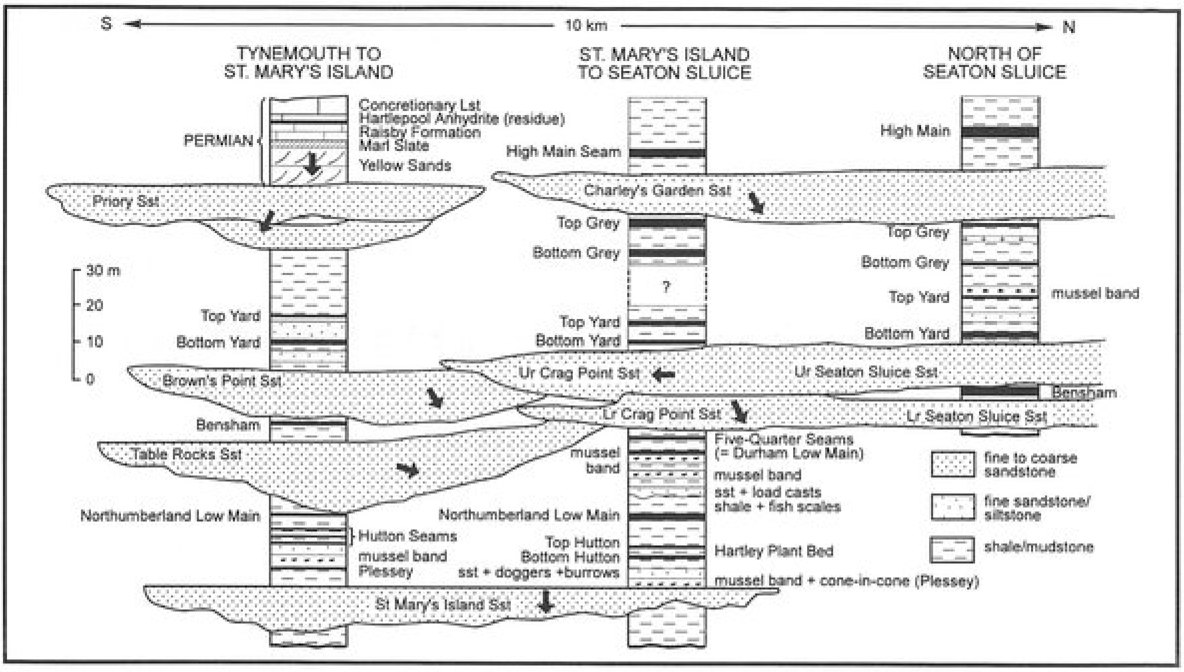
Locality 6, Seaton Sluice [NZ 338 769]

Turn off the A193 coast road [NZ 337 768] by the road bridge across Seaton Burn at Seaton Sluice to the car park in front of The King's Arms. Cross the wooden footbridge over 'the cut', a deep vertical trench cut through sandstone. Turn right down the footpath and proceed on to the old wharf on the north side of the cut, which is 274 x 9 by 16 m deep. The cut was excavated in 1761–64 by Thomas Delaval when Seaton Sluice was a busy industrial area and coal port, to provide a new harbour entrance, especially for coal barges. Two sandstones are exposed along the foreshore and in the cut, but northwards they dip into the subsurface. The lower, which has been correlated with the Lower Crag Point Sandstone, is a fine-grained, argillaceous sandstone characterized by lenticular bed geometries and predominantly wedge and trough shaped cross-bedding deposited by currents flowing to the southeast (Figure 8.2). The upper sandstone, in comparison, is much coarser-grained and more feldspathic, with anomalous concentrations of garnet. It is characterized by sheet-like bed geometries, and structured internally by planar and less commonly trough cross-bedding arranged in cosets up to 50 cm thick. At the seaward end of the cut on the north side, troughs migrated down the lee faces of some larger scale bars or sandwaves. Aggradation of these bars, possibly as part of large sandflat complexes, can be compared with the development of medial and lateral sand bars forming today in sandy braided river systems. The base of the sandstone is defined by an erosion surface, locally overlain by small pebbles and granules of quartz, siderite, coal clasts and plant material, which has removed all of the intervening Bensham Coal seam and associated strata from this part of the succession (Figure 8.2). The Upper Seaton Sluice Sandstone has been correlated with the Upper Crag Point Sandstone and unlike other channel sandbodies in the succession it was deposited by a braided river system flowing westwards, across rather than down the local and regional southerly palaeoslope. It is thought to have been deposited in response to a sudden lowering of depositional base level due to fault controlled uplift of the Fame Granite and older Carboniferous strata located not more than 80 km off the present day Northumberland coast.

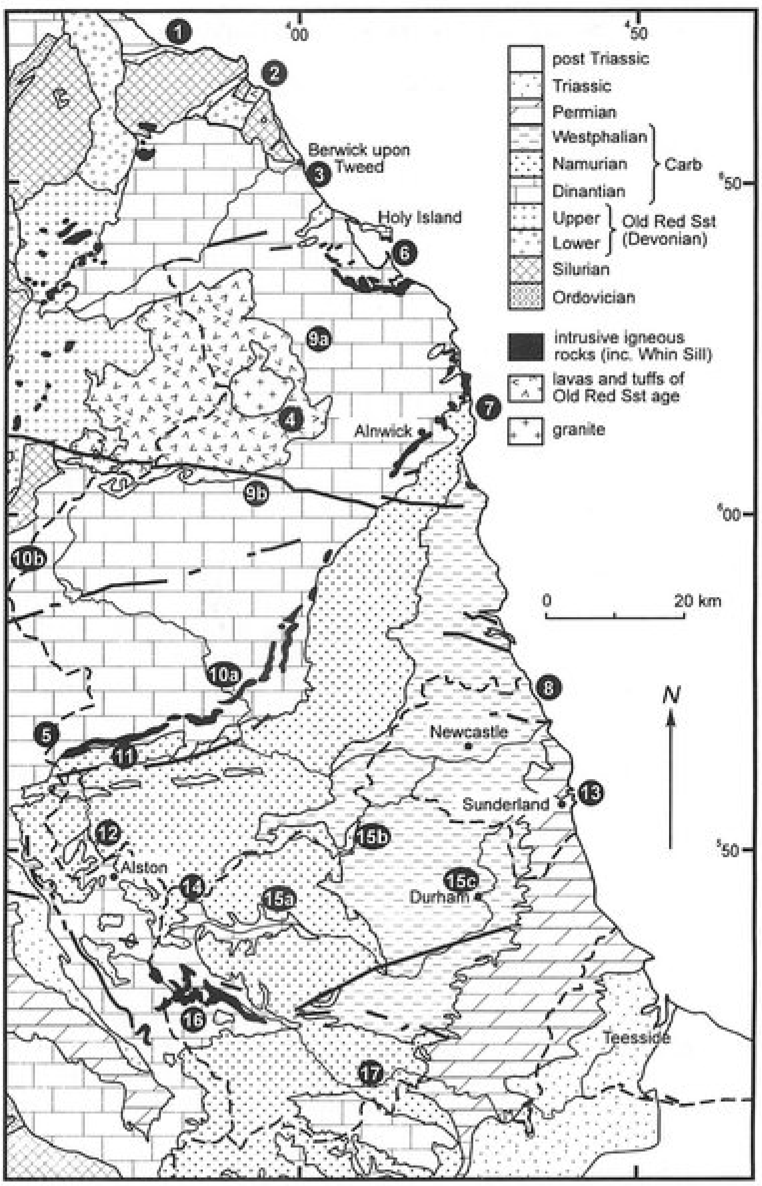
Bibliography



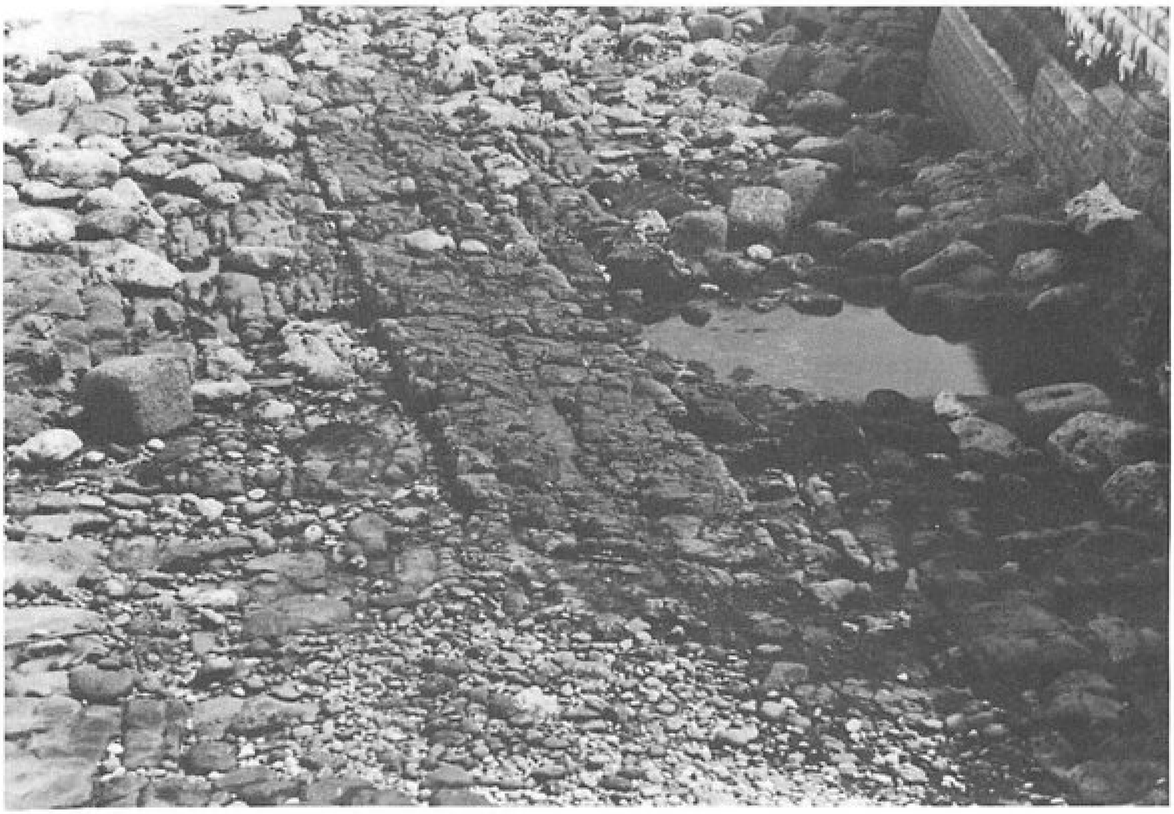
(Figure 8.1) Generalized geological map and stratigraphic sections of the coastal area between Tynemouth and to Lr' Seaton Sluice showing localities mentioned in the text.



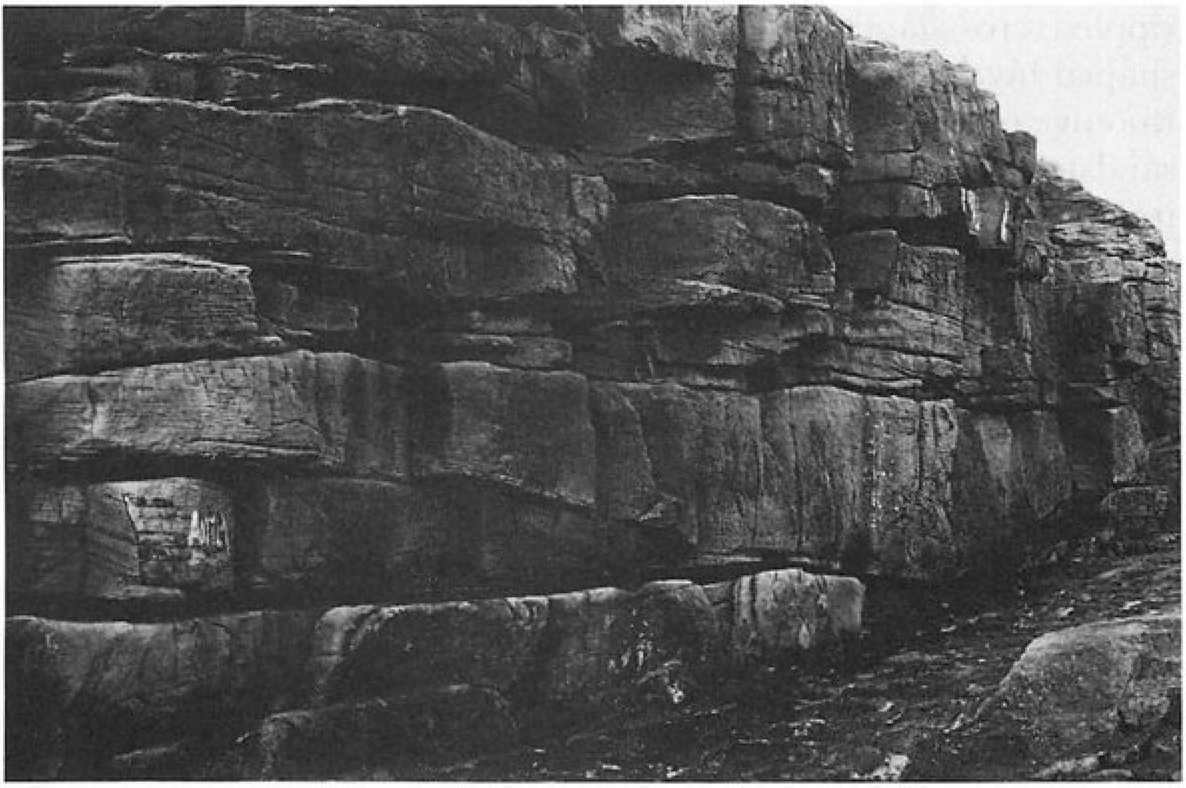
(Figure 8.2) Westphalian B Coal Measures stratigraphy between Tynemouth and Seaton Sluice. The arrows '..-'2, indicate the flow direction of currents responsible for the deposition of each major sandbody.



(Figure 1) Pre-Quaternary geological map of Northumbria and adjoining areas showing the location of excursions.



(Figure 8.3) The Tynemouth Dyke (Locality 1). Photo: C. T. Scrutton.



(Figure 8.4) Lenticular bed geometries in the Table Rocks Sandstone (Locality 3). Photo: B.R. Turner.