3 The Carboniferous rocks around Berwick-upon-Tweed

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Purpose

This excursion examines the sedimentology, palaeontology and structure of the Lower Carboniferous succession in the Tweed Basin.

Logistics

Localities 1–5 represent a good half-day and Localities 6–7 a full-day excursion. Berwick on the north side of the River Tweed estuary and Tweedmouth–Spittal on the south both have easy parking, and full facilities are available at all but Cocklawburn Reach (Locality 7). All the localities are on the coast and require low to Mid tide. The rocky foreshore can be slippery; wellingtons and hard hats are recommended.

Maps

O.S. 1:50 000 Sheet 75 Berwick-upon-Tweed; B.G.S. 1:50 000 Sheet 1/2 Berwick-upon-Tweed and Norham (Solid and Drift).

Geological background

In late Devonian and early Carboniferous times the structure of northern England consisted of a number of basins and blocks. The largest of these basins, the Northumberland Basin, was separated from the smaller Tweed Basin to the north by the Cheviot axis. This remained a positive area until late Asbian times, when regional subsidence occurred and the two basins merged into one. The Northumberland Basin owed its origin to Carboniferous extensional re-activation of a northerly dipping crustal scale shear zone. A similar origin is favoured for the Tweed Basin, which is interpreted to have formed in response to reactivation of a thrust slice in the Southern Uplands.

Up to 2200 m of Lower Carboniferous sediments were deposited in the Northumberland Basin and i 300 m in the Tweed Basin. Lower Carboniferous Dinantian stratigraphy in both basins is the same and consists of the Cementstone Group, the Fell Sandstone Group, the Scremerston Coal Group and the Lower and Middle Limestone Groups. The sequence seen on this excursion, from the top of the Scremerston Coal Group to the base of the Namurian Upper Limestone Group, records a series of marine transgressions and regressions across a lower delta plain environment, resulting in vertically stacked Yoredale cyclothems comprising a shallow marine bioclastic limestone, overlain by mudstone, siltstone and sandstone capped by a seatearth and coal. The marine influence progressively increases up-section.

Berwick-upon-Tweed lies on the north bank of the River Tweed and is one of Britain's most historic towns. It was constantly fought over during the Anglo-Scottish wars of the Middle Ages, changing hands some 13 times until 1482 when it was taken by the English; since then it has remained part of England. One of the most impressive features of the town is the Elizabethan walls, built 1558–1570; other features of interest include the Georgian Town Hall, the Barracks (the first to be purpose-built in Britain), the Royal Border viaduct railway bridge built by Robert Stephenson and the 300-year-old low-level stone bridge across the Tweed built of Lower Carboniferous sandstone.

Excursion details

Locality 1, Berwick cliff top, overlooking Green's Haven [NU 004 537] and Fisherman's Haven [NU 004 536].

From the A1, turn off to Berwick on the A6105 (Figure 3.3). Immediately after crossing over the railway bridge turn left towards Berwick Holiday Centre. Turn right past the centre across the municipal golf course to the cliff top where limited parking is available. Alternative parking is available in The Parade between the Barracks and Holy Trinity Church: access to the cliff top is through Walkergate and across the golf course.

The Lower Carboniferous Middle Limestone Group succession exposed on the foreshore at Berwick ranges from the sandstone below the Oxford Limestone to the Acre Limestone (Figure 3.1). From the cliff top at low tide, the spectacularly folded and faulted upper Middle Limestone Group strata can be seen on the foreshore at Green's Haven. A series of domes and basins is defined by the outcrop pattern of the more resistant limestone beds (Figure 3.2). The most prominent of these is the Eelwell Limestone which is exposed at intervals along the coast south of the Tweed (for example Locality 7), and further south at Beadnell Bay.

Locality 2, Meadow Haven Bay [NU 007 527]

Walk south along the cliff top path from Locality i to the Meadow Haven fault zone (Figure 3.1) where the steep cliffs change to slope features, and a footpath allows easy access to the beach. Beware of golfers and golf balls when walking along the cliff top path! The first outcrops associated with the Meadow Haven Fault zone occur at the base of the cliff and consist of reddish and white, rippled and cross-bedded sandstones and siltstones containing locally developed, deep-red iron oxide concretions and burrow structures, which become particularly common in the upper part. Ganister can be seen adjacent to part of the Meadow Haven fault zone which comprises sheared and faulted blocks showing both oblique slip and dextral movement. On the north side the beds dip into the fault plane, cut by a number of small tension faults. Shales, containing thin rippled silty and sandy interbeds and lenses, and a few brown ironstone nodules and lenses, are exposed in the unstable cliff face. These are underlain by the Upper Bath-House Wood Limestone which rises in the cliff c.30–40 m to the north. It is a hard, argillaceous biomicrite with a soft shaley top containing crinoid ossicles, brachiopods, gastropods, corals and bivalves. Bedding surfaces are covered with the swirling traces of *Zoophycos caudagalli* (locally called cock's tails), ubiquitous to all the limestones in the succession. They are the feeding burrow systems of an unknown worm-like organism.

Locality 3, Bucket Rocks syncline [NU 008 532]

At this locality the lower leaf of the Upper Bath-House Wood Limestone thins and passes into calcareous shale. A 21 cm thick coal seam and root-penetrated fireclay or seatearth, stained yellow by jarosite, occurs beneath the calcareous shale. The fireclay passes down into a cross-bedded and ripple cross-laminated sandstone spotted with reddish iron oxide burrow infills. The sandstone, which was deposited by palaeocurrents flowing to the southeast, is underlain by a calcareous sandstone with ripples in the coarser, more sandy parts. Two small faults, down-throwing to the north, drop the Upper Bath-House Wood Limestone to the base of the cliff on the north side of the point below the coastguard lookout. Here, it is a rubbly-looking fossiliferous limestone, the upper part of which has been selectively dolomitized; the presence of cavities suggest local de-dolomitization. Fossils occur scattered throughout the limestone or concentrated into distinct bands, whilst bedding surfaces are covered with superb *Zoophycos* feeding traces. Another feature of the limestone is the presence of numerous stylolite seams.

Locality 4, Ladies Skerrs dome [NU 008 536]

South of the southerly downthrowing normal fault, the following sequence can be seen in the cliff; burrowed shales, the Lower Bath-House Wood Limestone, c.6 m fossiliferous shales, then the Upper Bath-House Wood Limestone. The latter consists of two limestone units. A 1 m lower leaf is underlain by a 1–3 cm coal. It is separated by 1.5 m of shales from the upper leaf which consists of three beds separated by shaley partings. Bedding surfaces show abundant horizontal burrow traces.

Locality 5, Green's Haven Bay [NU 004 538]

North of the fault, the Upper Bath-House Wood Limestone forms the prominent, well jointed bedding plane surface, dipping 21° northwest. The overlying shales are marine with rare brachiopods at the base, but thin ironstone bands a little

higher up suggest a decreasing marine influence. Further north, tiny rippled silty lenses (starved ripples) occur in the thick shales and thicker siltstone, and fine sandstone interbeds with plane laminations, ripples and convolute laminations appear; some of the thicker interbeds have burrowed and bioturbated tops. Towards the top of this sequence, where the shales become more sandy, a thick unit, containing bulbous concretions, is extensively burrowed and bioturbated obliterating most of the primary sedimentary structures. This is overlain by a thick, 2 m seatearth with black rootlet traces, and a thin 2–20 cm coal. Black, locally burrowed shales beneath the Shotto Wood Limestone succeeded by more shale are exposed approaching the steps (Figure 3.1). The Eelwell Limestone is brown, vuggy and dolomitized in much of its outcrop, but on the northwest side of the paddling pool, it is un-dolomitized and contains abundant *Gigantoproductus* brachiopods, together with scattered corals including *Siphonodendron junceum* (a distinctive branching coral with close-spaced corallites about 3 mm in diameter). At the northern end of Green's Haven Bay shales occur adjacant to the southwest side of the northwest–southeast trending Green's Haven Fault; on the northeast side is a softish, feldspathic, medium to coarse and locally pebbly, trough and rarely, planar cross-bedded sandstone deposited by currents flowing from the west-northwest (Figure 3.1). The fault plane dips 65° southwest, and shows a dominant oblique slip movement with some dextral translation. The fault can be traced southeast via small reefs of rock into the dome at Ladies Skerrs.

From the parking area return to the A1167 (old A1) through Berwick, cross the Tweed Bridge and continue south (Figure 3.3). [NT 996 516] turn left for Spittal and continue to the end of Main Street where there is parking [NU 009 510].

Locality 6, Spittal

South from here for 4 km, there is almost complete foreshore exposure from the top of the Scremerston Coal Group, through the Lower and Middle Limestone Groups, and into the basal Upper Limestone Group. If possible, a second vehicle parked at Cocklawburn Beach (Locality 7) will enable a single continuous traverse to be made.

Some 30 m of shales, sandstones, seatearths and thin coals of the Scremerston Coal Group are exposed on the foreshore north of Huds Head. The first limestone, the 1.5 m, crinoidal, Dun Limestone, marks the base of the Lower Limestone Group (Figure 3.3). It forms a foreshore feature dipping 30° offshore, but is best seen where it rises in the cliff on the north side of Huds Head, where a seatearth and 36 cm coal is visible immediately beneath it. A band rich in the coral *Siphonodendron junceum* occurs near the base, together with large productid brachiopods and scattered other fossils. Brachiopods also occur in the shales above. The Dun Limestone cycle is the first of a series of coarsening-upward cycles consisting of marine limestone, shales, usually with ironstone bands and nodules, silts, sands, often first as starved ripples, lenticular and/or tabular units of cross-bedded sandstone, then usually a seatearth and coal. The environmental change at the base of the Limestone Groups is a subtle increase in marine influence and decrease in periods of emergence. Scattered thin coals occur throughout the succession and the limestones, at least below the level of the Oxford Limestone, are relatively thin and well spaced with thick intervening shales and sandstones, some showing strong channel form.

This lower part of the sequence can be traced in relatively undisturbed north-northwest striking beds across the foreshore south to the far side of Redshin Cove. The thick sandstones above the Dun Limestone forming Huds Head contain intersecting lenticular fine-grained cross-stratified units near the base and medium to coarse grained, multistoried, mainly planar cross-bedded sets deposited by migrating channel bars towards the top. In the cliff above, a major distributory channel filled with small-medium scale, mainly trough cross-bedded sandstones cuts down to the south through the shales overlying the prograding deltaic sequence. Opposite a prominent embayment where the cliff is replaced by a grassy slope, a prominent calcrete is overlain by the Woodend Limestone, which forms a feature on the foreshore, striking into the cliff to the south. This limestone is notable for its excellent fauna of fasciculate corals, mainly *Siphonodendron junceum* but also *S. martini* (with corallite diameters 7–8 mm). Many of the *S. junceum* colonies are virtually uncrushed and in position of growth. Towards the top of the limestone, and particularly on the top bedding surface, scattered colonies of *Lithostrotion maccoyanum* (massive with polygonal corallites 3–4 mm diameter) occur. The solitary corals *Dibunophyllum* (with a spider's web axial structure) and *Caninia* (no axial structure) are present together with the calcareous sponge *Chaetetes septosus.*

The Woodend Limestone is overlain by another classic coarsening-upward sequence ending with the Woodend Coals, associated with slumping in the grassy and degraded cliff and thus poorly exposed. About 15 m higher in the succession

is a 1.2 m cementstone band and some 2 m higher a very distinctive 50 cm Algal Band, consisting of subspherical algal oncolites, up to 9 cm diameter, which become more densely packed towards the top of the bed. A 4.5 m black oil shale, forming a broad slack on the foreshore, succeeds the Algal Band. In the sequence above, the Watchlaw Limestone can be identified just before a prominent step on the foreshore onto the thick sequence of cross-bedded sandstones of the Maidenkirk Brae Sandstone. Further progress south is difficult and only possible at low tide.

In the corner of the cove just beyond the step, climb a grassy dip slope to the cliff top path. From here, the lenticular nature of beds below the Watchlaw Limestone can be clearly seen on the foreshore to the north.

For those with a single vehicle, return to it and rejoin the A1167 at the roundabout and turn south for Scremerston. After 2 km turn left at a signpost for Cocklawburn Beach and rejoin the coast at Seahouse. Turn left, cross a cattle grid and proceed c.150 m into a field from where there is a cliff path down to Cargie's Kiln, or right to where vehicles can be parked at various points on the roadside opposite Saltpan Rocks and the Skerrs.

Locality 7, Cargie's Plantation [NU 019 498] to Cocklawburn Beach [NU 036 478]

Descend to the foreshore at Cargie's Plantation to continue the section southwards (Figure 3.3). The sequence here beneath the Oxford Limestone is confused by a series of small east–west to northwest–southeast faults. At Cargie's Kiln, the 5 m thick, poorly fossiliferous but crinoidal Oxford Limestone marks the base of the late Dinantian Middle Limestone Group. The limestone is split into posts by shaley partings, one of which near the base of the limestone contains particularly prominent rolled algal nodules. In the limestone, red algal haloes around bioclasts stand out on wave polished surfaces. The Middle Limestone Group consists of cycles in which the limestones are thicker and more laterally persistent on a county-wide scale than in the Lower Limestone Group and the sandstones thinner, although thin coals are still developed at the tops of some cycles.

Several thin limestones dipping between 30–60° east-northeast intervene between the Oxford and the next thick limestone, the Eelwell. Each forms the base for a coarsening-upward cycle, often with well developed ripples, small-scale lenticular cross-bedded sets and hummocky cross-stratification (Reynolds 1992) developed in the sandstones, a seatearth and sometimes a thin coal. Following each transgression, the fluvio-deltaic processes carrying progressively coarser elastic material into the basin now show more evidence of shoreline, particularly storm dominated reworking, and less evidence of distributary channel, interdistributary bay and floodplain sediments than in lower parts of the succession (Reynolds 1992).

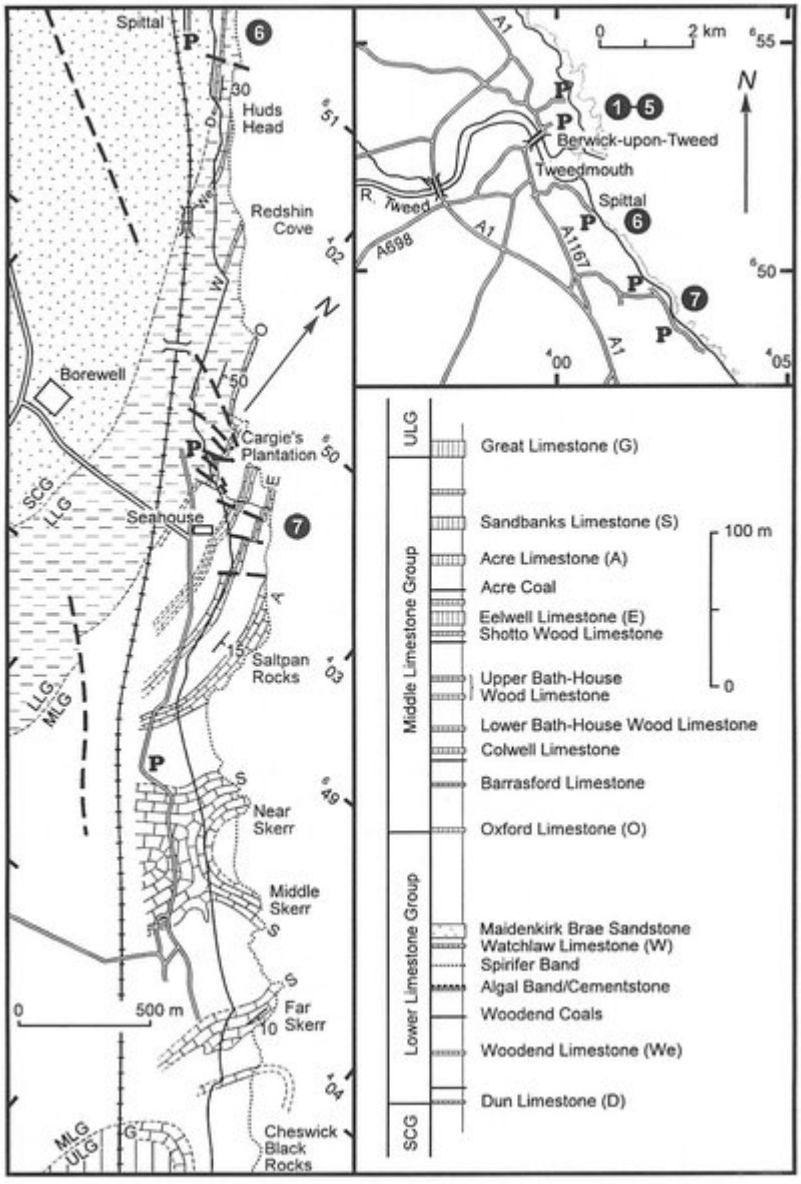
The Eelwell Limestone, 8 m thick and easily distinguished by a prominent fauna of large *Gigantoproductus* brachiopods and corals including *Siphonodendron junceum,* develops small folds and minor associated thrusts throughout its foreshore outcrop. The limestone is locally dolomitized, brown weathering and vuggy. Just south of Seahouse, it is involved in a sharp overfold facing west (Figure 3.4), which further south is thrust through its short limb. On the top surfaces of the gentle, whaleback folds to the east and south, polished sections through the rich fauna of spiriferid brachiopods at the very top of the limestone can be seen. Out on the foreshore here the 30 cm Acre Coal occurs beneath sandstones showing medium–large scale lenticular cross-bedded sets. Where the coal crops out in the cliffat the back of the foreshore, it is involved in a small thrust with i m vertical displacement. Just above are excellent examples of climbing ripples and a rootlet bed. The 4.5 m thick Acre Limestone, also developing minor folds on the foreshore, has a very thin, impersistent sulphurous coal beneath it. The limestone, crinoidal, with scattered fossils and small algal nodules, is brown weathering, dolomitized and vuggy in the cliff.

The sequence of outcrops on the beach to the south, the Skerrs, are all formed of the 8.5 m thick Sandbanks Limestone, a series of thin limestone beds with shale partings. Near Skerr to Middle Skerr is a broad, shallow syncline and from Middle Skerr to Far Skerr a complementary anticline. Polished surfaces at Middle Skerr show excellent sections of *Zoophycos.* There are layers rich in brachiopods, and prominent solitary corals, mainly *Aulophyllum fungites* (with a dense axial structure) and rarer *Palaeosmilia murchisoni* (with many septa and no axial structure). In the sandstones below trace fossils are well seen; first the beaded burrow *Eione moniliforme* and then at lower levels, 1 o cm long, dumbell-like depressions which are the bedding plane traces of the U-shaped burrow *Diplocraterion.* A careful search ofjoint surfaces may reveal vertical sections through the latter. Dark brown chert nodules occur towards the top of the

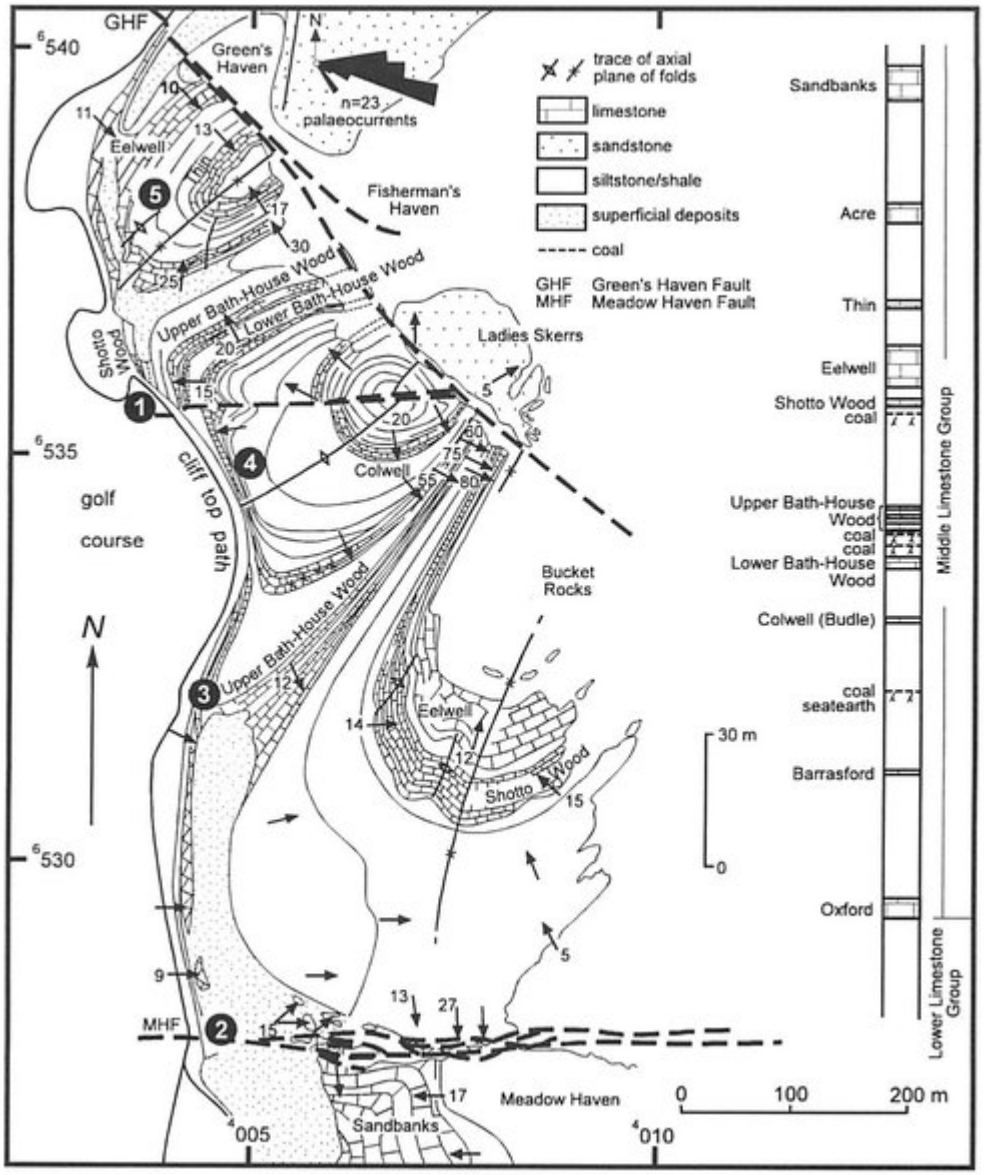
limestone at Far Skerr; chert is characteristic of this limestone (=Four Fathom Limestone) across Northern England.

The next reef on the beach to the south is a thin, brown-weathering un-named limestone. Cheswick Black Rocks beyond, the last outcrop on the beach to the south, are formed of coarse, cross-bedded sandstones immediately beneath the Great Limestone. This limestone, known locally as the Dryburn, marks the base of the Upper Limestone Group and the Namurian (Upper Carboniferous). It was formerly quarried inland at Scremerston but it cannot now be seen on the shore.

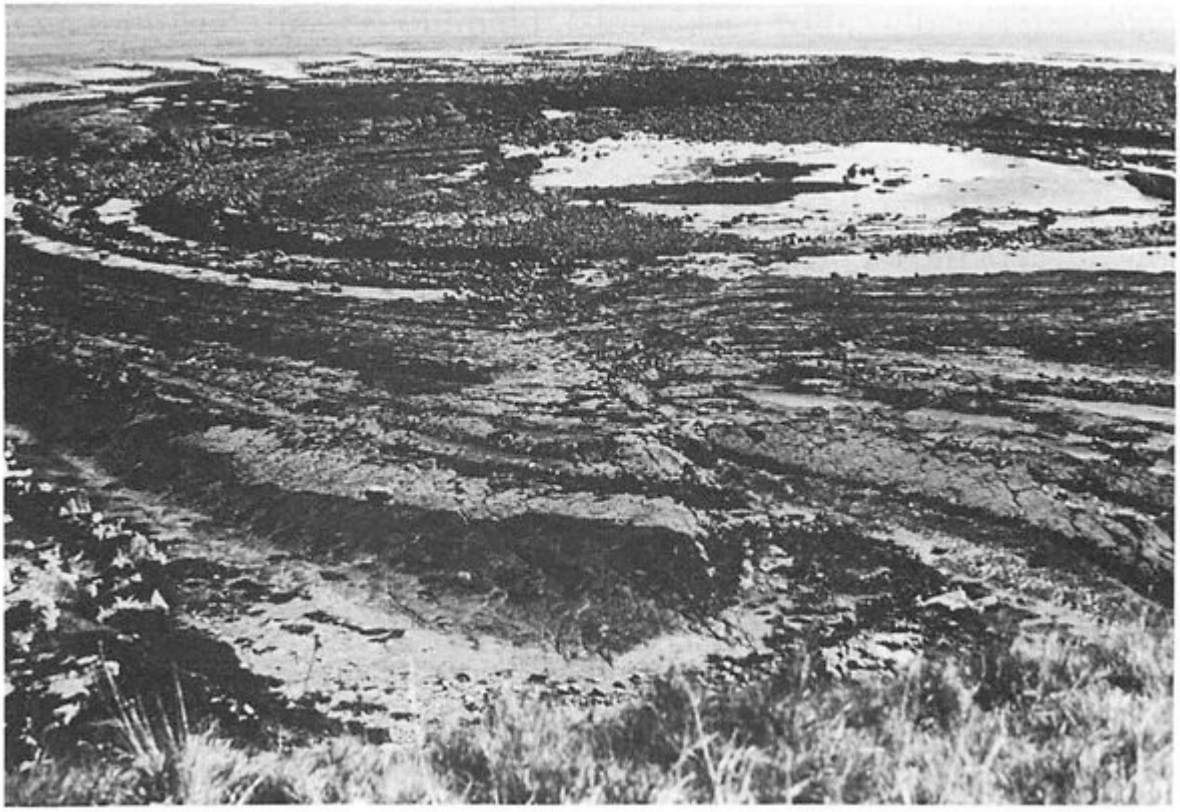
Bibliography



(Figure 3.3) Geological map and section of the Spittal–Cocklawburn Beach coastal section. S.C.G. = Scremerston Coal Group; L.L.G, M.L.G., U.L.G. = Lower, Middle and Upper Limestone groups respectively. Inset map of the Berwick-upon-Tweed area.



(Figure 3.1) Geological map and section of the Meadow Haven–Green's Haven area, Berwick-upon-Tweed.



(Figure 3.2) Ladies Skerrs dome (Locality 4) from the clifftop at Berwick (Locality 1). Photo: C. T. Scrutton.

(Figure 3.4) West-facing overfold in the Eelwell Limestone, Saltpan Rocks (Locality 7). Photo: C. T. Scrutton.