Iron Scar–Hundale and Hun Dale Point–Scalby Ness, North Yorkshire

[TA 017 964], [TA 020 957]–[TA 027 945], [TA 023 949]–[TA 037 908]

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Introduction

The two sites known as 'Iron Scar–Hundale' and 'Hundale Point–Scalby Ness', assigned respectively to the Aalenian–Bajocian and Bathonian GCR blocks, overlap at Hundale Point and, apart from a *c.* 600 m stretch to the south of Iron Scar, together cover about 5 km of the coastline north of Scarborough (Figure 5.25). The slight promontory known as 'Iron Scar' provides the only coastal exposure, and the type locality; of the Eller Beck Formation. From north of Cloughton Wyke to Scalby Ness, the coastal exposures provide fine sections, including the type localities, of the Cloughton, Scarborough and Scalby formations (Figure 5.26). Sited within the structural feature known as the 'Peak Trough' (Milsom and Rawson, 1989), the coastal exposures here generally show maximal formation thicknesses.

Description

Iron Scar

The following section is taken from manuscript notes supplied by Dr R.W.O'B. Knox (BGS). The subdivision into units follows Knox (1973).

	Thickness (m)
Eller Beck Formation (overlain by Cloughton Fm) '*Upper sandstone unit*'*:* Sandstone, flat bedded; top penetrated by rootlets; some surfaces with symmetrical ripple-marks	1.68
'*Lower sandstone unit*'	
Sandstone, thin bedded, intercalations of silty shale and beds of impersistent, silty, siderite mudstone; occasional shelly bands	1.83
Sandstone, thin bedded, laminated; interbedded with silty shale and ironstone	0.56
'*Shale unit*'*:* Shale, silty; laminae of fine sand in upper part; shell casts in lower part	1.22
'*Ironstone unit*'*:* Ironstone, ooidal siderite mudstone; scattered fossils; ironstone-filled burrows, including *Diplocraterion* and *Rhizocorallium,* at base	up to 0.08
Saltwick Formation	
Siltstone-shale, pale-grey, delicately laminated; corn-minuted plant-material; very small *Rhizocorallium*'burrows, occasional runnels; rare bivalves seen on base of some runnel casts	1.68
Mudstone, poorly laminated; some sphaerosiderite	—

Similar sections are exposed in places in the cliffs to the north but the density of burrowing decreases in that direction. At Iron Scar proper, a channel, infilled with massive sandstone and scattered blocks of siltstone and sideritic silt-stone, cuts down *c.* 1.4 m from the top of the 'Lower sandstone unit'.

North side of Cloughton Wyke–Scalby Ness

The following description is based largely on Gowland and Riding (1991), Knox *et al.* (1991) and Rawson and Wright (1992, 1995).

North of Cloughton Wyke, the cliffs expose the Sycarham, Lebberston and Gristhorpe members of the Cloughton Formation overlain by the Scarborough Formation and then the Moor Grit Member at the base of the Scalby Formation (Figure 5.27). The Sycarham Member comprises coal measures facies of argillaceous sandstone, siltstone, shale and low-grade coal. The Lebberston Member (represented by the Millepore Bed) forms a series of reefs running south-eastwards out to sea. It consists of three layers, each representing a coarsening-upwards cycle with sandy limestone passing up into shelly, calcareous sandstone. The top layer is cemented by siderite and, as a result, is extremely hard; well-developed cross-bedding also makes it very distinctive. The middle layer is the most fossiliferous with many shells preserved in the white-weathering clay mineral dickite ($Al_4Si_4O_{10}(OH)_8$). Bivalves, including *Arcomya elongata* (J. de C. Sowerby), *Entolium demissum* (Phillips), *Modiolus imbricatus* (J. Sowerby), *Pholadomya saemanni* Morris and Lycett, *Pleuromya beani* (Morris and Lycett), *Pseudolimea duplicata* (J. de C. Sowerby) and *Trigonia* sp., dominate the fauna, which also includes the bryozoan *Collapora* (*Millepora*) *straminea* (Phillips) (Wright in Rawson and Wright, 1992; Rawson and Wright, 1995).

Nearer to Cloughton Wyke, the lowest part of the overlying Gristhorpe Member (the Yons Nab Beds) is exposed in the low cliff. The lowest bed is a 0.6 m-thick, ripple-drift cross-laminated sandstone, which is overlain successively by 1.6 m of flaser-bedded, shaly sandstone with numerous bivalves including oysters, pectinids and *Trigonia,* 1 m of shale with coaly, carbonaceous layers, and then 2.6 m of sandstone with occasional *Diplocraterion* burrows.

A little farther south, the overlying beds of the Gristhorpe Member, *c.* 12.5 m thick, are exposed in the cliffs and rock platform near the centre of Cloughton Wyke. The lower and middle parts consist of alternating mudstones, siltstones and sandstones. Mudstones and siltstones predominate in the lower part and are mostly well bedded, sometimes showing delicate lamination. Thin coals and well-defined surfaces of rootlet penetration also occur, some with the vestiges of the plant *Equisetites* in the overlying sediment. Burrowed surfaces, some showing the trace fossil *Diplocraterion,* are also visible. Sandstones, totalling *c.* 2 m in thickness, predominate in the middle part of the member. Sedimentary structures include horizontal- to wavy-lamination, wave-ripple cross-lamination, planar lamination with parting lineation, and small-scale trough cross-lamination (Figure 5.28). Groove casts are present on the base of some sandstone sheets, notably the lowest. The upper part of the Gristhorpe Member consists of *c. 6–7* m of thin, channel sandstones, poorly bedded siltstones, and mudstones with rootlet beds. These have yielded an abundant flora including *Ptilophyllum pecten* (Phillips), *Cladophlebis, Czechanowskia, Nilssoniopteris* and *Otozamites.* Continuing southwards towards Hundale Point, the boundary between the Gristhorpe Member (Cloughton Formation) and the overlying Scarborough Formation is taken where dark siltstone overlies grey, poorly bedded silt-stone (Knox *et al.,* 1991). Trace fossils in the form of *Diplocraterion* and characteristic J-shaped burrows pipe dark-grey silt of the Scarborough Formation down into the paler beds of the Cloughton Formation (Rawson and Wright, 1995).

The basal 7.6 m of the Scarborough Formation (Helwath Beck Member) consist of a complex sequence of dark-grey mudstones and siltstones, interbedded with very fine-grained micaceous sandstones with sedimentary structures. The member culminates in an upward-coarsening sandstone showing a variety of delicately preserved sedimentary structures, and including an assemblage of well-preserved trace fossils such as *Arenolites, Diplocraterion, Planolites, Skolithos, Teichichnus* and *Thalassinoides.* One metre above the base, a bed of ripple-drift laminated sand has been intensely distorted and 'balled up'.

The overlying beds of the Scarborough Formation comprise a series of coarsening-upward cycles, with residual primary sedimentary structures, capped by a thick mudstone sequence that becomes increasingly silty with thin sandy layers. Following Parsons (1977b) as amended by Gowland and Riding (1991), these beds are divided into six members: from below, Hundale Shale, Hundale Sandstone, Spindle Thorn Limestone, Ravenscar Shale, White Nab Ironstone and Bogmire Gill. The measured section with numbered beds of Parsons (1977b), who included informal bed names based on Hudleston (1874), has been largely superseded by descriptions of the section based on more recent detailed sedimentological work and sequence stratigraphical studies (notably Gowland and Riding, 1991); the latter authors featured a graphic log showing details of the sedimentary structures, trace fossils, bivalves, palynomorphs and lithostratigraphy, as well as the biostratigraphical classification and deduced depositional environments.

The Hundale Shale Member, totalling 2.64 m, is seen best in the upper rock platform between Hundale Scar and Hundale Point. The lower and greater part (2.11 m) of the member is a dark-grey siltstone that coarsens upwards into discontinuous, partially calcite-cemented, silty, fine- to medium-grained sandstone centimetre-scale stringers. It has a trace-fossil assemblage dominated by *Planolites, Teichichnus* and *Thalassinoides;* sand-filled burrows of *Thalassinoides* are prominent in the upper part, together with rare cidarid echinoids. Bivalves include abundant *Gervillella scarburgensis* (Paris) as well as *Camptonectes laminatus* (J. Sowerby), *Meleagrinella lycetti* (Rollier) and *Nanogyra nana* (J. Sowerby). *Gresslya abducta* (Phillips) and *Pleuromya uniformis* (J. Sowerby) can be seen in life position at the top of this unit, which is strongly bioturbated and overlain by an iron-rich calcareous mudstone that weathers red (Tower Iron Scar'). The latter is 0.41 m thick and includes an additional bivalve fauna of '*Astarte*' *minima* Phillips, *Plagiostoma rodburghensis* (Whidborne) and *Pholadomya* sp., as well as the gastropods *Alaria* cf. *unicarinata* Hudleston, A. cf. *praelonga* Hudleston, *Melanioptyxis* cf. *altararis* Cossmann, *Natica adductor* Phillips, *Nerinea cingenda* Phillips and *Proceritbium vetustum* Phillips, echinoderm debris and serpulids. The uppermost part of the member is a 0.12 m-thick, dark-grey, poorly fossiliferous, carbonaceous siltstone.

The overlying Hundale Sandstone Member comprises two coarsening-upward siltstone-sandstone sequences with an intervening thin, red-weathering shale-mudstone couplet containing '*Astarte*' *minima, Camptonectes laminatus, Meleagrinella lycetti* and *Nanogyra nana.* The lower siltstone-sandstone (2.01 m thick) is thin-bedded and flaggy with ripple forms and abundant trace fossils including *Asterosoma, Chondrites, Diplocraterion, Planolites, Rbizocorallium, Selichnites, Teichichnus* and *Thalassinoides.* The upper unit is more massive with hummocky cross-stratification, scour surfaces and shell lags, and a well-preserved trace-fossil assemblage including *Rhizocorallium, Teichichnus* and *Thalassinoides.* The member is capped by a coarse, shelly, calcareous sandstone packed with serpulids, bivalves, echinoderm fragments and belemnites.

The Spindle Thorn Limestone Member, *c.* 3.67 m thick, is well exposed in the base of the cliff. It comprises three poorly defined, coarsening-upward sequences; the coarsening largely reflects an increase in shell-debris content. Many of the fossil taxa recorded in the underlying members are present, together with the bivalves *Isognomon* sp., *Modiolus imbricatus, Myopborella signata* (Agassiz), *Pinna beani* Cox and Arkell, *P. cuneata* Phillips, *Protocardia* sp., *Pseudolimea* aff. *duplicata* and *Quenstedtia* sp., some in growth position. The belemnite *Megateuthis* is common but the ammonites *Dorsetensia* and *Stephanoceras* occur only rarely. Gastropods, echinoid spines and crinoid columnals are also present with the trace fossils *Teichichnus* and *Thalassinoides,* and less abundant *Rhizocorallium* and *Skolitbus.*

The overlying Ravenscar Shale Member is also well exposed in the base of the cliff. It comprises 8.1 m of mid- to dark-grey, shaly siltstones with numerous ammonites, including *Dorsetensia* and *Stephanoceras,* and a relatively low-diversity bivalve fauna of which *Meleagrinella lycetti* is by far the most abundant. The belem-nite *Megateuthis* and small colonies of serpulids are also recorded. The member is overlain by bioturbated, silty sandstones and sandy silt-stones, with the bivalves *Gervillella scarburgensis, Meleagrinella lycetti* and *Liostrea,* followed by sideritic siltstone capped by nodular siderite. The latter contains bivalves and gastropods, and the ammonite *Teloceras.* These beds comprise the White Nab Ironstone Member, which here totals 1.33 m in thickness.

The Bogmire Gill Member is the final part of the Scarborough Formation with a preserved thickness of 2.5 m beneath the transgressive base of the Moor Grit Member of the overlying Scalby Formation. It comprises a single coarsening-upward sequence grading from micaceous, sandy siltstone to fine-grained sandstone. Trace fossils, including *Chondrites, Skolitbos* and *Teichichnus,* are predominant.

The Scarborough Formation disappears rapidly southwards beneath beach level, and from Hundale Point to Scarborough, the cliffs and rock platform are composed of sandstones, ironstones and shales of the Scalby Formation. The fine- to coarse-grained sandstones of the Moor Grit Member (*c.* 10 m thick) form the cliff throughout much of the bay immediately south of Hundale Point to Long Nab. They display a wide variety of sedimentary structures including spectacular giant sets of large-scale trough cross-stratification up to 10 m thick, and are rich in coalified plant remains with subordinate charcoal fragments (Cope, 1993). According to Knox *et al.* (1991), detailed analysis of the basal sandstones of the Scalby Formation shows that they can be divided into three units: the lowest comprises mud-free sandstone with medium- to large-scale cross-stratification; the middle unit comprises sandstone with a basal muddy layer and with muddy laminae and medium-scale cross-stratification; and the uppermost unit comprises extremely muddy sandstone or silt-stone with medium-scale cross-bedding or, locally, horizontal bedding, and with abundant soft-sediment deformation in the muddier sets. This uppermost unit marks the base of the Long Nab Member of Leeder and Nami (1979); the latter is exposed in the cliff section from the south side of Long Nab into Burniston Bay (or Wyke) and in spectacular foreshore exposures there. Above this basal sandstone unit, the overlying beds of the Long Nab Member comprise 2–3 m of grey clay with some dark, carbonaceous beds full of flattened plant-stems; rootlets penetrate the underlying sandstone. In both clay and sandstone, sideritization is intense, with large sideritic concretions and beds of sphaerosiderite. The clays are overlain by thin, level-bedded alternations of sandstone and silty clay and with localized channel-fills first described by Black (1928, 1929). In many places in the cliffs, the level-bedded strata are seen to pass laterally into strongly cross-bedded channel sandstones with the channels frequently cutting right through to the underlying clays. Above the rock platform, near the centre of the bay, and just above the level at which channels are developed, casts of dinosaur footprints (Figure 5.29) are preserved in a bed of silty sandstone (Burniston Footprint Bed), which forms an overhanging ledge at Burniston Steps (Hargreaves, 1913, 1914; Fox-Strangways and Barrow, 1915). Towards the southern end of the bay and about 3 m above the Footprint Bed, there is a 0.9 m-thick bed of well-sorted, ripple-drift laminated, fine-grained sandstone; the lower surface reveals numerous infilled burrows and the upper surface, numerous rootlets. Followed southeastwards and near where this bed wedges out, its base reveals spectacular infilled, slightly sinuous, U-shaped scour channels or gutter marks, at least 7 m long and 0.10 m deep, running parallel to the cliff. At Cromer Point, at the southern end of Burniston Bay, the sea has cut a natural arch through a massive channel sandstone that shows well-defined lateral accretion sets and abundant well-developed mudstone rip-up clasts; the sandstone passes laterally and rapidly into laminated siltstones and sandstones.

The basal sandstones of the Long Nab Member are again well exposed, dipping southwards, in the rock platform in Scalby Bay (Figure 5.30), to the south of Cromer Point. In the centre of Scalby Bay, they are seen in a 180° sweep across the rock platform with cross-bedding dips swinging round from north-east through south-west to south-east. The cliffs expose a series of small, sand-filled channels stacked one above the other, some choked with the carbonized remains of tree trunks, and with much slumping. Near high water mark in the rock platform north-east of Scalby Lodge, a 10 m-long trail of dinosaur footprints is exposed, having been revealed by the selective erosion of the overlying argillaceous sandstone (Delair and Sarjeant, 1985, fig. 3). At Scalby Ness, the gentle seaward dip carries the overlying silty shales of the Long Nab Member into the base of the cliff. These constitute the Scalby Plant Bed (Black, 1929), which yields relatively abundant well-preserved leaves of *Ginkgo huttoni* (Sternberg) (Rawson and Wright, 1992). A borehole [TA 0363 9108] drilled at Scalby Ness for the Yorkshire River Authority cored, beneath 17.8 m of Quaternary deposits, *c.* 27.5 m of Scalby Formation, on *c.* 21 m of Scarborough Formation, on *c.* 37 m of Cloughton Formation. Drilling terminated within the Sycarham Member and it is estimated that at least a further 40 m of Ravenscar Group underlie the site (Lott and Humphreys, 1992).

Interpretation

The coastal sections described above expose a large part of the predominantly non-marine Ravenscar Group in which the Eller Beck Formation, Lebberston Member and Scarborough Formation represent three separate marine intervals. Phillips (1829) and Fox-Strangways (1892) speculated that the non-marine beds were of estuarine origin, but Kendall and Wroot (1924) and Black (1928, 1929), suggested a deltaic origin. Since then, the depositional environment of these beds has been the subject of much discussion mainly centred on whether they represented the deposits of a delta or coastal alluvial-plain (Alexander, 1989 and references therein). Features interpreted as characteristic of both these environments are recognized, as summarized by Rawson and Wright (1992). Coarsening-upwards cycles of bioturbated, laminated, intertidal siltstones with crevasse-splay sheet sandstones, succeeded by rapidly filled distributory channels with slumps and water-escape structures suggest a deltaic origin; meandering streams, floodplains with desiccation cracks and footprint trails, lakes with beds of the bivalve *Unio,* marsh deposits, fossil soils with rootlet beds and the extensive development of sphaerosiderite suggest an alluvial origin. Rawson and Wright (1992) concluded that the overall evidence suggests that following each marine interval, there was rapid development of small prograding deltas, deposited by rivers flowing from the north, which ultimately coalesced into a large coastal alluvial-plain close to sea level and susceptible to marine influence; there is no evidence of a large single river-system feeding into a large delta (Alexander, 1986, 1987; Rawson and Wright, 1995). The marine incursions represented by the Eller Beck and Scarborough formations are thought probably to have come from the east or south-east, and that represented by the Lebberston Member, probably came from the shelf to the south (Knox, 1973; Parsons, 1977b; Rawson and Wright, 1992).

The bulk of the Saltwick Formation, the top of which is seen beneath the Eller Beck Formation at Iron Scar, consists of fluvio-deltaic deposits including lacustrine, levee, crevasse-splay and mudcracked overbank sediments as well as channel sandstones; thick roots mark periods of major plant colonization, especially near the base (Livera and Leeder, 1981). The formation shows an upward transition from a well-drained floodplain complex with major bedload channels to a saturated marsh drained by smaller mixed load channels suggestive of a gradual abandonment of a delta lobe with time. According to Livera and Leeder (1981), sedimentation in the overlying Eller Beck Formation evidently occurred as a prograding strand line with deposition by wave and tidal currents. Bioturbation is common in the middle parts of the sandstone suggesting that wave energy was moderated by the shallow water-depths (6–7 m) over the marine platform. The top of the sandstone was densely colonized by plants, which mark the return to non-marine sedimentation. The section at Iron Scar is the type locality of the formation (Hemingway and Knox, 1973; Knox, 1973).

The Cloughton Formation comprises coal-measure facies cut by channel sandstones but these do not show the vertical passage seen in the Saltwick Formation and described above (Rawson and Wright, 1995). The Lebberston Member (represented by the Millepore Bed) generally rests with a sharp, erosive base on the underlying fluvio-deltaic Sycarham Member, the type locality of which is at Sycarham Cliff [TA 021 957] (Hemingway and Knox, 1973). North of Cloughton Wyke, the Millepore Bed was probably deposited as a southerly migrating strand line. At Cloughton Wyke, a hardground is overlain by storm-derived conglomerate with beach deposits above and below (Livera and Leeder, 1981). According to these authors, the Yons Nab Beds at Cloughton Wyke, which overlie the Millepore Bed, are now taken to comprise the basal part of the Gristhorpe Member rather than the upper part of the Lebberston Member (following Knox in Rawson and Wright, 1995; see Gristhorpe Bay, Yons Nab and Red Cliff–Cunstone Nab GCR site report, this volume); they seem to represent part of a prograding system of sand ridges separated by silt-dominated lagoonal deposits. The low level of bioturbation suggests medium wave energy, whilst the minor tidal channel at Cloughton Wyke and lack of major washover sandstones suggests that the environment was influenced by both tides and waves, neither of which was dominant. The thin coal with poor root foundation, seen in the basal dark shales of the Gristhorpe Member at Clough-ton Wyke, was probably formed by drifted plant input into standing water; this and the overlying siltstones and sandstones represent a continuation of the lagoonal environments proposed for the Yons Nab Beds. Sheet sands and sandstones of crevasse-splay origin, which dominate the middle part of the overlying fluvio-deltaic sequence of the Gristhorpe Member, extend over hundreds of metres. They overlie lacustrine, plant-rich sediments and are themselves cut into by later channel sandstones (Livera and Leeder, 1981); they appear to have been immediately colonized after deposition by plants.

The overlying Scarborough Formation is the highest and best-developed marine sequence in the Ravenscar Group. Detailed work by Gowland and Riding (1991) and Knox *et al.* (1991) has suggested the depositional environments represented by the different members. The Helwath Beck Member is believed to represent fair-weather, and storm, sedimentation (Knox *et al.,* 1991) in an increasingly shallow (possibly <4 m deep), brackish-water, marine embayment open to the east; its sedimentary structures are wave-induced. The 'balled up' bed of ripple-drift laminated sand near its base is a widespread horizon of soft-sediment deformation that can be traced northwards for more than 5 km and which was probably caused by seismic shock (Livera, 1981; Gowland, 1987; Gowland and Riding, 1991). The overlying Hundale Shale Member represents a nearshore siliciclastic shelf shoal and the top beds a muddy carbonate, shallow-marine shelf environment. Hummocky cross-stratification, scour surfaces and shell lags in the upper part of the overlying Hundale Sandstone Member indicate deposition from powerful, episodic storm-driven flows and, in general, a vertically accreted inner-shelf sand-shoal. The abundance of inferred stenohaline fossils, such as crinoids and belemnites, in the top sandstone unit, suggests deposition in an open marine shelf setting for at least the uppermost part of the member. Elsewhere, crinoids are common throughout this member, which is why it was originally called the 'Crinoid Grit' (Richardson, 1911c). The fossil assemblage combined with the presence of silt and clay in the overlying Spindle Thorn Limestone Member suggests deposition in a shallow-marine setting transitional between a siliciclastic coastal system and an open carbonate shelf, but the coastline probably lay outside the confines of the present outcrop. The presence of ammonites in the Ravenscar Shale Member is thought to indicate deposition in an open marine setting, although Gowland and Riding (1991) suggested that the low-diversity bivalve fauna indicated physiological stress, with low oxygen levels, in the sea-floor community. The association of ammonites, bivalves, gastropods, echinoderms and serpulids in the White Nab Ironstone Member is sufficient to suggest a relatively open shallow-marine shelf depositional environment. Gowland and Riding (1991) felt that Leeder and Nami (1979) had convincingly attributed the typical coarsening-upward sequence seen in the Bogmire Gill Member to the progradation of a wave-dominated sandy shoreface, and that eastward progradation of the shoreface was indicated by the fact that the member conformably overlies the Ravenscar Shale Member in the western part of the Cleveland Basin, but is conformable on the White Nab Ironstone Member in coastal outcrops (Gowland, 1987; Gowland and Riding, 1991). At Hundale Point, type locality of the Scarborough Formation (Hemingway and Knox, 1973), the fluvial channel sandstones of the Moor Grit Member of the Scalby Formation, with a basal erosion surface, overlie the progradational wave-dominated shoreface deposits of the Bogmire Gill Member. Since recent palynological analyses fail to support a significant time gap at the contact (Riding and Wright, 1989), Gowland and Riding (1991) thought it attractive to interpret the Bogmire Gill Member as representing the wave-dominated coastal fringe of a Scalby Formation delta lobe.

There has been considerable speculation about the depositional environments of the Scalby Formation, the type locality of which is at Scalby Cliff [TA 031 924] (Hemingway and Knox, 1973). Black (1929) suggested that the Moor Grit Member represented the foreset deposits of a prograding delta-front, and that the overlying level-bedded, finer-grained sediments of the Long Nab Member represented a delta-top environment, but Nami and Leeder (1978) proposed a predominantly alluvial model with the Moor Grit Member representing the channel-fills of a braided river-system. The basal beds of the Long Nab Member, which are spectacularly exposed on the foreshore of both Burniston and Scalby bays, are interpreted as a meander belt complex crossing an alluvial plain. A map of the meander belt channels in Scalby Bay, based on field mapping by J.K. Wright in 1969, is included in Rawson and Wright (1992, 1995) and another, between Long Nab and Scalby Ness, is included in Nami and Leeder (1978). Fisher and Hancock (1985) believed that Leeder and Nami's (1979) interpretation of these beds as an 'uplifted fluvial sequence' was not tenable and that the Scalby Formation was deposited in an overall delta-plain setting with saline interdistributary environments. They believed the Moor Grit Member to represent a deltaic distributary system and that the Long Nab Member was also dominated by similar saline-influenced delta-plain deposition with smaller, variably sinuous distributary channels, some of which may have been tidal. According to Hancock and Fisher (1981), the delta front lay to the south-east, and is seen in offshore well sections. Cromer Point and Long Nab are formed of isolated channel sandstone bodies.

The plants of the Scalby Plant Bed, which occurs close above the 'meander belt complex', are believed to be drifted rather than *in situ,* in contrast to those of the Gristhorpe Plant Bed (see Gristhorpe Bay, Yons Nab and Red Cliff–Cunstone Nab GCR site report, this volume). According to Black (1929), the plants are often fragmentary and large pieces of delicate fronds are never found; the plants are spread out fairly evenly along the bedding planes, and there is no evidence of roots or of a seatearth. Both Cloughton Wyke and Scalby Ness feature as sites in the GCR Mesozoic Palaeobotany Block (Cleal *et al.,* 2001). A little higher in the succession, the Burniston Footprint Bed is a sheet sandstone thought by Knox *et al.* (1991) to represent the invasion of a shallow lake by sandstone brought in by unidirectional sheet flow. Desiccation cracks, groove casts and climbing ripples are well displayed. The dinosaur footprints were made in soft, silty clay and subsequently infilled by a gentle incursion of silt and sand that preserved the footprints as moulds (Rawson and Wright, 1995).

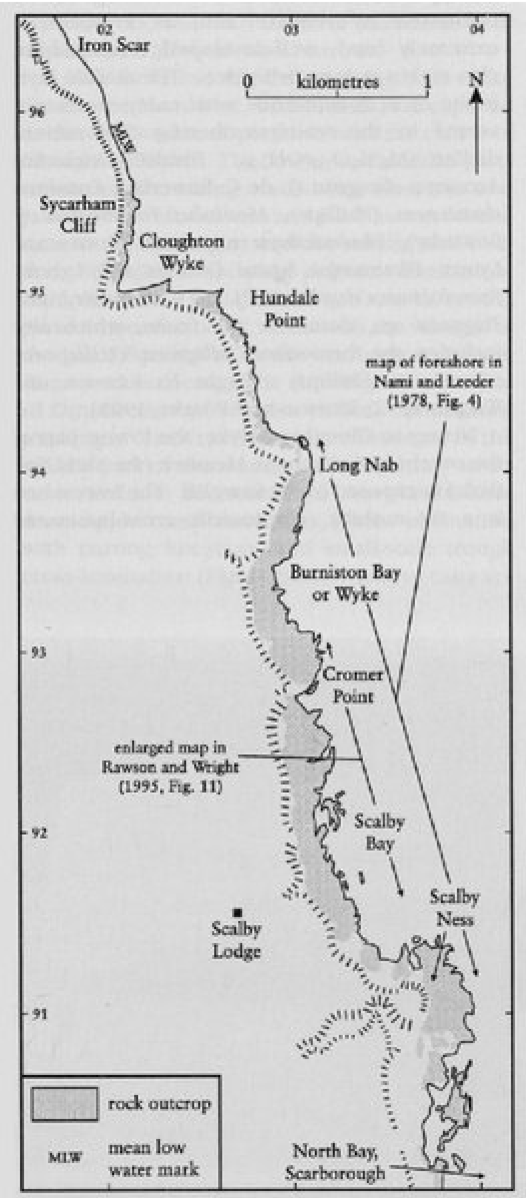
Dating of the succession is dependent on ammonite faunas in the Scarborough Formation and palynomorphs in the Scalby Formation. The age of the exposed succession is constrained by reliable dating elsewhere of the Dogger Formation as Aalenian in age (Opalinum–Murchisonae zones) and the Cornbrash Formation as Early Callovian in age (Herveyi Zone, Terebratus Subzone). The only well-dated horizon within the Ravenscar Group is the Scarborough Formation where species of the ammonite *Dorsetensia* from the Ravenscar Shale Member include *D.* aff. *deltafalcata* (*Quenstedt*)*, D. liostraca* S.S. Buckman and *D. romani* (Oppel) indicative of the Lower Bajocian Humphriesianum Zone, Romani Subzone. The highest part of the member has yielded *Stephanoceras* and *S.* (*Normannites*) suggestive of the Humphriesianum Zone and Subzone. Specimens of *Teloceras* cf. *acuticostatum* Weisert and *T.* cf. *lotharingicum* Maubeuge in the White Nab Ironstone Member indicate a higher level of the latter zone and sub-zone (Parsons, 1977b; Gowland and Riding, 1991).

Palynological data (dinoflagellate cysts) suggest that the Moor Grit and basal Long Nab members of the Scalby Formation are of latest Bajocian to Bathonian age. Those recovered from the upper part of the Long Nab Member inland indicate the Bathonian Stage (Riding and Wright, 1989). The current view is that the Scalby Formation probably represents a long period of very interrupted sedimentation spanning much of late Bajocian and Bathonian times.

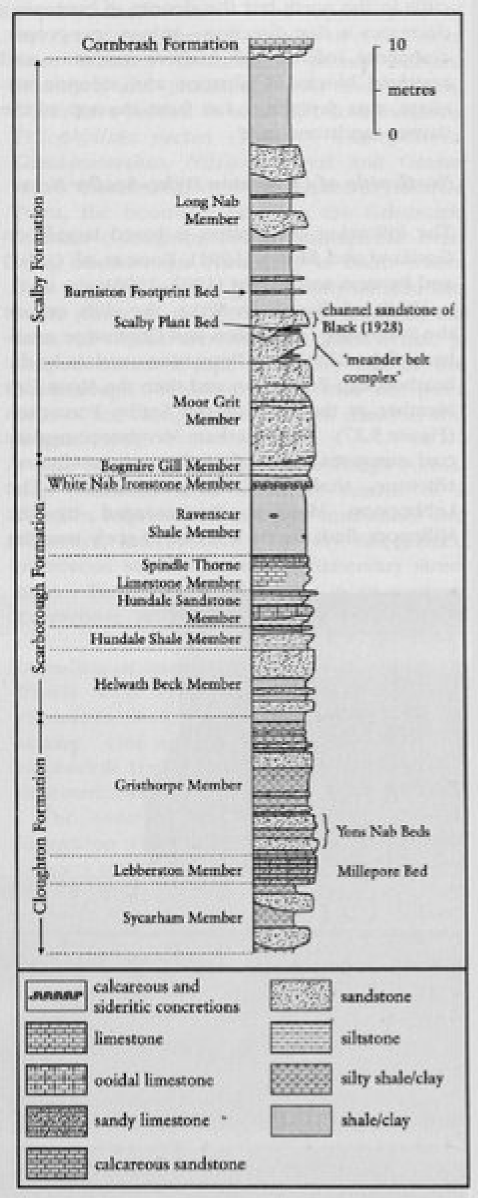
Conclusions

The coastal exposures of the two GCR sites (Iron Scar–Hundale and Hundale Point–Scalby Ness) include the type localities of the Eller Beck, Cloughton, Scarborough and Scalby formations, and some of their constituent members. They are thus important reference sections for the Cleveland and North Sea basins. The spectacular sedimentary features seen in these exposures bear witness to a Mid Jurassic environment in which small prograding deltas, deposited by rivers flowing southwards, periodically coalesced into a large coastal alluvial-plain close to sea level. These exposures, more than any others, have played a vital role in providing analogues for the oil-bearing Middle Jurassic strata of the North Sea area.

[References](#)

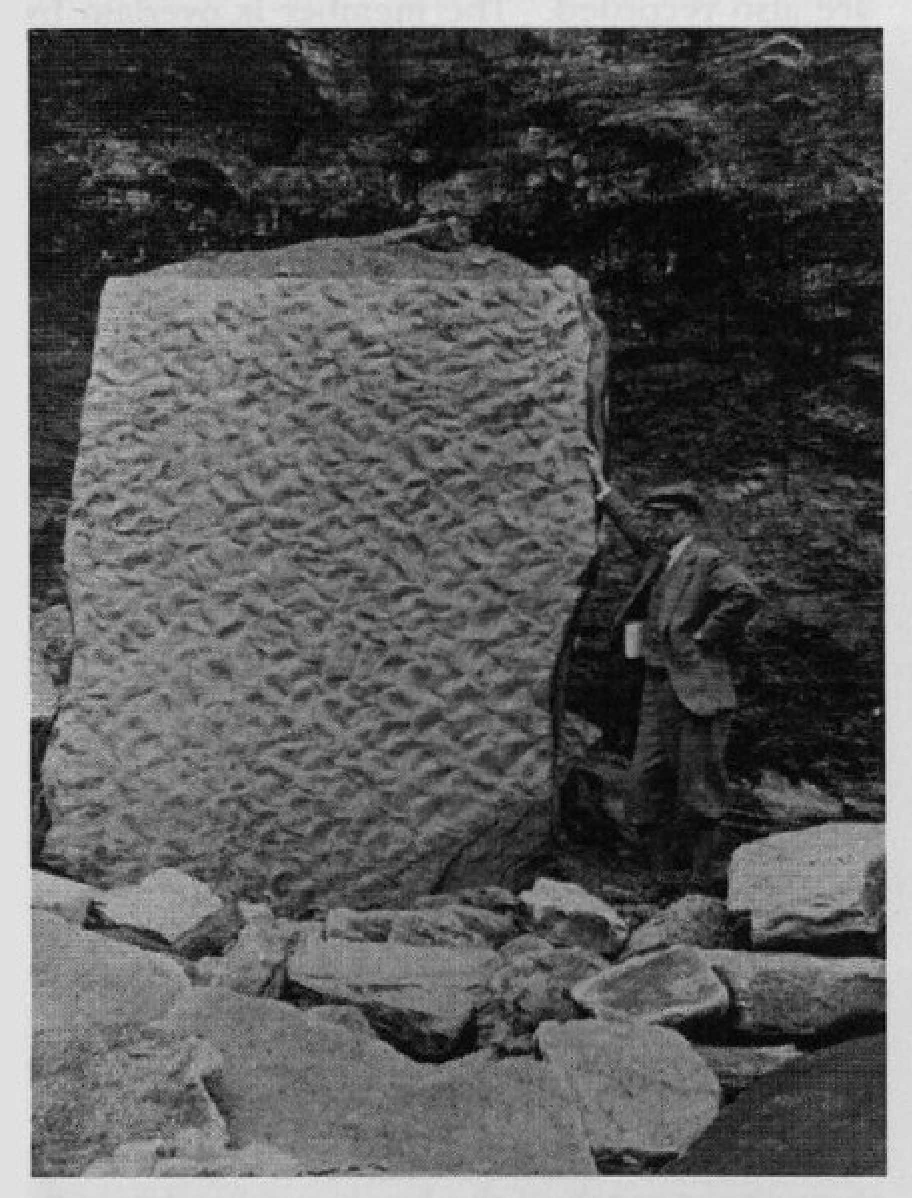


(Figure 5.25) Locality map for Iron Scar–Hundale and Hundale Point–Scalby Ness.)



(Figure 5.26) Graphic section of coastal exposures between Cloughton Wyke and Scalby Ness. (After Rawson and Wright, 1995, fig. 9.))

(Figure 5.27) Cloughton Wyke and cliffs from Hundale Point; the cliff in the foreground is Moor Grit Member, the reefs on the right Scarborough Formation. The reefs at the projecting headlands in the distance are formed by the Millepore Bed (Lebberston Member) and Eller Beck Formation. (Photo: British Geological Survey, No. A5494, 1931.))



(Figure 5.28) Ripple-marked sandstone (Gristhorpe Member), north side of Cloughton Wyke. (Photo: British Geological Survey, No. A5497, 1931.))

(Figure 5.29) Dinosaur footprint in the Burniston Footprint Bed. (Photo: D.N. and J.K. Wright; reproduced with permission of the Geologists' Association.))

(Figure 5.30) Scalby Bay foreshore showing 'meander-belt complex' of the Long Nab Member. (Photo: J.K. Wright; reproduced with permission of the Geologists' Association.))