Excursion 10 Southerness To Borron Point: Lower Carboniferous of the Solway Basin

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OS 1:50 000 Sheet 84 Dumfries, Castle Douglas & surrounding area

BGS 1.50 000 sheets 5E Dalbeattie, 6 (Annan)

Route maps: (Figure 35) and (Figure 36)

Main points of interest Lower Carboniferous stratigraphy and structure; limestones, sandstones and siltstones. algal beds, shallow marine fossils and trace fossils.

Logistics This coastal itinerary begins at Southerness, reached via a minor road from the A710 between New Abbey and Dalbeattie. Parking for large coaches is available only at Southerness, from which Localities 1–4 (Figure 35) can be visited. At low tide, it is possible to walk 2.5 km north-eastwards from Southerness across the sandy Gillfoot Bay to Powillimount to reach Localities 5–10, (Figure 36). Alternatively, cars and minibuses only can be parked at the shore beyond Powillimount Farm for Localities 5–10. For the best appreciation of the sections, the shore should be walked at low tide. Total return walking distance (excluding the optional crossing of Gillfoot Bay) is about 1 km at Southerness and 5 km from Powillimount to Hogus Point. As with all coastal sections, the rocks may be wet and slippery.

Introduction

Lower Carboniferous rocks of Dinantian age are well exposed along the Southerness shore and between Powillimount and Borron Point. Unlike the strata which lie close to the North Solway Fault (as at Rockcliffe, Excursion 3) the sections at Southerness are representative of a wide range of depositional environments from fluviatile to open shallow marine conditions.

The rocks contain a rich macrofossil assemblage which enables them to be correlated with the equivalent Lower to Upper Border Group strata of the Langholm district, ranging in age from Courceyan to Asbian (Table 1). They have been described in detail by Craig (1956) and Deegan (1970).

The oldest strata, the Kirkbean Cement-stone Formation, are found in scattered inland exposures on the south flanks of Criffell, notably in Kirkbean Glen [NX 975 591], where they rest partly on a thin development of basaltic lavas (Birrenswark Volcanic Formation) and partly on Upper Old Red Sandstone strata; this sequence rests with marked angular unconformity on Silurian turbidites. Access to the Kirkbean section *is* unfortunately restricted and this excursion concentrates on the younger rocks exposed at the coast.

1 Southerness shore: Southerness Limestone Formation

Cars and coaches may be parked at Southerness village [NX 977 543]. From there proceed on to the foreshore by the old lighthouse and walk west for 0.4 km to the faulted eastern boundary of the Southerness Limestone Formation (Locality 1 a, (Figure 35)). The type section (Craig 1956) of the Southerness Limestone Formation occupies a 0.3 km stretch of coast from here to a gently NNE-plunging anticline (Locality 1b). Localities 2 and 3 are specific points of interest within the type section which exposes some 135 m of fossiliferous, thinly bedded calcareous mudstones, siltstones and limestones. At least four prominent thick beds of sandstone are present. Easterly dips vary from 5 to 45°.

Although a number of east—west faults displace the strata, a reasonably complete section across the east limb of the anticline can be measured (Deegan, 1970). In the upper part of the formation Deegan identified three sedimentary cycles ranging in thickness from 8 to 15 Prominent algal horizons are developed at similar positions in two of the three cycles. An idealised cycle may be summarised as follows:

- Flaggy sandstone with plant remains
- Interbedded limestone and micaceous mudstone
- Interbedded limestone and calcareous mudstone
- Nodular algal band
- Thin muddy limestone with calcareous mudstone
- Fine-grained rippled sandstone
- Flaggy micaceous sandstone with ripple marks and plant remains

The cyclicity reflects varying depositional environments and may be attributed to gradual subsidence combined with variations in terrigenous sediment input possibly related to periodic dip-slip movement on basinal bounding faults. Each cycle commences with sandstones, probably deposited in a littoral environment, which are succeeded by calcareous beds formed under shallow subtidal conditions. Sandy limestones containing ooliths indicate that the sediments were affected by wave action. However, the algal beds show little sign of reworking and probably represent slightly deeper water sedimentation below the wave base. A traverse of the shore section enables the cyclicity identified by Deegan to be followed. Specific highlights include the Syringothyris Limestone (Craig, 1956) and algal beds.

2 Syringothyris Limestone

A good exposure of the *Syringothyris* Limestone, estimated by Craig (1956) to be 16.7 m thick, is seen some 600 m west of the lighthouse (Locality 2, (Figure 35)). The limestone comprises several beds of argillaceous limestone and calcareous mudstone, and contains a varied marine fauna of brachiopods including *Syringothyris cuspidata,* bivalves, polyzoa and crinoid ossicles. Faunal similarities with the Harden Beds of Langholm were noted by Lumsden et al. (1967) and indicate that the Southerness Limestone Formation probably spans the boundary between the Lower and Middle Border Groups of Langholm (Table 1).

3 Algal stromatolite beds

Above the Syringothyris Limestone, about 550 m west of the lighthouse, two distinctive algal stromatolite bands, 1.2 m and I m thick, are present within the sequence. Craig (1956) and Failicher (1977) referred the stromatolites to the genus *Somphospongia.* They resemble the dome type described by Leeder (1975) from the Lower Border Group of the Northumberland Basin. Individual domes are up to 30 cm in diameter with a relief of 10 to 15 cm and are set in a calcareous mudstone matrix. They are composed of alternating micritic and detrital laminae. Calcareous algal filaments commonly wrap fragments of shell including gastropods and ostracods. The irregular, nodular xterior of the algal growths indicates limited reworking. Basing his observations on studies of modern stromatolites, Leeder (1975) inferred that domed types formed in a low intertidal to shallow sub: tidal depositional environment.

4 Southerness Lighthouse: Gillfoot Sandstone Formation

Walk back towards Southerness, across the fault (Locality la) which downthrows east and brings the Gillfoot Sandstone Formation in against the Southerness Limestone Formation.

Between 120 and 150 m of strata assigned to the Gillfoot Sandstone Formation are exposed on the shore between here and a position south of Powillimount Farm [NX 9880 5620]. The formation conformably overlies the Southerness Limestone Formation, and Craig (1956) placed the top of the formation at the base of a breccia forming the base of the succeeding Powillimount Sandstone Formation (Locality 5).

The Gillfoot Sandstone Formation comprises white and purplish, flaggy, quartzose sandstones; conglomerates with intraformational fragments; red flaggy siltstones; and mudstones. A few red to grey, thin-bedded, sandy limestones with scattered detrital fossil remains are also present. Conglomerates, which form about 20 per cent of the succession, have a calcareous matrix and contain intraformational fragments in addition to pebbles of vein quartz, greywacke and microdiorite derived from the Southern Uplands hinterland to the north. Some more feldspathic layers are dominated by

microdiorite and felsic rock debris derived from Lower Palaeozoic minor intrusions.

The formation is sparsely fossiliferous. A derived fauna, collected by Craig from thesandstone on which the lighthouse stands, suggests that the strata are of Arundian age and equivalent to part of the Middle Border Group of Langholm (Lumsden et al., 1967).

The lithologies indicate a more marginal depositional setting than that of the underlying formation. The conglomerates may have been transported from the hinterland and deposited by periodic sheetfloods flowing over low-lying supratidal areas. Textures in some of the sandstones indicate wave action and a littoral environment. Shallow subtidal environments may be indicated by the presence of thin fossiliferous, sandy limestones.

5 Powillimount Shore: Powillimount Sandstone Formation

Access to the Powillimount shore is via the road which links Powillimount Farm with the Kirkbean to Southerness road. A small car park at the shore beyond the farm (Figure 36) is suitable for cars and minibuses only. Immediately below the car park some 160 m of strata exposed on the shore between Powillimount Bay [NX 9880 5610] and Thirlstane [NX 9925 5690] are assigned to the Powillimount Sandstone Formation. The top 25 m are distinguished as the Thirlstane Sandstone Member, a prominent ridge of thick-bedded sandstone with spectacular penecontemporaneous deformation structures (Craig, 1956; Deegan, 1970; Ord et al., 1988).

The base of the Powillimount Sandstone Formation is drawn a short way SW of the car park, at the base of a grey calcareous breccia, above the highest bed of purple mudstone in the Gillfoot Sandstone Formation. The strata form part of the SE limb of a major NE-trending anticline and on the coast are further folded about a tight, gently plunging syncline—anticline pair, the axial planes of which trend NNE. Faunal assemblages are similar to those in the Middle Border Group of Langholm. Aspects of the fauna immediately below the Thirlstane Sandstone resemble those of the overlying Arbigland Limestone Formation.

Lithologies include calcareous and quartzose sandstone, sandy limestone with beds of dark grey fissile mudstone, and calcareous mudstone. Locally, thin coals and associated seatearths are present. Sandstone beds are laterally extensive, ranging in thickness from 0.3 to 3 m. They are well sorted and commonly exhibit ripple cross-lamination. Many contain abundant carbonaceous plant remains and are extensively burrowed, particularly by *Chondrites.* Limestones range from arenaceous to argillaceous and contain detrital fossil remains, ooliths and rolled algal nodules. One distinctive oncolite bed, 0.3 m thick, contains rounded algal-coated lithic and fossil fragments. The individual oncolites are generally spherical and up to 1 cm across. Oncolites are produced by the accretion of sediment on to mobile grains through the action of algae, and their presence indicates constant agitation of the sea floor by wave action.

The characteristic lithologies, especially rolled algal nodules and detrital fragments, point to a shallow-marine environment exposed to gentle wave action. Deegan (1970) proposed that the sediments were deposited in a tidal lagoon protected from the effects of severe storms by some form of offshore sand barrier. The presence of thin coals and seatearths indicates periodic shallowing of lagoonal waters and the development of vegetated low-lying supratidal flats.

6 Thirlstane natural arch: Thirlstane Sandstone Member

Walk about 50 m NE from the car park to a prominent sandstone ridge [NX 991 565] which can be followed to beyond the Thirlstane natural arch. The ridge is formed by the 25 m-thick Thirlstane Sandstone Member. At the base of the Thirlstane Sandstone the contact with the underlying strata is irregular, and intraformational fragments and large plant remains are present in the lowest beds. The fine natural arch at Thirlstane and nearby exposures to seaward display various sedimentary structures in a pinkish grey, medium-grained, well-sorted, quartzose sandstone. The rocks are characterised by large-scale trough cross-bedding and a spectacular development of liquefaction structures which increase in frequency and magnitude from south to north along the outcrop. It is worthwhile examining the extraordinary degree to which the original bedding has been disrupted. In a detailed study of these structures Ord et al. (1988) recognised different types of structure including oversteepened and recumbently folded cross-stratification, domes, sand

volcanoes and zones of anastomosing, vertical cracks. They attributed the magnitude and frequency of the liquefaction structures to causes such as local seismicity, and deduced the presence of a syndepositionally active fault lying north of the present outcrop.

Deegan (1970) proposed that the Thirlstane Sandstone formed as an offshore sand barrier which initially enabled the inshore lagoonal environment of the Powillimount Sandstone Formation to develop. The evidence is equivocal, however and, as Ord et al. suggest, an alluvial origin is also a possibility.

7 Thirlstane to Arbigland Garden: Arbigland Limestone Formation

All the strata exposed between Thirlstane (Locality 7) and Hogus Point [NX 997 589] (Locality 10) are assigned to the Arbigland Limestone Formation, estimated to be some 300 m thick (Craig, 1956). The conformable junction between the Thirlstane Sandstone Member and the Arbigland Limestone Formation (noted by Smith, 1910) is often obscured by shifting sands; the most obvious contact is a normal fault, (Locality 7) 200 m NE of the Thirlstane natural arch [NX 993 569]. The fault plane appears to have a reverse throw and may have been rotated through vertical. Between this fault and an ESE-trending hinge fault opposite Arbigland Garden, the strata strike parallel to the coast. North of the second fault a narrow zone of disrupted bedding is succeeded by a series of beds striking ESE. Perched prominently on these is a huge erratic block of Criffell granodiorite known locally as the 'Devil Stone'. Tradition has it that the Devil bit off this chunk of Criffell and spat it out on the shore. Conventional glacial theory would suggest that the block was eroded and transported to its present position by a glacier during the last ice age.

The lithologies of the lower part of the Arbigland Limestone Formation resemble those of the Powillimount Sandstone Formation. Key features to look out for include thick-bedded, bioturbated, calcareous sandstones with coalified plant casts, thin sandy limestones locally with ooliths and algal debris, dark grey carbonaceous mudstones, and thin coal partings.

8 Arbigland Bay to Borron Point: Arbigland Limestone Formation and pericline

Walk from the Devil Stone across the sandy Arbigland Bay. Diversions from the geology here include the fine gardens of Arbigland House, built by William Craik in 1755, and Paul Jones Cottage, where John Paul Jones (1747–92), founder of the American Navy, was brought up. The gardens may be visited (vehicular access from the Kirkbean to Southerness road) on certain weekdays.

North of the bay a small, shallow, periclinal basin structure is present (Locality 8). North of here the strike of the strata swings from east–west through ENE to NE, to become subparallel with the line of the coast around Borron Point [NX 995 580]. The strata are cut by numerous normal faults of ESE and SE orientation.

9 Arbigland Bay to Borron Point: faunal assemblages and sedimentary features of the Arbigland Limestone Formation

A traverse of the shore between Arbigland Bay and Borron Point is worthwhile for anyone with an interest in the sedimentology and faunal characteristics of shallow marine shelf sediments. The strata here were termed by Deegan (1970) the Middle Arbigland Beds. They are richly fossiliferous and contain a fine compound rugose coral fauna including spectacular massive hemispherical colonies of *Lithostrotion clavaticum,* first recorded by Smith (1910). Some are in life position with individual corallites visible on the upper surface. Overturned colonies show only the outer walls of the corallites radiating from the central columella. Please do **not hammer them out.**

Deegan (1970) described the strata below McCulloch's Castle [NX 996 577] (Locality 9) as mainly thin argillaceous and sandy limestones interbedded with calcareous mudstones and several prominent thick beds of massive bioturbated sandstone. Many beds of sandstone and sandy limestone have been extensively and repeatedly reworked by sediment feeders, and burrow forms such as *Chondrites, Diplocraterion* and *Rhizocorallium* are commonly seen. The limestones and mudstones have an abundant and diverse fauna including corals, brachiopods, bivalves, gastropods, crinoids,

bryozoa and orthocones. Faunal equivalence with the Upper Border Group of Langholm (Lumsden et al., 1967), of Asbian age, is considered most likely. In the Langholm district, the Glencartholm Volcanic Beds form the base of the Upper Border Group and these rocks have been equated with the Clattering Band of Bewcastle (Day 1970) which George et al. (1976) place at the base of the Asbian. It follows that if correlation of the Middle Arbigland Beds is extended to the Clattering Band then the lower part of the Arbigland Limestone Formation (Locality 7) is probably Holkerian (as noted by George et al.).

At Borron Point stratigraphically higher rocks are downthrown by two small faults. Here the strata are steeply inclined and locally overturned. The sequence is characterised by thick-bedded bioturbated sandstone, and ripple cross-laminated fine-grained sandstone interbedded with calcareous mudstone and a few argillaceous limestones. Shallow sandstone-filled scours and washouts are common.

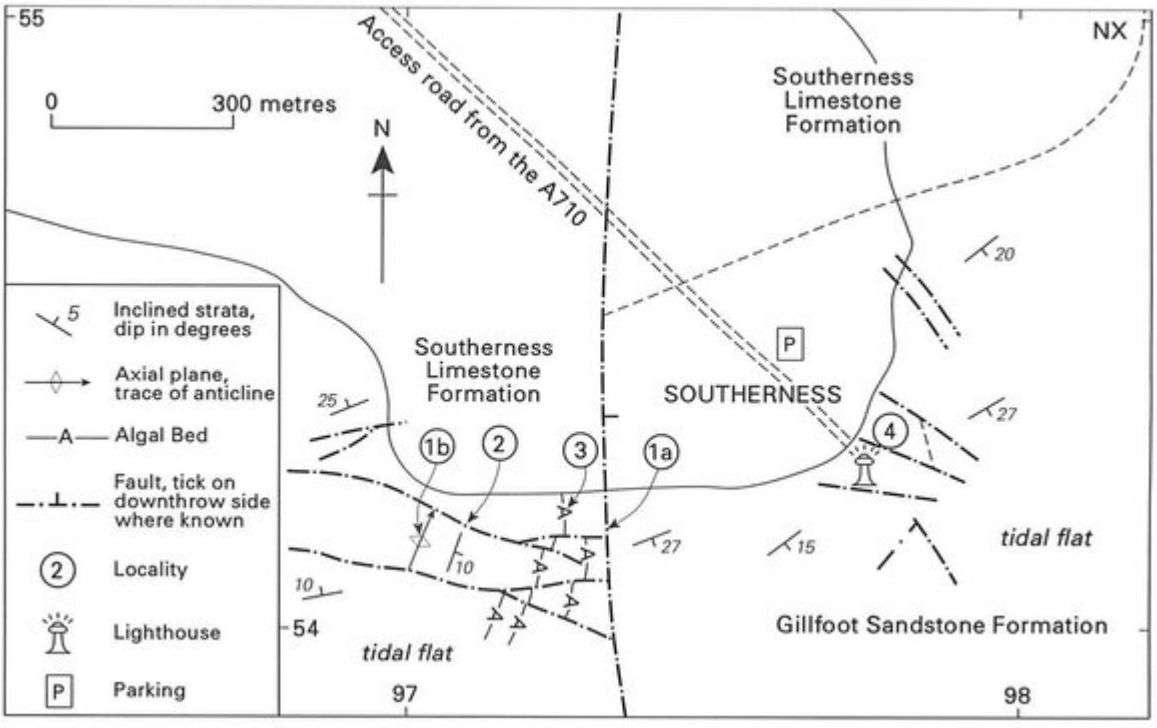
10 Hogus Point: northernmost exposures of the Arbigland Limestone Formation

Those who wish to visit the northernmost exposures of the formation at Hogus Point [NX 997 588] should continue along the shore north from Borron Point. Alternatively the excursion can be completed at Borron Point and the route retraced to Powillimount Farm.

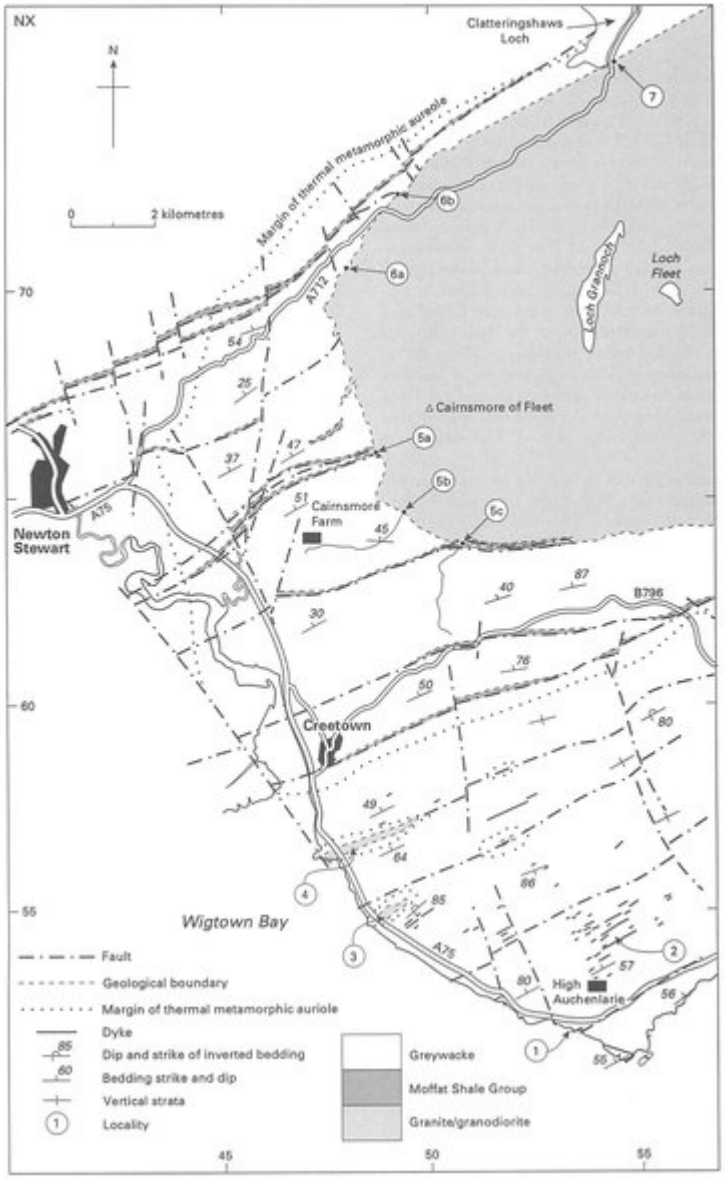
The strata at Hogus Point are reasonably well exposed. They are disposed about a tight, gently NE-plunging anticline—syncline fold pair. The rocks comprise thick units of thin-bedded silty, calcareous mud-stone, well-bedded sandstone and thin-bedded sandy limestone. Although Craig (1956) considered the strata at Hogus Point to be the highest in the sequence, a fauna collected more recently indicates a position no higher than the beds lying south of Borron Point. The indications are that the rocks lie on the upthrow side of a SE-orientated normal fault, the trace of which may lie north of Tallowquhairn Farm [NX 993 584].

Lithological characteristics of the sequence between Thirlstane and Arbigland Garden together with the sparse, locally detrital, fauna are consistent with a restricted lagoonal environment in which there was limited reworking of sediment. Overall, however, the Arbigland Limestone Formation was probably deposited within the intertidal to subtidal zone. An open, shallow-marine environment is indicated by the abundant fauna in the Middle Arbigland Beds (Deegan, 1970).

References



(Figure 35) Locality map and outline geology for the Southerness shore section (Localities 1–4).



(Figure 36) Locality map and outline geology for the shore section between Powillimount and Hogus Point (Localities 5–10).

<table>
<tr><th colspan="2">Age</th><th>Langholm (after Lumsden et al., 1967)</th><th>Kirkbean Glen (after Craig, 1956; BGS, 1993)</th><th>Southerness–Borron Point–Hogus Point (after Craig, 1956; BGS, 1993)</th><th>Castlehill Point–Gutcher's Isle (after BGS, 1993)</th></tr>
<tr><td rowspan="8">Dinantian (Lower Carboniferous)</td><td>Brigantian</td><td>Upper Liddesdale Group</td><td rowspan="8"></td><td rowspan="3">?
Arbigland Limestone Formation</td><td rowspan="8"></td></tr>
<tr><td rowspan="3">Asbian</td><td>Lower Liddesdale Group</td></tr>
<tr><td>Upper Border Group</td></tr>
<tr><td>Glencartholm Volcanic Beds</td></tr>
<tr><td rowspan="2">Holkerian</td><td rowspan="3">Middle Border Group</td><td>Thirlstane Sandstone Member</td><td>?</td></tr>
<tr><td>Powillimount Sandstone Formation</td><td rowspan="2">Rascarrel Formation</td></tr>
<tr><td rowspan="2">Arundian</td><td>Gillfoot Sandstone Formation</td></tr>
<tr><td>Harden Beds</td><td>Southerness Limestone Formation</td></tr>
<tr><td rowspan="2">Chadian</td><td rowspan="2">Lower Border Group</td><td>Syringothyris Limestone</td><td rowspan="2">?</td><td rowspan="2"></td></tr>
<tr><td>?
Kirkbean Cementstone Formation</td><td>?</td></tr>
<tr><td>Courceyan</td><td colspan="2">Birrenswark Volcanic Formation</td><td></td></tr>
<tr><td colspan="2">Late Devonian</td><td colspan="2">Upper Old Red Sandstone</td><td></td><td></td></tr>
<tr><td colspan="2">Silurian</td><td>Riccarton Group</td><td>Hawick Group</td><td></td><td>Hawick Group</td></tr>
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This table does not show relative thickness of different groups, formations and members.

(Table 1) Lower Carboniferous stratigraphy correlated along the northern margin of the Solway Basin.