Silurian sedimentary succession, Girvan–Ballantrae district

Introduction

At Girvan, the base of the Silurian succession rests with gentle unconformity on Ordovician strata in the coastal section to the south of the town, and in the Craighead Inlier to the north-east. At Woodland Point, on the coast, the angle of unconformity is about 8° and a significant part of the Ordovician Ashgill succession (the entire Drummuck Subgroup) is missing. In the Craighead Inlier the stratigraphical break is smaller but the unconformity is a little more abrupt. All of the Silurian strata are encompassed by the Girvan Group. The succession arose from two major shallow- to deeper-water transgressive cycles during the Llandovery, followed by a marine regression during the early Wenlock. This depositional pattern is reflected by the arrangement of the Girvan Group’s three subgroups: Newlands, Dailly and Straiton. The lowest of these, the Newlands Subgroup, contains all of the units in the first of the major transgressive cycle and crops out in three distinct areas: in the coastal section, in the inland part of the Main Outcrop, and in the Craighead Inlier; there are subtle differences in lithofacies between the three areas. Strata deposited during the second of the major transgressive cycles make up the Dailly Subgroup which is fully developed in the inland part of the Main Outcrop, but elsewhere has only its basal division preserved in the Craighead Inlier. At the top of the Girvan Group, the Straiton Subgroup occurs only inland within the Main Outcrop and includes the strata deposited during marine regression and the transition to terrestrial conditions. A rich shelly fauna is preserved at a number of stratigraphical levels throughout the succession, with brachiopods and trilobites well represented (Plate 11).
Girvan coastal section

All of the Silurian strata in the coastal section lie within the Newlands Subgroup. The Craigskelly Conglomerate Formation is the oldest unit seen and rests on strata of the Ordovician Shalloch Formation with slight unconformity. It is a coarse conglomerate, variably clast- to matrix-supported, and contains interbedded sandstone lenses (P005981). The range of clast compositions is broadly similar to that seen in the Ordovician conglomerates occurring lower in the sequence. Radiometric (U-Pb) dating of detrital zircon crystals from the interbedded sandstone shows a largely bimodal population: Early Ordovician and Mesoproterozoic. The Craigskelly Conglomerate is succeeded by the Woodland Formation. This division features a basal member of massive, carbonate-rich sandstone beds that contain a shelly fauna of brachiopods and trilobites, a middle, more thinly bedded member, and an upper member of siltstone and graptolitic mudstone; the graptolites establish the revolutus (known until recently as cyphus) Biozone.

There is then a return to a coarse clastic facies in the overlying Scart Grits Formation, the youngest Silurian unit seen on the coastal section. It consists of massive, coarse-grained turbidite sandstone beds, with a distinctive quartz-pebble conglomerate at the base (the Quartz or Cow Rock Conglomerate) that has disturbed and channelled into the underlying strata of the Woodland Formation. The quartz-rich character of the conglomerate stands in marked contrast to the compositions of the conglomerates lower in the sequence.

Craighead Inlier

Newlands Subgroup

In the Craighead Inlier, the basal unit is the Mulloch Hill Conglomerate Formation, a grey-buff polymict rudite containing well-rounded pebbles but with a mid section dominated by sandstone showing hummocky cross-stratification. This feature suggests deposition in a relatively shallow environment within reach of storm wave base, a conclusion reinforced by the presence of a sparse, low-diversity shallow-water shelly fauna of crinoids and brachiopods. The conglomerate grades up into the overlying Mulloch Hill Sandstone Formation, a sequence of grey-green sandstone, with siltstone and mudstone interbeds, which features hummocky cross-stratification in its lower part. It contains a diverse shelly fauna that is indicative of a shallow-water environment for much of the formation, but suggests a change to deeper water conditions towards the top. The Mulloch Hill Sandstone is succeeded in turn by the interlaminated siltstone and mudstone of the Glenwells Shale Formation, which may be turbiditic in origin. The lower part of the formation mostly comprises calcareous siltstone, whilst the upper part contains graptolitic mudstone proving the revolutus Biozone.

Another conglomeratic unit, the Glenwells Conglomerate Formation, overlies the Glenwells Shale. The Glenwells Conglomerate is very coarse-grained and poorly sorted, with clasts over 8 cm in diameter, and contains sporadic interbeds of coarse sandstone. It probably originated as a channel-fill deposit in a deep-water, submarine fan setting. The conglomerate is succeeded by the Newlands Farm Formation, an ochreous-weathering unit of blue-grey calcareous siltstone and thinly bedded sandstone containing a rich and well-documented shelly fauna interpreted as a deep shelf community. Graptolitic, blue-grey mudstone follows and comprises the Glenshalloch Shale Formation, the graptolites indicating the magnus and possibly the leptotheca biozones, before a return to coarse sandstone comprising the Saugh Hill Grits Formation. In this unit, the constituent strata are greenish grey turbidites with a few thin mudstone interbeds and sporadic layers of pebble conglomerate. Overlying the Saugh Hill Grits, and at the top of the Newlands Subgroup, is the
graptolitic mudstone of the Pencleuch Shale Formation, the graptolites proving the *convolutus* Biozone and possibly the *sedgwickii* Biozone.

**Dailly Subgroup**

In the Craighead Inlier, only the lowest unit of the Dailly Subgroup is preserved at outcrop. It comprises the red-stained sandstone of the Lower Camregan Grits Formation, which contains a sparse brachiopod fauna. Exposure of this unit is very limited at Craighead, and its character is best described from the more extensive development in the Main Outcrop.

**Main Outcrop**

**Newlands Subgroup**

The Newlands Subgroup succession in the Main Outcrop is slightly less varied than in the Craighead Inlier, so that only three formations are recognised, roughly correlating to six or Newlands seven at Craighead ([P912323](#)). The lowest part of the subgroup to be seen at outcrop, the Tralorg Shale Formation, comprises a range of mudstones, some brown, some grey-green, some black and graptolitic with a fauna indicative of the *revolutus* Biozone. Brachiopods contained in concretions from the lower part of the sequence are of deep-water character. The Tralorg Shale Formation is faulted against Ordovician strata so that the stratigraphical base is not seen; it is succeeded abruptly by the Saugh Hill Grits Formation, which has a stratigraphically more extensive development than at Craighead ([P912323](#)). As there, the formation is made up of sandstone turbidites with thin interbeds of grey-green mudstone and sporadic conglomeratic layers. A conspicuous mudstone towards the middle of the formation has been separately defined as the Penwhapple Burn Shale Member, and can be tentatively correlated with the Glenshalloch Shale Formation which underlies the Saugh Hill Grits at Craighead. In the Main Outcrop, the proportion of mudstone increases towards the top of the Saugh Hill Grits Formation and graptolites recovered there prove the *triangulatus* or *magnus* biozones. Above the Saugh Hill Formation, and at the top of the Newlands Subgroup, lies the Pencleuch Shale Formation, a sequence of grey and black mudstone which is pyritic in its upper part and contains an abundant and diverse graptolite fauna. The graptolites are from the *gregarius*, *convolutus* and *sedgwickii* biozones, but their distribution suggests that this part of the succession has been tectonically shuffled.

**Dailly Subgroup**

Within the Main Outcrop, the Dailly Subgroup is made up of alternating formations dominated by either sandstone or mudstone. At the base, as in the Craighead Inlier, lies the Lower Camregan Grits Formation. It comprises medium- to thickly bedded turbidite sandstone with sporadic development of hummocky cross-stratification showing that deposition took place within storm wave base. A shelly fauna of shallow-shelf character is present at several levels, and though there is some evidence for this having been transported, such redistribution is likely to have been relatively local. The succeeding pale grey sandstone and siltstone of the Wood Burn Formation also features some examples of hummocky cross-stratification and contains shelly faunas, but in this case there is a stratigraphical variation in the fossils that suggests deepening shelf conditions. The Wood Burn Formation is abruptly succeeded by the distinctive purple mudstone of the Maxwellston Mudstone Formation. This unit was possibly deposited from distal, low density turbidite flows and contains graptolites indicative of the *guerichi* Biozone. There follows the Upper Camregan Grits Formation, comprising generally thickly bedded turbidite sandstone, and then the Penkill Mudstone Formation, a variable mudstone sequence with thin sandstone interbeds in the upper part. Graptolites are
abundant in parts of the Penkill Formation, and establish a stratigraphical level spanning the turriculatus and crispus biozones (P912323).

Continuing into the upper part of the Dailly Subgroup, the Protovirgularia Grits Formation conformably overlies the Penkill Mudstone; it is named after a distinctive trace fossil found therein. Thickly bedded turbidite sandstone dominates, with a few mudstone interbeds. One of the latter, near the top of the formation, carries graptolites that define the crispus-griestoniensis biozonal boundary. The succeeding Lauchlan Mudstone Formation is a sequence of red and purple, fissile sandstone and mudstone, with a few dark and pyritic mudstone interbeds. A sparse, deep-water brachiopod fauna has been recorded near the top of the formation, as have rare graptolites of the spiralis Biozone. The establishment of this biostratigraphical level is important since the overlying unit of fissile sandstone-mudstone turbidites, the Drumyork Flags Formation, has a similar graptolite fauna, and also an acritarch flora, which confirm that the top of the Drumyork Formation also lies within the spiralis Biozone. Thus, more than 600 m of turbiditic strata were deposited in a time interval equivalent to less than a single biozone (P912323), perhaps only half a million years or even less. In the succeeding Blair Shale Formation, a unit of thinly bedded grey to brown sandstone and mudstone, graptolites from the lower part of the formation confirm the spiralis Biozone. There is no faunal evidence for the age of the upper part of the Blair Shale, and the top is not seen since the formation is faulted against younger strata of the Straiton Subgroup.

**Straiton Subgroup**

The Straiton Subgroup occurs only in the north-east part of the Main Outcrop and includes two units recording marine regression and the onset of terrestrial deposition. The lower of the two units, the Knockgardner Sandstone Formation, is a sequence of thinly bedded, grey-green sandstone, laminated mudstone and siltstone, and sporadic thick sandstone beds. Some of the thick sandstones carry hummocky cross-stratification, indicating deposition within reach of storm wave base, and the relatively shallow depositional environment is confirmed by the presence of a brachiopod fauna of shallow shelf aspect. An early Wenlock age is suggested by the brachiopods and supported by a sparse acritarch flora. The Knockgardner Formation is succeeded by greenish, coarse-grained sandstone forming the lower part of the Straiton Grits Formation. This sandstone contains a sparse fauna of ostracods and bivalves, along with a low diversity acritarch flora, that suggests deposition in a very shallow marine or lagoonal to fresh-water setting. The upper part of the formation consists of unfossiliferous, coarse red sandstone and conglomerate with a clear terrestrial character. They are the youngest Silurian strata to be seen in the various Girvan outcrops and are unconformably overlain by Carboniferous beds of the Inverclyde Group.

**Bibliography**


