Largs Coast, North Ayrshire

[NS 191 633]–[NS 192 619]

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Introduction

The section of Late Devonian rocks on the west coast of Scotland north of Largs (Figure 3.41) is an important GCR site for understanding the internal structures of Upper Old Red Sandstone braided river deposits. Outcrops of intercalated pebbly sandstones and finer-grained sandstones with thin silty mudstone interbeds are well exposed along the shore. These rocks demonstrate the lateral and vertical facies variations and the scale of bar forms in a braided river channel, and the relationship of the bar forms to the river floodplain deposits.

The sedimentology and tectonic setting of the Largs section and others along the coast of the Firth of Clyde have been studied by Bluck (1967, 1978, 1980a,b, 1986, 1992, 2000). This account is based on Bluck's detailed analysis of the geometry of the sandbodies at the site. He is one of a group of workers who have made major advances in the understanding of Old Red Sandstone fluvial facies, sedimentary processes and environments by comparing the rocks with modern analogues.

The Upper Old Red Sandstone rocks north of Largs belong to the Kelly Burn Sandstone Formation of the Stratheden Group (British Geological Survey, 1990; Paterson *et al.,* 1990; Browne *et al*., 2002). The base of the Kelly Burn Sandstone Formation is transitional with the Skelmorlie Conglomerate Formation. Its top is a sharp, possibly disconformable junction with the Lower Carboniferous Kinnesswood Formation. The Late Devonian age of the Stratheden Group is constrained by a rare Fammenian fish fauna (Browne *et al.,* 2002), the Tournaisian age of the overlying Kinnesswood Formation (Browne *et al.,* 1999) and the Early Devonian age of the underlying Lower Old Red Sandstone.

The Midland Valley of Scotland is interpreted to have been delimited in Late Devonian times by the Highland Boundary Fault in the north and the Southern Upland Fault to the south, with a central, western high (Bluck, 1978; Browne *et al*., 1985). In the Firth of Clyde area, extensional half-grabens formed by sinistral strike-slip movement on the Highland Boundary Fault are thought to have controlled sediment dispersal and accumulation (Bluck, 1978, 1992). Sediments were laid down in these basins by river systems that flowed to the east and northeast on the north side of the Midland Valley (Bluck, 1978). The Largs site exposes finer-grained sedimentary facies that are distinct from the proximal, coarser conglomerates of the underlying Skelmorlie Conglomerate Formation (Bluck 1967, 1992; Browne *et al.,* 2002).

Description

The Largs coast section, 3 km WNW of the town of Largs, comprises approximately 300 m of cross-stratified sandstones, pebbly sandstones and conglomerates interbedded with planar bedded, fine-grained sandstones and thin silty mudstones (Figure 3.41). Together, these facies form upward-fining cycles 2–10 m thick (Bluck, 1980b, 1992). The sedimentary rocks are cut by several faults and numerous Tertiary felsic alkaline and dolerite dykes (British Geological Survey, 1990).

A typical cycle begins with coarse-grained, pebbly, cross-stratified sandstone that rests on an erosion surface cut in the underlying fine-grained sandstone. The coarse-grained sandstone is generally overlain by finer-grained sandstones with complex sedimentary structures, lateral facies variations and numerous internal erosion surfaces. Two examples of such cycles are described in detail.

Locality 1. West of Knock Castle [NS 1913 6303]

This outcrop (Figure 3.42) commences with an upward-coarsening unit 2.8 m thick resting on a basal erosion surface and comprising 0.5–1 m-thick beds of cross-stratified, pebbly sandstone. The foresets of the cross-stratification have a comparatively low spread of dip directions. Above this, a 4 m-thick, upward-coarsening unit consists of four facies that interfinger down-dip and have transitional boundaries. The facies are:

1. An eastward-thinning sandstone wedge with soft-sediment folding and re-folding structures.
2. A cross-stratified sandstone that thins to the east and has converging dips.
3. A sheet of upward-coarsening, coarse-grained, pebbly sandstone that caps the outcrop.
4. A coarse-grained sandstone of uncertain affinity.

Cross-bedding indicates a north-westerly palaeo-flow and the whole outcrop becomes finer-grained in that direction.

Locality 2. WNW of Quarter [NS 1917 6215]

Two groups of fades can be observed at this locality The lower group comprises alternations of planar sheets of sandstones and thin, subordinate, silty mudstones with desiccation cracks. The sandstones exhibit cross-stratification, low-angle cross-stratification and parallel lamination, and locally rest on erosion surfaces. These beds dip in the same direction as the coarser overlying group and have similar northeasterly palaeocurrents.

An erosion surface separates the two groups. The basal part of the upper group comprises pebbly sandstones with large-scale cross-stratification that dips radially outwards. Smaller-scale cross-stratification migrates along and down the larger foresets. Above this, a mudstone bed grades laterally to the east and north into clay-rich sandstones and westwards into a wedge of pebbly sandstones. In turn, these partly interfinger with, and are overlain by, pebbly sandstones that form a tabular cross-stratified unit with much internal re-activation and ripple cross-lamination.

Interpretation

A key feature in the recognition of bar form in braided river systems is the upward coarsening of the sands from a sharp base, caused by the downstream migration of the coarse-grained head of the bar over the finer-grained tail (Muck, 1992; (Figure 3.43)). Also, braided pebbly alluvium has palaeocurrents that vary laterally and vertically and a fades distribution that indicates the influence of the bar form on river flow ((Figure 3.43); Bluck, 1980b; Miall, 1996). The Knock Castle section and the upper part of the Quarter section can be interpreted as different types of braided river-bar deposits. At the Knock Castle outcrop, the consistent dips and volume of coarse-grained, cross-stratified sandstones in the lower part are attributed to bedform deposition within a river channel (Bluck, 1980b). The upper part is interpreted as a mid-channel bar form, where the bar head (represented by the coarse-grained, pebbly sandstone sheet) migrated north-west over the bar tail (represented by the deformed sandstone; see (Figure 3.43)). The converging palaeocurrents in the cross-stratified sandstones towards the bar tail are observed on modern bar forms that have channels to each side (Bluck, 1980b, 1992). The variability of facies and palaeocurrents implies that the bar split the flow of the river and was subject to variations in water-level. The bar sequence thickens downstream and indicates a minimum water depth of about 3 m. The Knock Castle outcrop is therefore an overall fining-upward cycle interpreted as the growth of a mid-channel bar over an earlier mid-channel bedform (Bluck, 1980b).

At the outcrop WNW of Quarter, the structure and palaeocurrents of the lower pebbly sandstones indicate a linguoid bar within the river (Bluck, 1980b; (Figure 3.44), Stage 1). The fades arrangements and geometry in the upper part of the section suggest that the linguoid bar later acted as a lateral bar at least 1 m high, separated from the bank by an abandoned channel in which muds accumulated (Bluck, 1980b; (Figure 3.44), Stage 2). During flood events, the lateral bar acted as a 'chute bar' when the river flowed across it. The direction of bar migration, as indicated by the sandstone sheets, was normal to the general flow of the river (Figure 3.44). In addition to the bar facies, the lower part of the Quarter section, comprising finer-grained, planar sheet-like sandstones and thin mudstones, is interpreted as the deposits of a floodplain that was periodically subaerially exposed (Bluck, 1980b). The sandstones were ripple-topped, lobate sand sheets deposited by decelerating flows. Palaeocurrents suggest that the sheet flooding occurred on a broad flood-plain, with flows in the same direction as the channel and no levees to the channel. Preservation of fine lamination

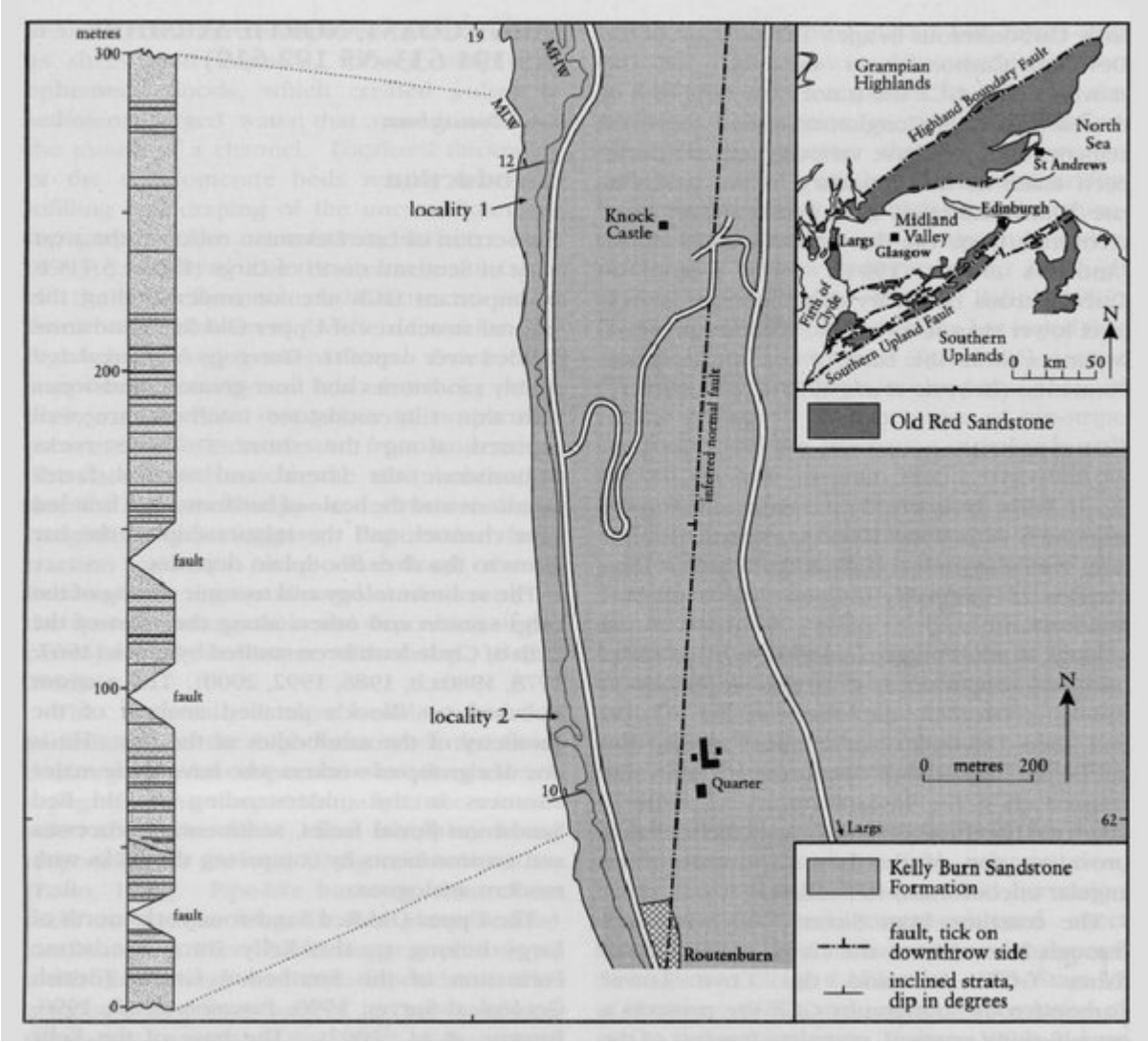
and the lack of iron reduction suggest that that the floodplain had a meagre plant cover or was unvegetated (Bluck, 1980b).

The sedimentary rocks of the Largs section occur in fining-upward cycles with sharp, basal erosion surfaces, and are interpreted as the deposits of a braided river system (Bluck, 1967). The cyclicity is thought to result from the migration of the active river channel over the floodplain. The overall dip of cross-stratification implies flow to the north-east, but the accretion directions of bars and bedforms are commonly to the north-west. The Largs site is therefore interpreted to have been at the north-west margin of a 'cone' of sediment prograding to the ENE (Bluck, 1980b).

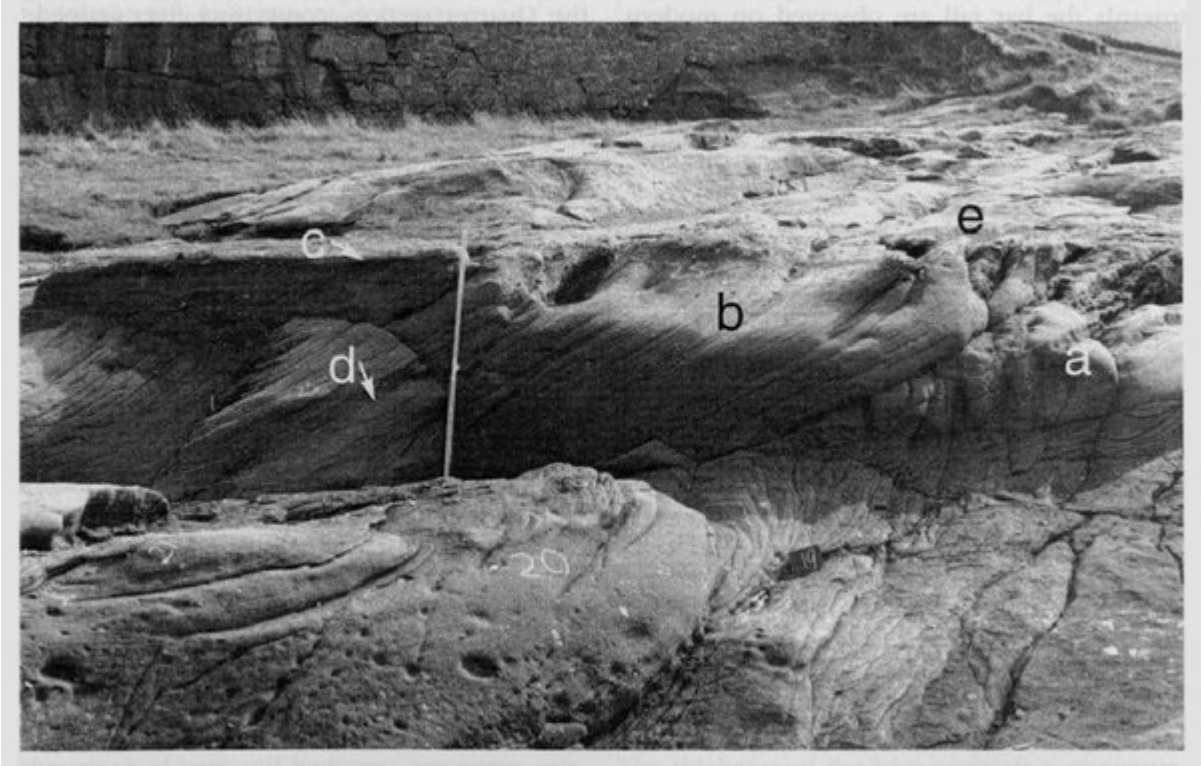
Conclusions

The well-exposed Largs Coast GCR site is a key locality for observing and understanding the typical three-dimensional structures and processes of sediment deposition in an ancient braided stream system. Detailed sedi-mentological study at the site has allowed the reconstruction of a braided river system subject to changing water-levels and channel switching. Of the two sections discussed in detail, one illustrates the change from a channel bedform to a migrating mid-channel bar, and the other shows the transition from a linguoid mid-channel bar to a lateral bar at the side of the river channel (Figure 3.43), (Figure 3.44). Floodplain deposits are identified between the barforms. The thickness of the bars suggests a minimum water depth of 1–3 m at this locality.

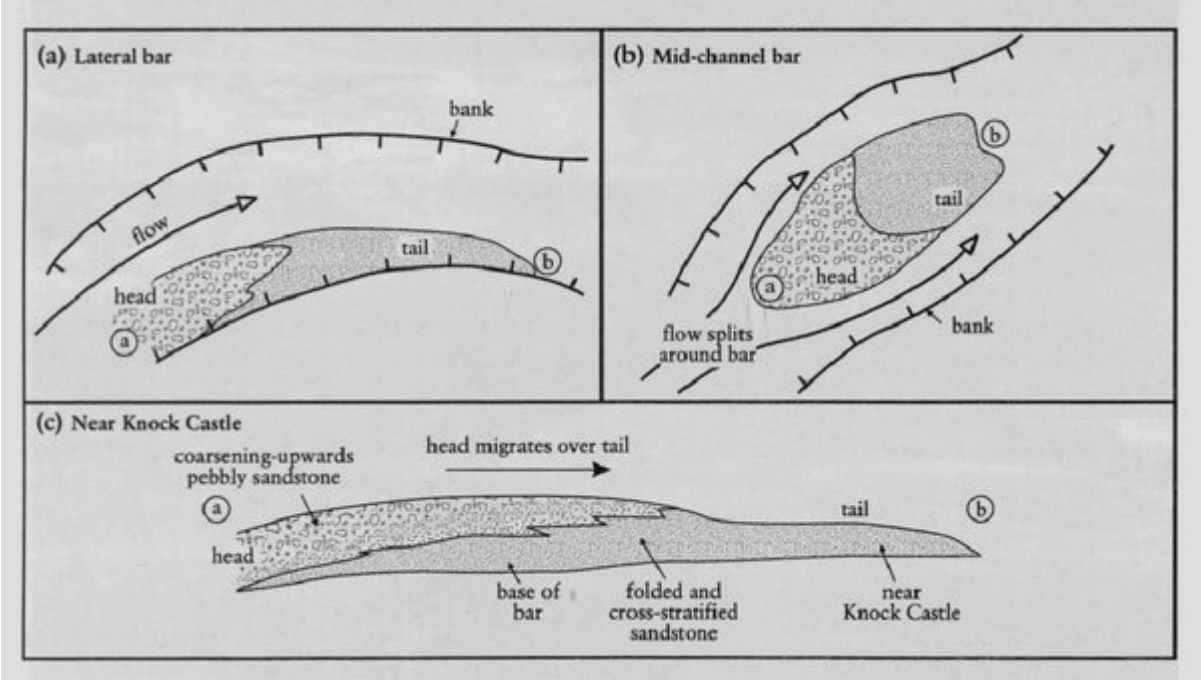
References



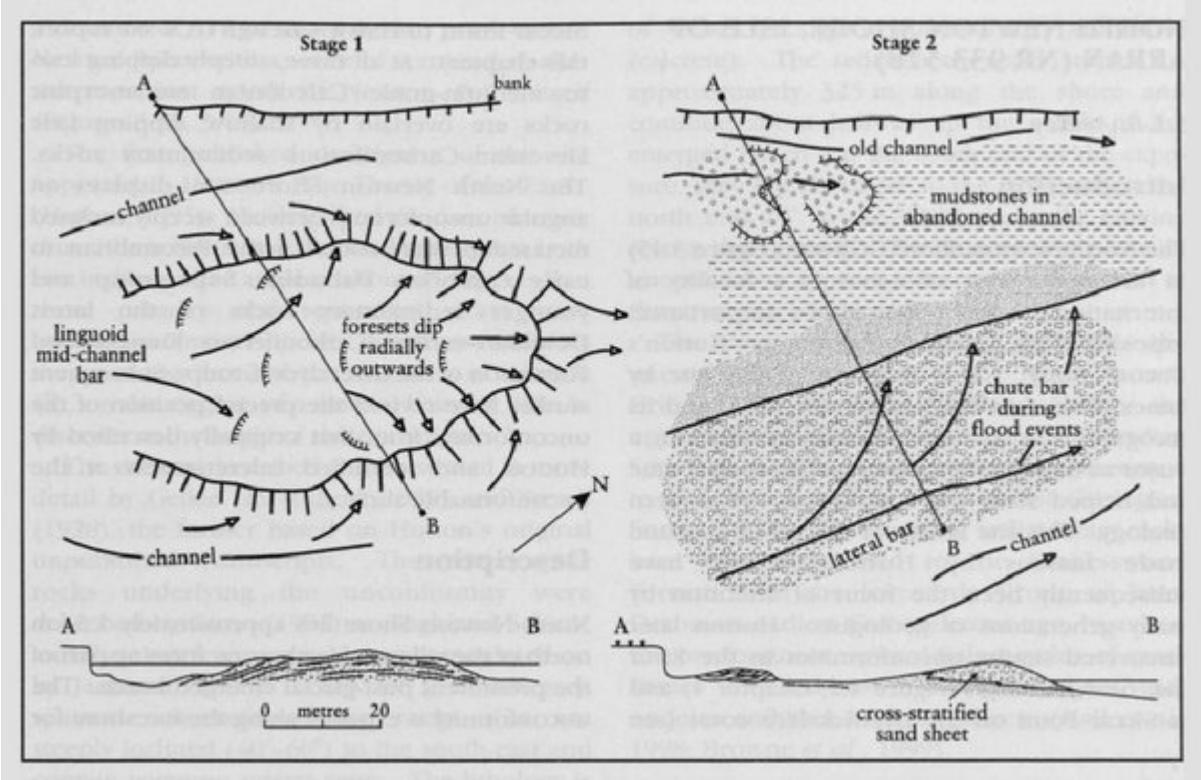
(Figure 3.41) Geological sketch map of the Largs coast section and summary graphic log. The inset shows the location of Largs, Ayrshire. After Bluck (1980b).



(Figure 3.42) Cross-bedded sandstones, west of Knock Castle [NS 1913 6303]. An upward-coarsening unit interfingering between coarse sediment (e) and fine sediment (d) at (a); gradational contact between coarse and fine sediment at (b); sharp, erosive contact at (c), and counter-current ripples at (d); scale rule 1 m. (Photo: Bluck.).



(Figure 3.43) (a) Flow around lateral bar; and (b) mid-channel bar; (c) cross-section through a bar. After Bluck (1992).



(Figure 3.44) Plan and cross-sectional views (A-B) of the interpreted development of bars at Locality 2, WNW of Quarter. Stage 1 records the growth of a linguoid mid-channel bar, Stage 2 records the development into a lateral and chute bar. After Bluck (1980b).