King's Cave to Drumadoon, Arran, Strathclyde

[NR 884 309]–[NR 884 291]

Introduction

The coastal exposures between King's Cave and Drumadoon on the west coast of Arran present a good sequence of Triassic continental sediments of the Lamlash Sandstone and Auchenhew Mudstone formations. The sequence comprises waterlain red mudstones, siltstones, and sand stones with sedimentary structures such as symmetrical and asymmetrical ripples, wavy, lenticular, and flaser bedding, and also pseudomorphs after halite. Most clastic units fine upwards, and there is common evidence of bi-modal palaeocurrents. These features, and the occurrence of burrows, indicate a marine intertidal environment and make this an important site for understanding the Triassic palaeogeography of south-western Scotland.

Publications that relate specifically to the area of King's Cave and Drumadoon include Lovell (1971), Pollard and Lovell (1976), and Pollard and Steel (1978), and general accounts have been given by MacDonald and Herriot (1983) and McKerrow and Atkins (1989).

Description

The coastline between King's Cave and Drumadoon Point is characterized by high cliffs and a series of well-developed wave-cut platforms (Figure 3.16); several natural caves have been cut into the cliffs. The largest of these is King's Cave, where Robert the Bruce may have watched the famous spider (McKerrow and Atkins, 1989). The eroded surface of the sandstones along the section is irregular because of the uneven distribution of calcium carbonate cement (MacDonald and Herriot, 1983). This GCR site is included in the Drumadoon–Tormore Site of Special Scientific Interest (SSSI).

In many places, the sandstones exposed on the foreshore and in the cliffs are cut by faults. The faults do not appear to have a large throw, and igneous dykes commonly follow the fault planes (Pollard and Lovell, 1976).

Sedimentology

The cliffs expose a thick sequence of grey and reddish sandstones, many of which are cross-laminated. The lower portions are assigned to the Brodick Breccia, or Brodick Beds, probably Permian in age (Warrington , 1973). Above these are about 400 m of the Lamlash Sandstone Formation (Warrington *et al.,* 1980), formerly 'the Lamlash Beds' (Tyrrell, 1928; Piper, 1970; Lovell, 1971; Warrington, 1973), consisting of a lower and an upper portion. The lower half of the formation is composed of cross-bedded red sandstones, containing agates, as well as breccias and conglomerates. Above these are red, yellow, and white sandstones displaying cross■bedding, and with sporadic conglomerate units. The sediments become finer-grained towards the top of the unit. The Glen Dubh Sandstone Formation appears to be of similar age (Warrington *et al.,* 1980) and interdigitates with the Lamlash Sandstone Formation and perhaps also with the Brodick Breccia.

These sandstone units are overlain by a largely argillaceous unit, formerly termed simply 'the Auchenhew Beds' (Tyrrell, 1928; Piper, 1970; Lovell, 1971; Warrington, 1973), but since divided into the Lag a'Bheith Formation and the overlying Auchenhew Mudstone Formation. The former is dominated by mudstones, but contains some sandstone units, and the latter is almost entirely argillaceous.

The Auchenhew Mudstone Formation (Warrington *et al.,* 1980, p. 26) comprises red and greenish marls with thin sandstone units (Figure 3.17)a. The sediments are generally parallel-bedded. Several small faults and pitch-stone, felsite, quartz-feldspar-porphyry and dolerite dykes cut through the sediments (Judd, 1893; MacDonald and Herriot, 1983).

A composite section through the Auchenhew Mudstone Formation (Figure 3.18) has been compiled by Pollard and Steel (1978). The lower parts of the succession are best seen in the central part of the bay to the south of King's Cave. The sediments here consist of a repetition of coarsening-upwards cycles. At the base are red, blocky, muddy siltstones, which may include laminae with scattered pseudomorphs after halite, that are overlain by red and red-green mottled silty mudstones, which may preserve ripple laminations. At the top are greyish-green or white sandstones with ripple laminations, sporadic low-angle cross-bedding and occasional interbedded mudstones with mudcracks.

The middle part of the sequence was measured north of the waterfall gully at the top of the cliff, on the upthrown side of a fault (Figure 3.18). It comprises approximately 16 m of interbedded greyish-green sandstones and red mudstones, with scattered quartz geodes, overlain by 2 m of fine-grained, reddish, quartz sandstones, and it is divisible into at least three fining upwards cycles. The lowest part of the basal cycle is characterized by megaripple bedding. The basal section of the top cycle typically preserves fine examples of climbing-ripple laminations. Sedimentary structures, such as flaser and lenticular bedding, are common throughout, and trace fossils (*Siphonites, Cylindricum;* (Figure 3.17)b), bioturbation and pseudomorphs after halite, which often take the form of partial hopper crystals and are associated with rippled sandstone, are also present (Pollard and Steel, 1978).

The upper part of the Auchenhew Mudstone Formation is best exposed in the cliffs of a hanging gully and waterfall near Cleiteadh nan Sgarbh ([NR 886 302]; Pollard and Lovell, 1976). The sequence exposed here is approximately 25 m thick (Figure 3.18). At the base are massive micaceous sandstones with ripple cross-laminations and some mudcracked surfaces. These are overlain by thinly bedded micaceous mudstones, siltstones, and quartz sandstones, which grade up into a thin unit of nodular and lenticular sandstones that contain fragments of rock and feldspar and have been cemented with calcite. The upper part of the cliff section has been divided into four units. Unit I consists of red-green, calcareous, silty mudstones that contain irregular and laterally discontinuous beds of well-cemented sandstone. Unit II is dominated by red-green calcareous silty mudstones, and has a thin (approximately 0.2 m thick) sandstone bed just over half-way up the unit. The overlying Unit III is more complex, and contains red-green siltstone, cross-laminated sandstone, three well-cemented sandstone beds, which preserve ripple cross-laminations, climbing ripple laminations and wavy bedding, and silty mudstones. The top of the gully cliff consists of a thin basal sandstone and red-green silty mudstone (Unit IV). In all four units the silty sediments contain carbonate nodules, the 'potato stones' reported by Gregory (1915), (Pollard and Lovell, 1976; Pollard and Steel, 1978).

Palaeontology

Pollard and Lovell (1976) discovered a trace fossil assemblage in fallen blocks of Auchenhew Mudstone Formation below the cliffs near Cleiteadh nan Sgarbh [NR 886 302]. Three trace fossil morphologies have been recorded: '*Siphonites*', *Cylindricum,* and epichnial ridges. The age of the Auchenhew Mudstone Formation is constrained by an Anisian miospore assemblage recovered by Warrington (1973) from the underlying Lag a'Bheith Formation in south-eastern part of the Isle of Arran.

Interpretation

The Lamlash Sandstone Formation is interpreted as having been deposited in a desert subject to periodic floods. A similar environment is postulated for the Glen Dubh Sandstone Formation. Persistent subaqueous deposition becomes more important upwards through the succession, and continues into the fully subaqueous Lag a'Bheith and Auchenhew Mudstone formations (Lovell, 1971; Warrington *et al.,* 1980). Acritarchs in a palynomorph assemblage from the underlying Lag a'Bheith Formation in southeast Arran (Warrington, 1973) indicate marine influences.

The lower and middle parts of the Auchenhew Mudstone Formation were deposited under marginal marine or intertidal conditions (Pollard and Steel, 1978); trace fossils from the upper section suggest freshwater environments (Pollard and Lovell, 1976). The lower parts of the formation consist of cycles of mudstone and muddy siltstone capped by sandstone. The coarsening-up sequence with the symmetrical ripple marks and mudcracks was deposited in shallow water in areas subject to periods of emergence, leading eventually to permanent subaerial exposure. It is not known if these sediments were deposited under freshwater or marginal marine conditions, although the presence of pseudomorphs after halite

supports the latter interpretation (Pollard and Steel, 1978). However, such pseudomorphs are also known to form under non-marine conditions (Lovell, 1981).

The middle of the Auchenhew Mudstone Formation is characterized by interbedded sandstones and mudstones capped by red sandstone. The lenticular and flaser bedding, climbing ripples, and evidence for subaerial exposure suggest deposition on prograding low-energy tidal flats. The isolated sandstone wedges, with their well-developed cross-bedding, are thought to have been deposited in small channels or creeks incised in a low-lying landscape. Palaeocurrents indicate that the dominant direction of flow was towards the south-west, and may indicate ebb currents in the channels and across the intertidal flats (Pollard and Steel, 1978).

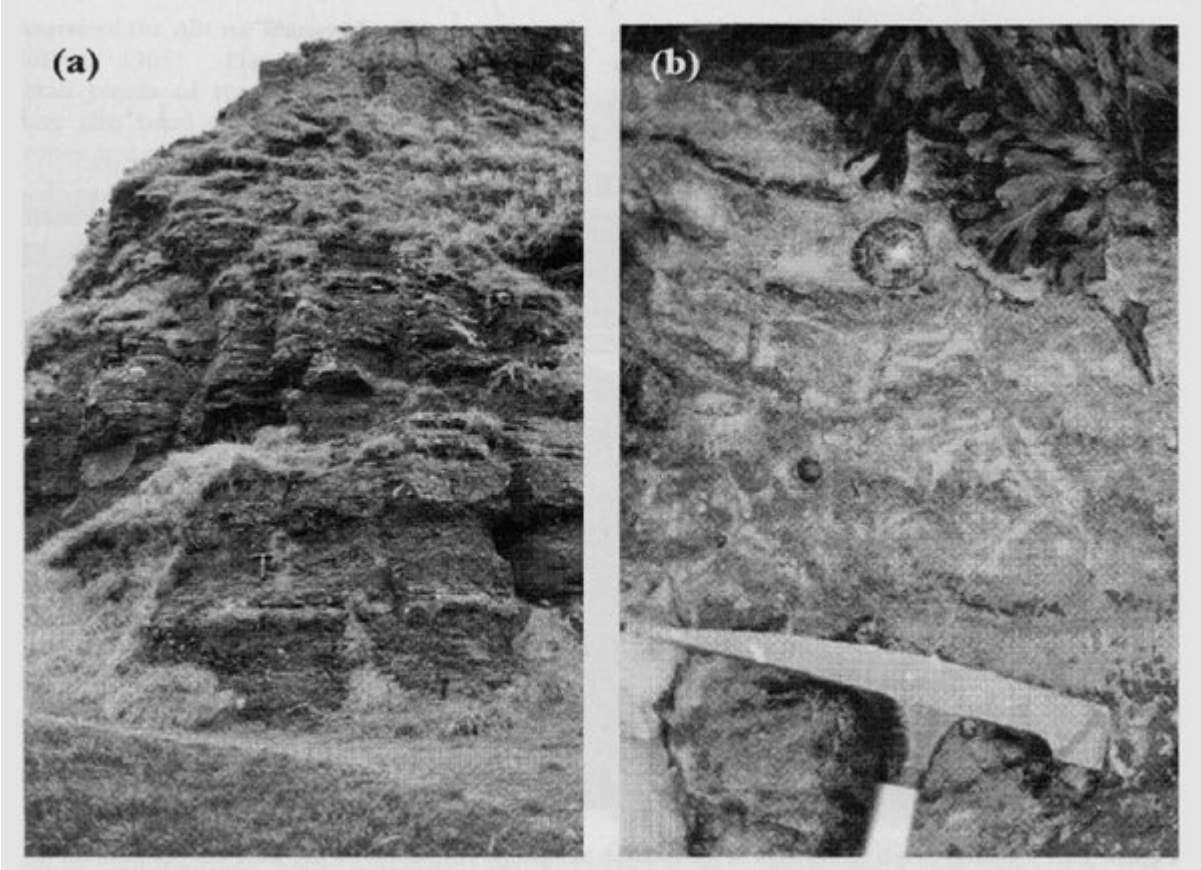
The sediments and trace fossils of the lower parts of the waterfall section are characteristic of deposits that accumulated under dominantly terrestrial conditions. Although the trace fossil assemblage is not diagnostic of any palaeoenvironment, it is likely that the traces were made by freshwater arthropods living in the muddy sediments deposited on a river floodplain. The overlying alternations between siltstones and sandstones (units I to IV), some exhibiting well-preserved cross-laminations and calcrete nodules, are indicative of a river floodplain (Pollard and Lovell, 1976). However, Pollard and Steel (1978) considered the 'potato stones' to be a result of the replacement of evaporite minerals by calcite or quartz, probably in sabkha-type environments.

Conclusions

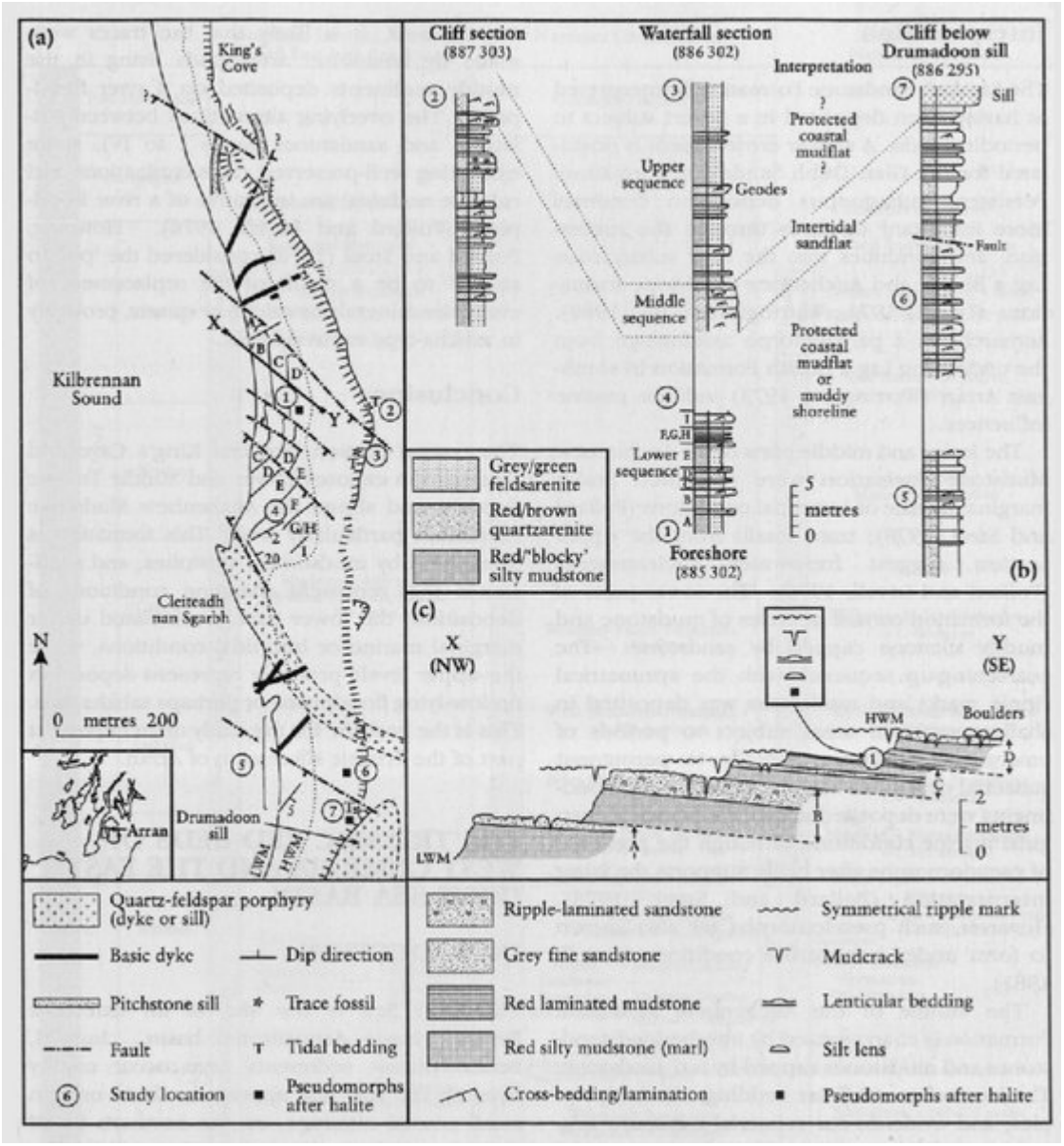
The coastal section between King's Cave and Drumadoon exposes Lower and Middle Triassic deposits and shows the Auchenhew Mudstone Formation particularly well. This formation is dominated by mudstones, siltstones, and sandstones that represent changing conditions of deposition; the lower part accumulated under marginal marine or intertidal conditions, while the upper levels probably represent deposition on low-lying floodplains or perhaps sabkha flats. This is the best site for the study of an important part of the Triassic succession of Arran.

References

(Figure 3.16) Outcrop of red sandstones of the Lamlash Sandstone Formation on the wave-cut platform on the foreshore at Drumadoon, looking south. (Photo: C. MacFadyen.)



(Figure 3.17) The Triassic sediments between King's Cave and Drumadoon: (a) succession of siltstones and mudstones of the Auchenhew Mudstone Formation; and (b) burrows, cf. Cylindricum, on the surface of a ripple-marked, fine-grained sandstone. (Photos: C. MacFadyen.)



(Figure 3.18) (a) Map of the west coast of Arran; (b) sedimentary logs through the King's Cave to Drumadoon Triassic succession, and (c) diagrammatic NW–SE cross-section of the foreshore and cliffs (see map (a) for location). The logs are composed from measurements made in seven locations shown on the map. (After Pollard and Steel, 1978.)