Craigyfulfran

[SN 5821 8253]–[SN 5867 8360]

Introduction

The cliff exposures along the coast to the north of Aberystwyth (Figure 3.37) provide the classic section of the Aberystwyth Grits Group. They have been described and discussed by numerous authors since the term Aberystwyth Grits' was introduced by Keeping (1881). Along with other sections in the region, including the site at Aberarth–Morfa, they have played a major part in the development of the concept that the Aberystwyth Grits were deposited by submarine turbidity currents that flowed into the deeper parts of the Welsh Basin from shallower areas to the south-west.

Geological mapping of the Aberystwyth area goes back to 1848, when maps at the scale of 1 inch to 1 mile were published by the Geological Survey of England and Wales. Keeping (1878, 1881) produced the first detailed study specifically directed at the rocks of the Aberystwyth neighbourhood, but misinterpreted the stratigraphical order of the strata. This error was corrected by Marr (1883) and Jones (1909), who recognized the true superpositional sequence. In the 1900s, the numerous papers on the geology of Central Wales by O.T. Jones included two referring specifically to the Aberystwyth district (Jones and Pugh, 1935a, b), in which it was noted that the lithology and fauna of the strata show that they belong to a distinctive environmental suite, termed the graptolitic facies. Studies on the sedimentology of the Aberystwyth Grits include the seminal paper by Wood and Smith (1959), and the petrological and geochemical evidence for the provenance of the sediments was assessed by McCann (1991). The tectonics of the Aberystwyth Grits were studied by Price (1962), who identified an anticlinal structure in the Aberystwyth region with the axis running north–south. The British Geological Survey returned to the area in 1965–1975, and undertook geological mapping for the production of Sheet 163 (England and Wales). The accompanying memoir (Cave and Haim, 1986) provides a detailed summary of the geology in the area that includes Aberystwyth and Machynlleth. A number of excursion guides also provide details of rocks in the general area and in the specific exposures between Aberystwyth and Clarach.

The section of cliff exposures extending from the north end of Aberystwyth North Bay in the south to Clarach Bay in the north makes up the type locality for the Aberystwyth Grits Group. The section incorporates Craigyfulfran ('Cormorant Rock'), after which the locality is named (Figure 3.41). Typical greywacke–mudstone tubidite rhythms are displayed, with the finer-grained sediments predominant. Sedimentary structures indicating flow directions; trace fossils are common.

This classic section, therefore, displays a wide variety of characteristic features of the distal deposits of turbidity flows. It has been very widely referred to in the literature, and has played a major part in the development of ideas on the sedimentology of turbidite systems. The readily accessible coastal cliffs provide excellent evidence of the nature of depositional systems in this area of the Welsh Basin during early Silurian times. The mud-dominated turbidite units at Craigyfulfran contrast with the sand-dominated more proximal units seen in sections to the south (e.g. Aberarth–Morfa), and together with these sections allow reconstruction of the elongate submarine lobe complex that developed in the area that is now central western Wales. Detailed summaries of the Aberystwyth Grits Group and of its deposition in a fault-controlled sandstone-lobe turbidite system were given by Wilson *et al.* (1992) and Davies *et al.* (1997, pp. 126–32, 145–50). These deep-water sediments with their fauna of trace fossils and occasional graptolites contrast markedly with the shallow water facies seen in Aeronian and Telychian network sections to the south (e.g. Marloes) and east (e.g. Hillend Farm, Gullet Quarry).

Description

The best-known and most visited part of the section is immediately north of the northern termination of Aberystwyth promenade, where the beds at the base of the cliff dip ENE at about 50°. At the top of the cliff some beds dip steeply westwards, and there are conspicuous folds and faults. The turbidites along the shore are mud dominated, with sandstone units 1–10 cm thick occurring in packages, in which the thicker sand stones are separated by dark mudstones containing several thinner, paler, less prominent sandy horizons (Figure 3.42). The thicker sandstones show grading,

parallel lamination and small-scale cross-lamination, and convolute lamination is developed in the upper portions of several of these sandstone beds (Figure 3.43). The bases of many of the sandstone units show well-developed bottom structures, including flute and groove marks (Figure 3.44); the direction of flow indicated by these features is towards the north and NNE. Trace fossils are also commonly preserved as moulds on the lower surfaces of sandstones (Figure 3.45). Crimes and Crossley (1980, 1991) identified the occurrence of more than 25 different types of trace fossil in the Aberytstwyth Grits Group, and McCann (1990) assigned the assemblage to the Graphoglyptid association, which includes the ichnogenera *Gordia, Helminthoida, Helminthopsis, Paleodictyon, Protopaleodictyon* and *Spirophycus,* among others. Body fossils are rare in this part of the section; one specimen of the brachiopod *Eocoelia* has been reported, but graptolites are not known.

To the north of the breakwater similar strata continue, with a prominent sinistral strike-slip fault trending 095° apparent at [SN 5820 8273]. The beds from here northwards again dip to the east and the strike section shows the lateral continuity of the beds; there is no pinching out or thickness variation in the sandstones. Towards Craigyfulfran (Cormorant Rock, [SN 5828 8296]), the beds become more complexly folded and faulted. Some of the smaller fold structures do not relate to the larger folds, and have been interpreted as a response to downslope movement of material, occurring after considerable dewatering and diagenesis but before regional tectonic deformation (Fitches *et al.,* 1986; Siveter *et al.,* 1989). At Craigyfulfran there is a transition between turbidites with trace fossils, which indicate oxic bottom conditions, to anoxic turbidites with rare graptolites; pyritized burrows occur in the transition zone (Dobson *et al.,* 1995b). Loydell (1992) recorded that the graptolites found on the eastern face of Craigyfulfran are referable to the *utilis* Sub-biozone, which spans the base of the *turriculatus* Biozone.

From Craigyfulfran to Clarach Bay a steadily descending succession, totalling about 140 m in thickness, is exposed. Dobson *et al.* (1995b) reported that there is a marked disparity between the current directions displayed by the flute marks and the cross-bedding in this part of the succession, with the cross-bedding direction varying considerably. At Clarach Bay the section includes a band of pale volcanic ash, about 2 cm thick.

Interpretation

The Aberystwyth Grits Group in the Craigyfulfran section represents part of the submarine lobe complex that built north-eastwards into the Welsh Basin during latest Aeronian and early Telychian times (see 'Interpretation' of the Aberarth–Morfa site report). In contrast to the sections at Aberarth–Morfa and New Quay [SN 3868 6044] to the south, the turbidite sequences at Craigyfulfran have a low greywacke sand/mud ratio, with siltstones and mudstones strongly dominant. This indicates that these strata were deposited in the more distal parts of the lobe system, consistent with a source to the south or south-west. The orientations of flute marks on the undersides of some sandstone beds confirm a flow from the SSW. The turbidite beds mostly display only the Tcd, Tcde or Tde portions of the typical Bouma Tabcde cycle (Figure 3.46), indicating that the flow was not strong enough to carry the coarser detritus typical of Ta and Tb beds this far across the fan. Although the bases of many of the turbidite units are clearly erosive, there is only occasional evidence of amalgamation of successive sandstone beds into composite units as a result of downcutting; multiple beds, comprising more than two successive sandstones, have not been recorded. The rare dark, graptolitic beds represent the background sedimentation of fine hemipelagic mud, but these layers have been removed by erosion from the tops of many of the turbidite units.

The trace fossil associations displayed on the lower surfaces of many of the sandstones represent burrow systems that were excavated during the quiet periods between flows. At these times, the muds deposited by the preceding flow were colonized by a variety of soft-bodied infaunal organisms, several of which excavated complex tunnel systems (e.g. *Paleodictyon*). These tunnels were exhumed during the erosive episode of the succeeding flow, and preserved by casting when the flow waned and sand filled the sea-bed topography. Other trace fossils represent trails of surface-dwelling organisms. According to McCann (1990), this characteristic 'Grapho-glyptid association' is confined to sediments deposited as sandstone lobes and in channel-margin and interchannel environments.

A feature of the section, particularly well-displayed in the southern part, is the pattern of prominent Tcde turbidite units, with basal greywackes some 10 cm thick, separated by a number of Tde units with thin, inconspicuous siltstones at the

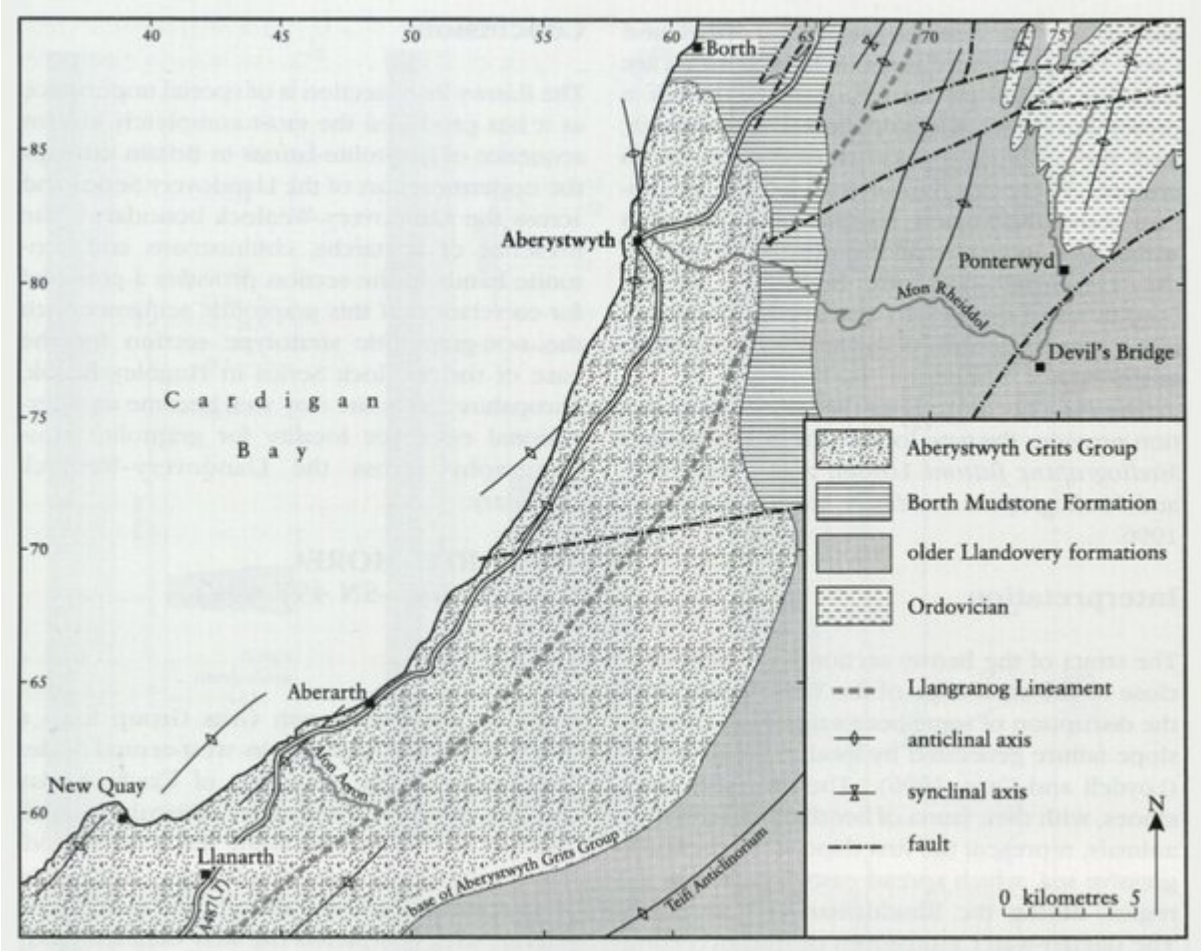
base. This rhythmicity may be due to fluctuating tectonic control or, more likely, to the influence of rises and falls in sea level (e.g. Mutti and Normark, 1987). The maximum input of detritus to the system would be expected during low sea-level stands when rivers and deltas could prograde over the shelf area to unload sediment directly into the deeper marine basin. Another explanation might be that the rhythms reflect a climatic influence, perhaps related to orbitally-controlled variations in insolation.

Conclusions

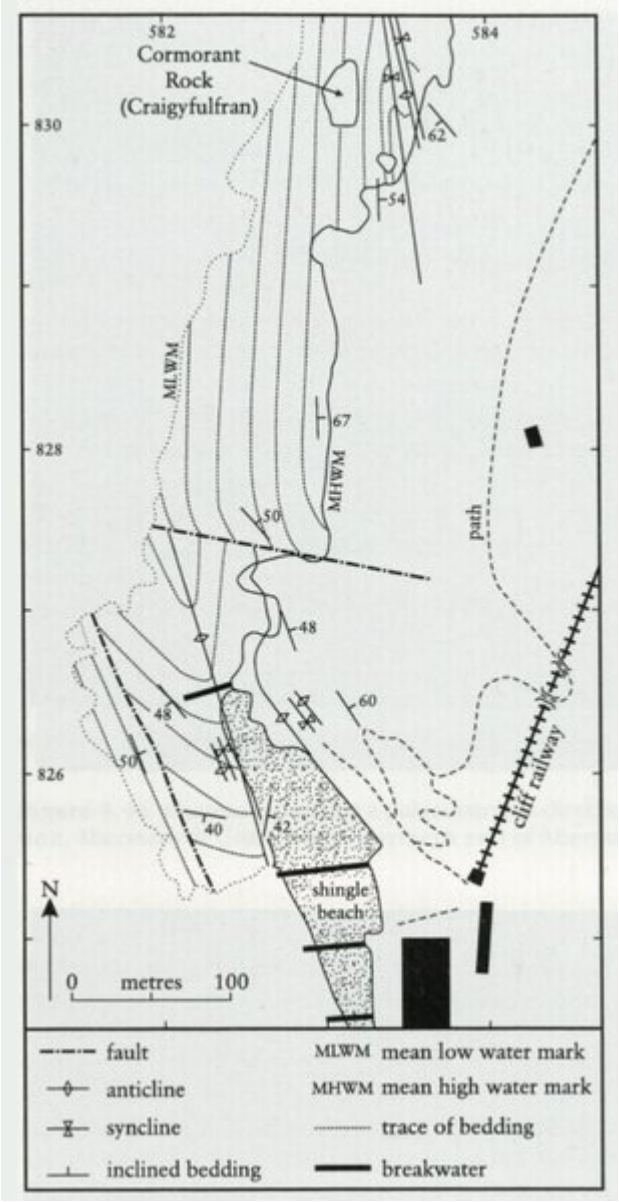
The cliffs between Aberystwyth and Clarach Bay comprise the type section of the Aberystwyth Grits Group, a classic deposit of interbedded sandstones and muds. These sediments have been interpreted as the products of turbidity flows, which carried vast amounts of detritus into the Welsh Basin from a source to the southwest. As the flows waned, they deposited their sedimentary loads, with coarser sands dominant to the south, nearer the source, and mud dominant in the more distal regions to the north, such as at Craigyfulfran. The turbidite deposits constructed a large, elongate submarine lobe that built north-eastwards out into the basin; the eastern boundary of the turbidite system was controlled by synsedimentary faulting. Areas of the lobe were colonized by soft-bodied marine animals, which have left traces of their activity as surface trails or as burrow systems in the sediments. Rare graptolites occur in the muds deposited in the quieter periods between the turbidity flows, and these have enabled dating of the strata as late Aeronian to early Telychian in age.

The section at Craigyfulfran has been very widely referred to in the literature, and is one of the most classic turbidite sequences in the world. It is of considerable national and international importance, is widely used as a teaching resource and is frequently visited by overseas scientists. It has major conservational value.

References

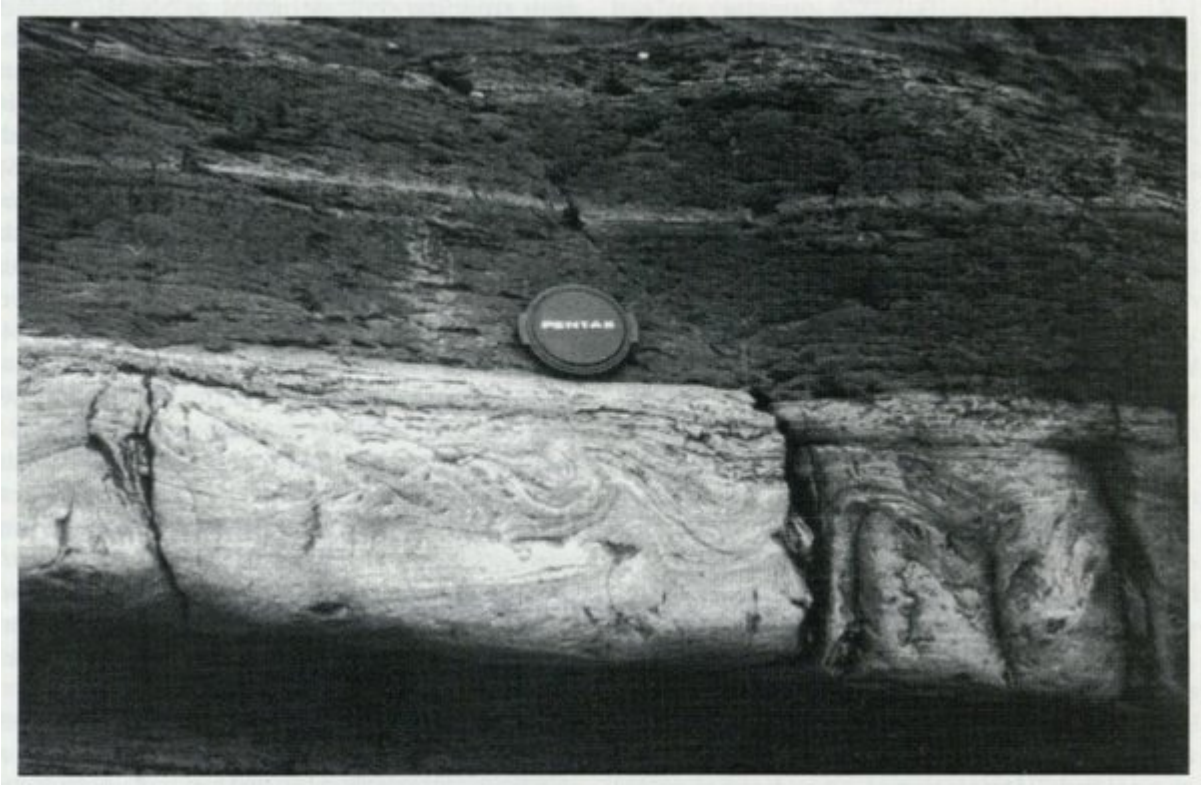


(Figure 3.37) Geological sketch-map of central western Wales, showing the extent of the Aberystwyth Grits Group and the GCR network sites at Aberarth and Craigyfulfran (Aberystwyth) (after Siveter et al, 1989).

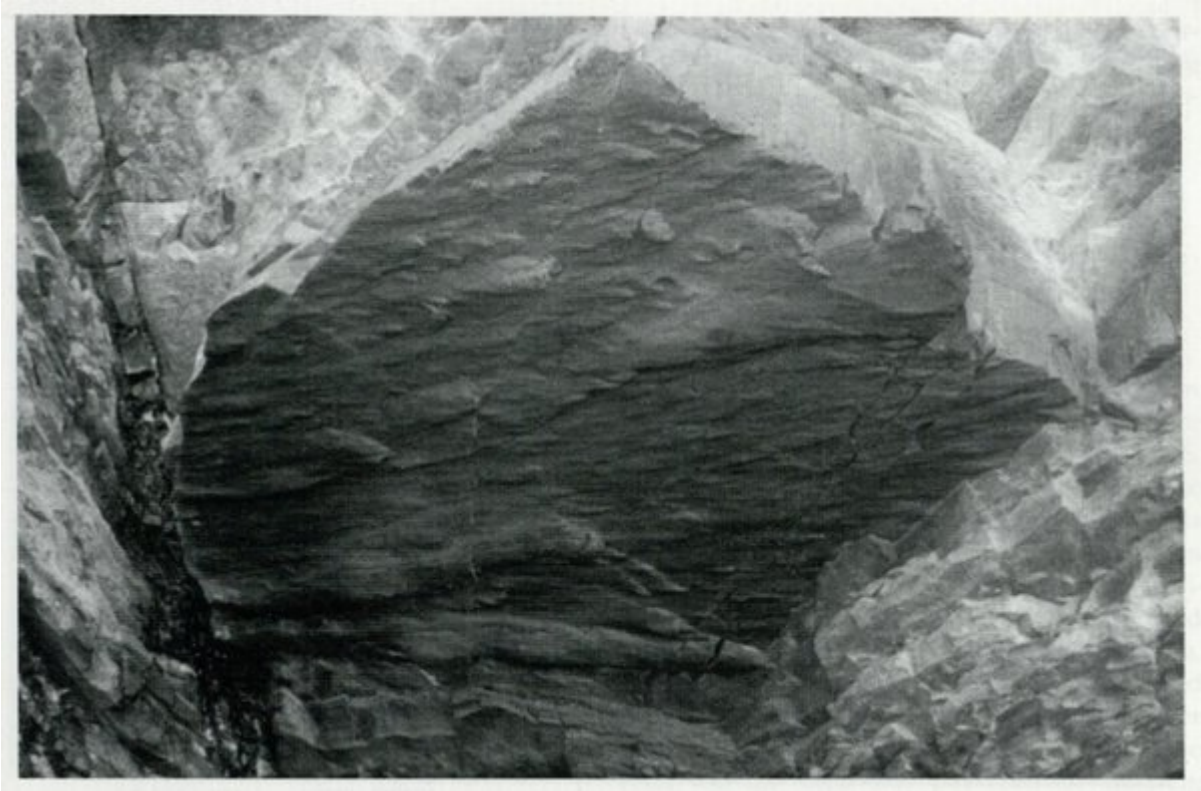


(Figure 3.41) Sketch map of the area from Craigyfulfran to the north end of the Aberystwyth promenade (after Bates, 1982a).

(Figure 3.42) Turbidite units of the Aberystwyth Grits Group at the northern end of Aberystwyth promenade. (Photo: R.J. Aldridge.)

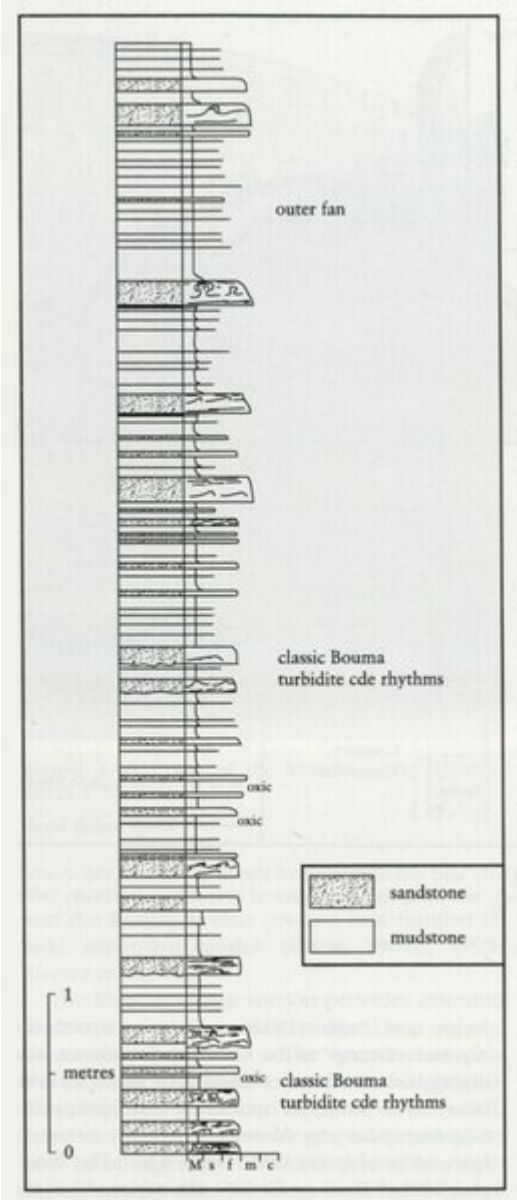


(Figure 3.43) Convolute lamination in a sandstone bed, Aberystwyth Grits Group, northern end of Aberystwyth promenade. (Photo: R.J. Aldridge.)



(Figure 3.44) Flute marks giving a palaeocurrent direction from the SSW, on the base of a 15 cm-thick sandstone unit, Aberystwyth Grits Group, northern end of Aberystwyth promenade. (Photo: R.J. Aldridge.)

(Figure 3.45) Trace fossils on the base of a sandstone unit, Aberystwyth Grits Group, northern end of Aberystwyth promenade. Width of frame, approximately 1 m. (Photo: RJ. Aldridge.)



(Figure 3.46) Representative sedimentary log of the turbidite Tcde rhythms measured at the headland at the north end of Aberystwyth promenade (after Dobson et al., 1995a).