Cailleach Head

[NG 986 979]–[NG 987 988]

A.D. Stewart

Introduction

Cailleach Head, between Loch Broom and Little Loch Broom (Figure 4.1), is the type area for the Cailleach Head Formation, the youngest part of the Torridon Group (*c.* 1000 million years old). Unlike other parts of the Torridonian sequence this formation is composed entirely of the coarsening-upward siltstone–sandstone cyclothems. Each cyclothem has grey fissile siltstone at the base and cross-bedded sandstone at the top, recording the gradual advance of deltaic sediments into a lake or shallow sea. The lowest 15 cyclothems, totalling 320 m, are very well exposed and readily accessible in the cliffs south of the lighthouse at Cailleach Head. The bedding dips 30°–40° to the south-east. Although this is one of the finest cyclothemic sequences in Europe it has never received more than passing mention in the literature (Stewart, 1988b). The fining-upward sequences found at the base of the group, for example at the Achduart GCR site, have a different origin.

The Cailleach Head Formation is only preserved to the west of the Coigach Fault, which cuts across the peninsula 1.2 km south-east of Cailleach Head (Figure 4.30), and throws down to the west some 6 km (Stewart, 1993). A small sliver of the Cambrian Eriboll Sandstone Formation is present immediately west of the fault at [NG 9908 9733] where it lies unconformably on the Cailleach Head Formation. Stewart (2002) records that the Cambrian quartzites strike 110° and dip 16° S. The adjacent Cailleach Head Formation beds strike 085° and dip 40° S, implying that the Cambrian unconformity cuts down through the Torridonian succession to the west. In contrast, in the vicinity of the Moine Thrust Belt the Cambrian unconformity cuts down to the east. The base of the Cailleach Head Formation lies below sea level at Cailleach Head, but it is exposed on Gruinard Island, 6 km to the south-west. Here it is conformable with the underlying sandstones of the Aultbea Formation. This implies that there could be about another 500 m of the formation below that exposed at Cailleach Head, giving an estimated total thickness of *c.* 1130 m.

Cailleach Head is also of historical interest, in that the first Precambrian microfossils found in Britain were obtained here. John Horne, who mapped the area for the Geological Survey in 1885, collected the phosphatic concretions in which J.J.H. Teall found clusters of unicellular microfossils and fibres (Geikie, 1903, p. 56; Peach *et al.,* 1907, pp. 287–8and plate 52). Gregory (1917) stated that the sampled locality is on the shore 265 m north-west of the Coigach Fault, but phosphatic concretions are found sporadically throughout the Cailleach Head Formation. Downie (1962) reported 'spore-like bodies, isolated and in clusters, cellular sheets of tissue, and filaments' from the siltstones containing the phosphatic nodules. He assigned them tentatively to the middle Riphean, but no further details have been published. Palaeomagnetic data from the Cailleach Head Formation are compatible with other parts of the Torridon Group (Irving and Runcorn, 1957). Van de Kamp and Leake (1997) briefly considered the geochemistry of these rocks as part of their overall Torridonian study.

Description

The Cailleach Head GCR site consists of cliffs about 45 m high, precipitous in places but everywhere accessible in calm weather from a rocky bench just above high-water mark. Inland the peninsula rises more gently to over 110 m and the bedrock is covered by till and peat. The type section of the Cailleach Head Formation starts at sea level 180 m north-east of the lighthouse at [NG 9864 9868], where the lowest cyclothem exposed is cut by a small fault. The section continues south and south-east along the coast to the Coigach Fault at [NG 9908 9733], encompassing about 630 m of strata. Continuous exposure ends about 500 m south of the lighthouse at [NG 9861 9793], covering a stratigraphical thickness of 326 m from the lowest cyclothem.

The cyclothems have an average thickness of about 20 m (Figure 4.31). The lower part of each cyclothem consists of tabular-bedded siltstones and sandstones (facies 1), and the upper part consists of trough-cross-bedded sandstone (facies 2) (Figure 4.32), (Figure 4.33). Both facies can be subdivided as described below. The base of each cyclothem is defined by a flat erosion surface overlain by dark-grey siltstones, or more rarely mudstone or fine-grained micaceous sandstone. The siltstone forms laminae averaging about 4 mm in thickness (sub-facies la), normally interlaminated with pale-brown- or cream-weathering ripple-laminated sandstone, from which sedimentary veins penetrate downwards into the siltstone. The lateral persistency (lateral extent divided by maximum thickness) of siltstone laminae in sub-facies la is over 10 000. Where the sandstones form more than 50% of a sequence, it is considered to belong to a separate sub-facies, 1b. Sub-facies lc consists of tabular beds of light-red-weathering, fine-grained sandstone. The lateral persistency of beds in sub-facies is is in the range 300–5000. Typical sedimentary structures are flat bedding with current lineation, and repeated sets of tabular, planar cross-beds. The bases of the sandstones commonly show drag and brush marks and isolated, compacted shrinkage cracks. These resemble trace fossils and it is not surprising that they were recorded as such by the Geological Survey (Geikie, 1900). The tops of the sandstones have symmetrical ripples, commonly in interfering sets. In two of the cyclothems large desiccation polygons cut the intervening grey siltstones of sub-facies 1a or 1b.

In the upper part of each cyclothem (facies 2), the sandstones are slightly coarser-grained than those of facies 1 (but only rarely reach medium grain-size), and trough cross-bedding is the typical sedimentary structure. There are two dominant sub-facies, 2a and 2b. The first weathers to a moderate pink colour and locally contains intercalations of the grey sandstone and siltstone (sub-fades 1b). Such intercalations are impersistent due to erosion at the base of the sandstone beds. The second sub-facies (2b) consists of greyish-red-weathering sandstone in which the iron minerals are concentrated in small spots. The sandstone typically shows abrupt lateral passage into yellowish-green and greyish-red micaceous sandstone and siltstone. The lateral persistency of units in facies 2 is in the range 10–100.

Siltstone fragments, up to 40 cm long, and channel features are present sporadically throughout facies 2. The largest channel is seen 15 m above the base of cyclothem N and is well exposed halfway up the cliff beneath the lighthouse [NG 9851 9850]. Here, sandstone of sub-facies 2a fills a channel 5 m wide and about 0.5 m deep in the underlying sub-facies 1b. The boundary between facies 1 and 2 is easily located in the sections by the appearance of trough cross-bedding, and by the abrupt change in the persistency factor. The average palaeocurrent direction from cross-bedding, cross-lamination and current lineation in the cyclothems is towards the north-east, with vector mean of 037° (52 observations).

Interpretation

The lowest sediments in each cyclothem (sub-facies la) were deposited from suspension into a body of water, below wave base, where bottom currents rarely penetrated. However, progressively more sandy sediment was introduced upwards through the sub-facies. The absence of carbonate, or macroscopic pyrite, suggests that the water body above the sediment was well circulated, oxygenated and dilute, probably a lake whose level was controlled by overflow rather than evaporation.

The flat-bedded tabular sandstones of sub-facies lc may have been deposited from fast-flowing, shallow floodwaters, crossing sandflats bordering the lake. When the lake level rose and temporarily covered the sandflats, the floodwaters decelerated on entering the lake and deposited sediment as straight-crested sand waves. Some of the sediment was carried beyond the sandflat and across the lake floor, thus accounting for the ripple-laminated sandstone bands in sub-facies 1b. After the floods had ended, waves reworked the sediment top into symmetrical ripples. No beach deposits have been identified.

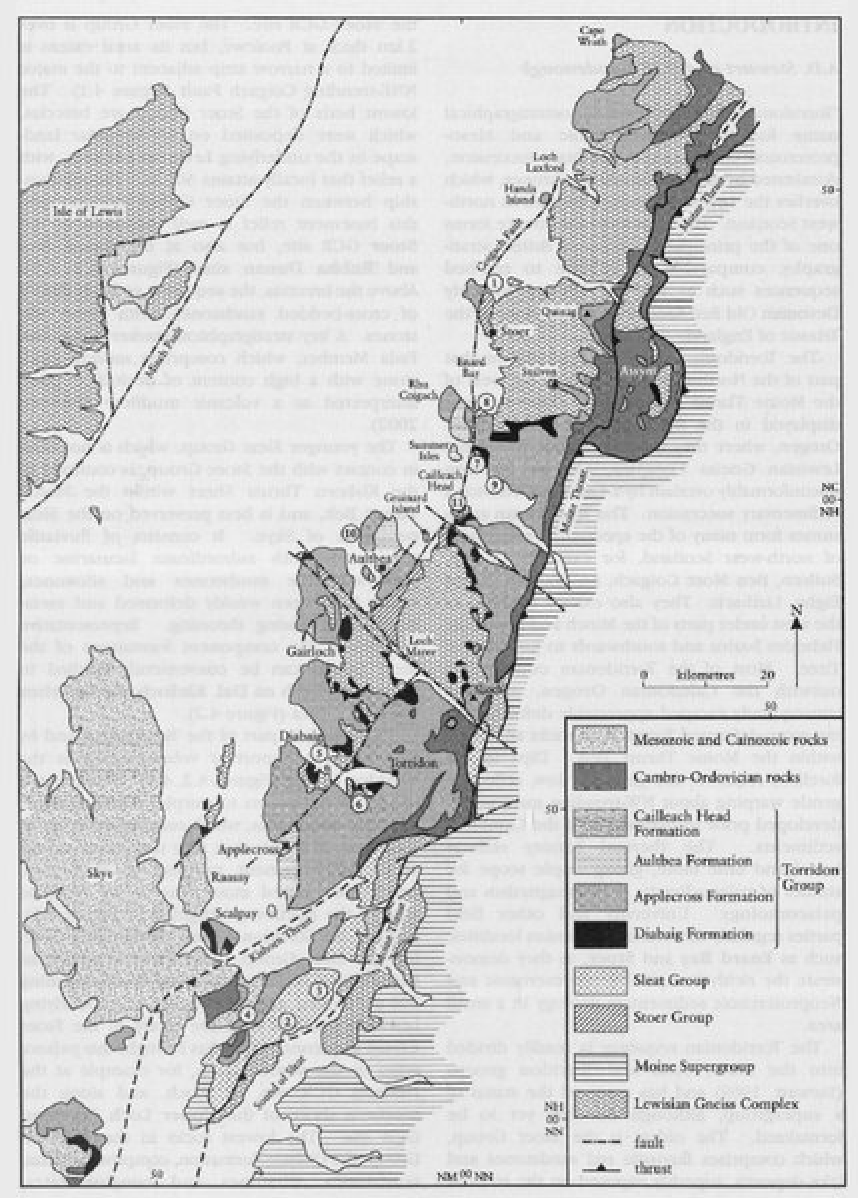
Upstream from the sandflat the floodwaters crossed a braided fluviatile plain. The currents were swifter than on the sandflat and formed the dunes responsible for the trough cross-bedding seen in facies 2.

If the hypothesis of a hydrologically open lake environment for the Cailleach Head Formation is accepted then the cyclothems must reflect periodic variations in water depth. The minimum water depth is given by the combined thickness of sub-facies la and 1b, which is about 5 m (10 m when decompacted). Fluctuations in water depth over about 10 m would have allowed deposition and occasional desiccation of the interbedded sub-facies 1b and 1c. At longer intervals the lake appears to have deepened abruptly by 15–25 m, resulting in deposition of sub-facies la and 1b directly on top of facies 2. Variations in lake water levels consistent with this hypothesis are well known from rift-valley lakes (Beadle, 1981) and are recorded in Mesozoic rift sequences in eastern North America (see Stewart, 2002, p. 35). The Cailleach Head Formation overlies some 5 km of fluviatile red sandstones, and was probably deposited in a NNE-trending rift basin. Van de Kamp and Leake (1997) considered the geochemistry of the Cailleach Head Formation and concluded that the detritus was derived from a local 'Hebridean' source. They suggested that at that time there had been renewed local uplift, leading to the formation of a highland area, which diverted the rivers that had deposited the Applecross and Aultbea formations, allowing deposition of local sediment in lakes in the rift basin.

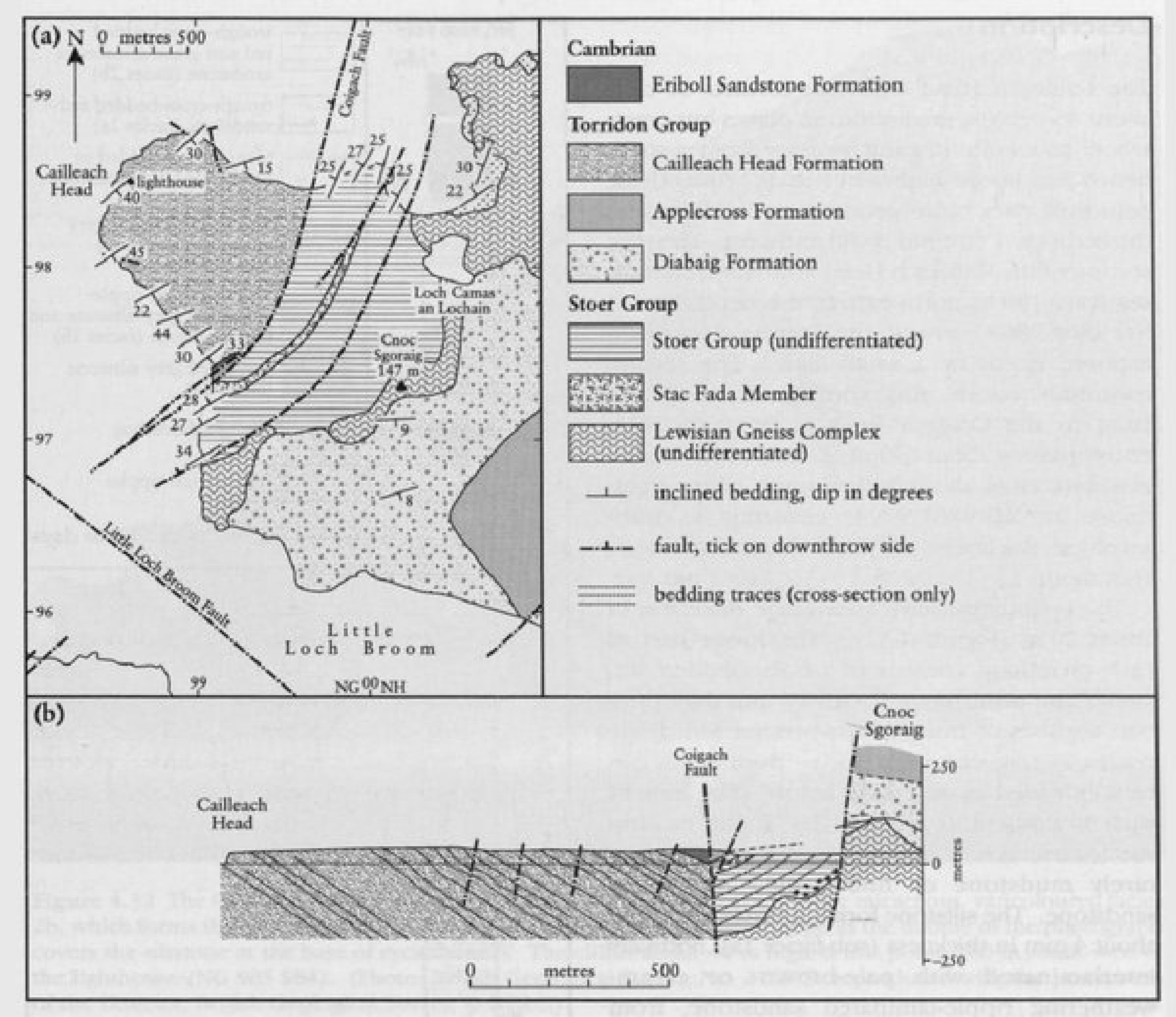
Conclusions

The Cailleach Head GCR site displays a beautifully exposed set of Precambrian sedimentary cyclothems from the uppermost part of the Torridon Group (about 1000 million years old). They form the type section of the Cailleach Head Formation. The cyclothems average 20 m in thickness and show an upward-coarsening sequence from siltstone to fine and coarse sandstone, representing the gradual advance of sandy braided streams into a shallow lake. The grey siltstones at the base of each cyclothem are the former lake bottom sediments, while the cross-bedded red sandstones above are the stream deposits. The sequence is interpreted to have been deposited in a large lake in a NNE-trending rift basin, which underwent periodic phases of deepening. Unicellular microfossils, the first Precambrian fossils found in Britain, were also obtained from phosphatic concretions at this locality. The GCR site provides the most complete set of Precambrian cyclothems in Europe and hence should be regarded as of international importance.

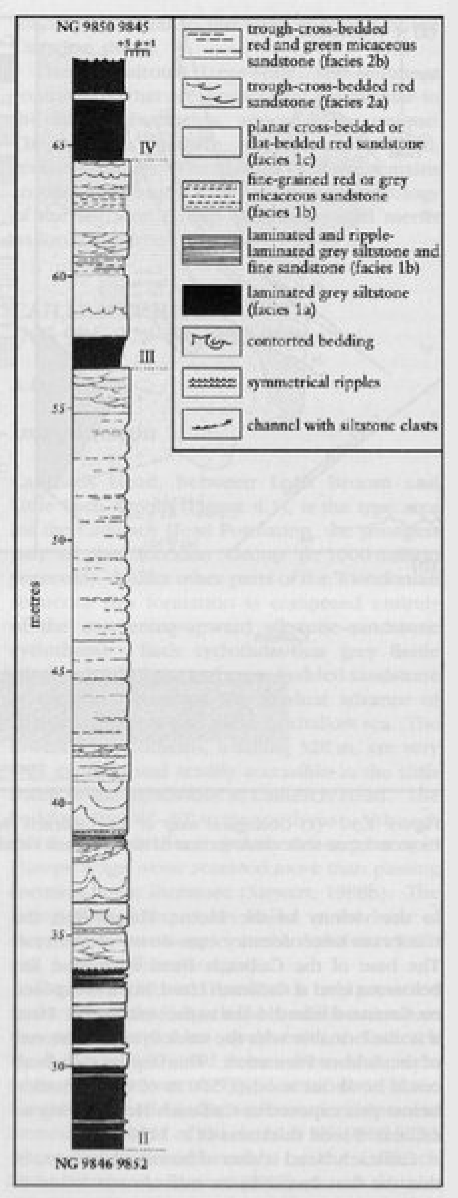
References



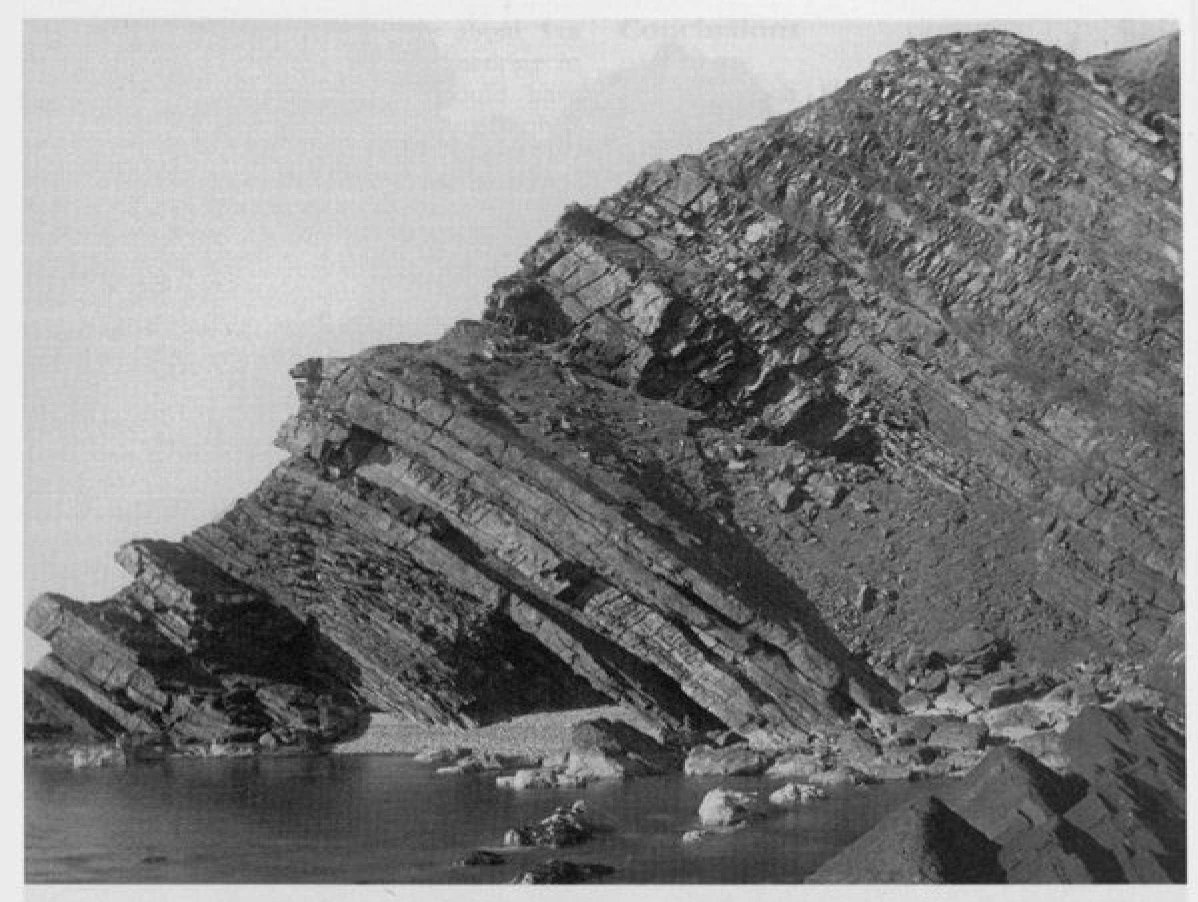
(Figure 4.1) Geological map showing the distribution of the main stratigraphical divisions of the Torridonian in north-west Scotland and the location of GCR sites: 1— Stoer; 2 — Loch na Dal; 3 — Kylerhea Glen; 4 — Loch Eishort; 5 — Diabaig; 6 — Upper Loch Torridon; 7 — Rubha Dunan; 8 — Enard Bay; 9 — Achduart; 10 — Aultbea; 11 — Cailleach Head.



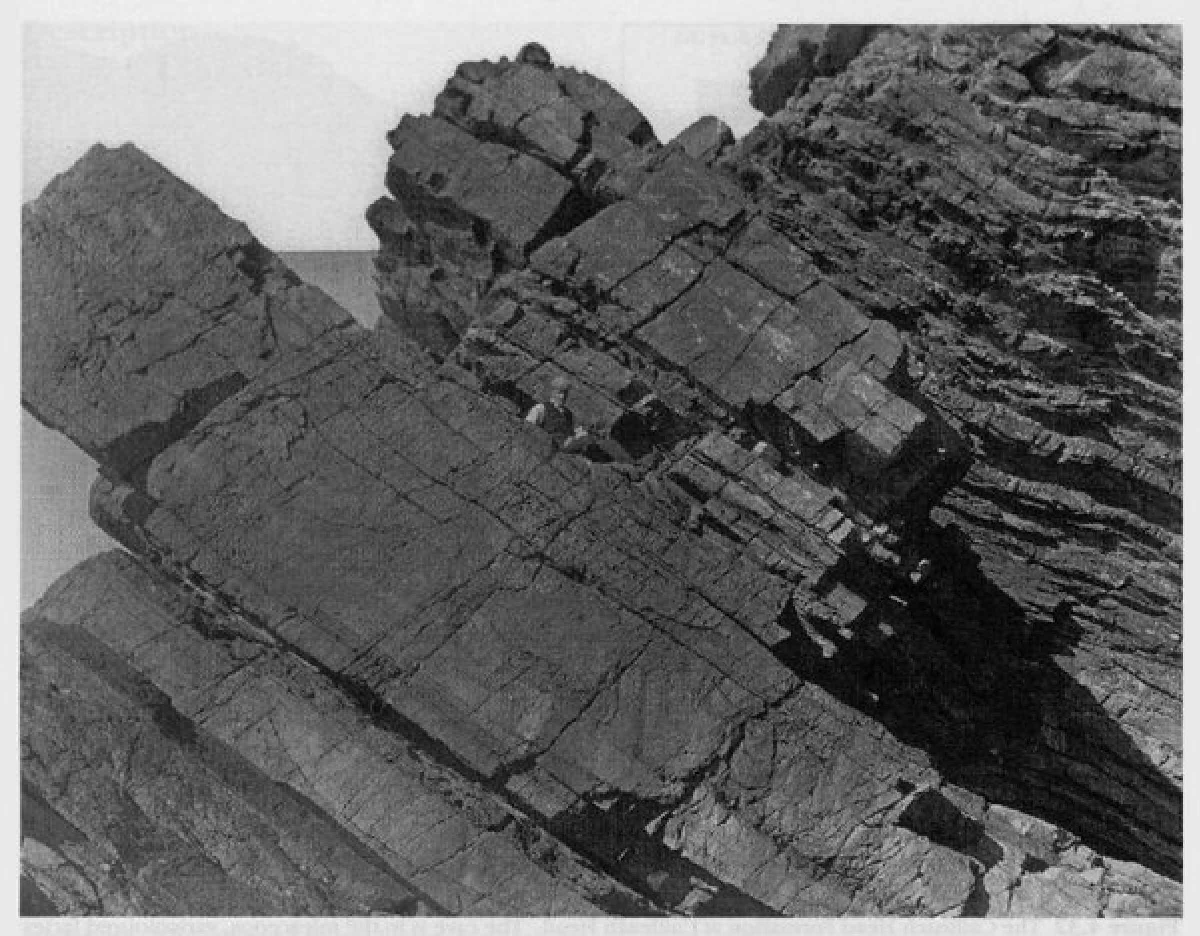
(Figure 4.30) (a) Geological map of the Cailleach Head peninsula (compiled by A.D. Stewart, 1994). (b) Projected true-scale cross-section of the Cailleach Head Formation. After Stewart (2002).



(Figure 4.31) Graphic logs of cyclothems II, III and part of IV in the Cailleach Head Formation at Cailleach Head. The grain-size scale near the top of the log spans +50 to +1 0 units (0.03–0.5 mm).



(Figure 4.32) The Cailleach Head Formation at Cailleach Head. The cave is in the micaceous, varicoloured facies 2b, which forms the top half of cyclothem II. The grassy, boulder-strewn slope in the middle of the photograph covers the siltstone at the base of cyclothem IV The cliff is about 40 m high at this point, 100 m south-west of the lighthouse [NG 985 984]. (Photo: British Geological Survey, No. 216879, reproduced with the permission of the Director, British Geological Survey, © NERC.)



(Figure 4.33) Cyclothem II in the Cailleach Head Formation at Cailleach Head. The sandstones below the man in the photograph belong to facies 1, those above belong to facies 2. The location is the left hand extremity of the cliff shown in Figure 4.32, which corresponds to the 32–44 m interval on the stratigraphical log, Figure 4.31. (Photo: British Geological Survey, No. P216884, reproduced with the permission of the Director, British Geological Survey, © NERC.)