Rubha Leac, Isle of Raasay, Highland

[NG 600 381]–[NG 599 367]

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Introduction

The Rubha na' Leac GCR site exposes an almost complete Upper Pliensbachian section, including one of the thickest developments in Britain of the Spinatum Zone at the top of the Pliensbachian Stage. As such the site has been of enormous importance in the investigation of the evolution and migration of amaltheid ammonites.

Outcrops of the Scalpay Sandstone Formation in the Hebrides rarely expose more than a small part of the total thickness, most usually only the uppermost 10–20 m, as for instance along the eastern coasts of Strathaird and Trotternish. The section on the Isle of Scalpay, from which the formation was named, has not been described recently but is also incomplete, especially towards the top. The only area of the Hebrides with complete sections through the Scalpay Sandstone Formation and contiguous strata are on the eastern side of the Isle of Raasay.

The most accessible section on Raasay is on the north-east corner of Beinn na Leac, a faulted outlier of Middle and Lower Jurassic strata. Here most of the Scalpay Sandstone Formation is exposed on the foreshore and cliffs immediately south of the arcuate fault which defines the outlier. This fault intercepts the coast in a small bay [NG 5994 3802] south of Rubha na' Leac (Figure 8.13). Rubha na' Leac itself is composed of conglomerates and sandstones of the Stornoway Formation (Upper Triassic to basal Jurassic) so that the name given to the Lower Jurassic GCR locality is somewhat inappropriate. There are no details of this locality in the [British] Geological Survey memoir (Lee, 1920), but Howarth (1956, 1958) provided a detailed measured section as well as lists and descriptions of the ammonites. Ager (1956a,b, 1958) discussed and monographed the brachiopods, and Hallam (1967a) described the facies and gave a list of macrofossils from the upper part of the succession. A field guide to the localities is contained in Morton and Hudson (1995).

The most spectacular outcrop and section is at the northern end of the GCR site (Figure 8.14) where the main part of the Scalpay Sandstone Formation forms a cliff (from [NG 5990 3794] to [NG 6004 3788]; section 3 of Howarth 1956, see (Figure 8.13)). Most beds are accessible in *situ* on the south side of the gully associated with the fault at the northern end of the cliff. The section continues upwards to just west of the defined boundary of the GCR site, to include the top beds of the Scalpay Sandstone Formation (at [NG 5987 3793]), the ledge formed by the Portree Shale Formation (not exposed), and the Raasay Ironstone Formation (exposed in an excavation at [NG 5983 3794]). This provides continuity of succession from the Lower Jurassic GCR site Rubha na' Leac into the Middle Jurassic GCR site Beinn na Leac (see Cox and Sumbler, 2002) and has therefore been included in this site description.

At the foot of the cliff, talus and large fallen blocks obscure the part of the succession between the cliff and the extensive outcrops on the foreshore. These fallen blocks can usually be identified with individual beds in the cliff and make available large easily accessible surfaces on which the facies and faunas can be examined. The obscured strata are exposed in an accessible section a short distance to the south, below An Leac (at [NG 5999 3745]; section 2 of Howarth, 1956).

An important outcrop occurs at the boundary between the talus slope and the rocky shore at [NG 6001 3781] approximately 200 m south of the bay. Here the distinctive marker beds identified by Howarth (1956), which enable correlation with other localities, are exposed (see below).

South of An Leac, and still within the GCR site, the succession is repeated by the small arcuate An Leac Fault (see (Figure 8.13)) while landslipping of blocks makes it difficult to decipher the succession. Farther south along the shore from the area shown on (Figure 8.13) towards North Fearns, lower beds of the Scalpay Sandstone Formation (including one with a large *Liparoceras*) and the transition into the Pabay Shale Formation can be observed but have not been documented.

Description

Outcrops of the Scalpay Sandstone Formation occur in two main forms within the area of the Rubha na' Leac GCR site. The upper part of the formation, dominated by massive fine-grained sandstones, forms a cliff about 70 m high which is near-vertical or overhanging. The lower, more silty, part forms the rocky foreshore. Numerous very large fallen blocks abound at the foot of the diff and on the foreshore, obscuring part of the succession, but are useful in complementing the in-situ outcrops. A lower cliff farther south, below An Leac, exposes the obscured middle part of the formation.

The structure of most of the GCR site, north of An Leac (see (Figure 8.13)) is simple, with the beds dipping at less than 10° to just north of west. There is no evidence of faulting, even on a small scale, and the few minor basalt or dolerite intrusions cause only limited baking of sediments. The area lies near the northern limit of the regional thermal effects of the central Skye Palaeocene plutonic centre (Thrasher, 1992).

Towards the southern part of the GCR site the An Leac Fault (Figure 8.13) is an arcuate listric fault, smaller in scale (throw about 30 m down to east) but similar in character to the main Beinn na Leac Fault (estimated throw 300 m). Coherence of the succession has been maintained within the fault block, but rotational landslipping of blocks, indicated by steeper dips, becomes significant farther south. At the northern end of the GCR site a third small fault, with a downthrow of 4 m to the east but decreasing southwards, is interpreted as a branch of the main Beinn na Leac Fault (Figure 8.13), This fault separates the cliff and dip-slope of the main part of the Scalpay Sandstone Formation to the east from the overlying strata to the west and forms a gully leading from north of An Leac towards Rubha na' Leac east of the main North Fearns to Hallaig track.

Within the GCR site, as strictly defined, all the strata are included in the Scalpay Sandstone Formation. The age range is from the Capricornus Subzone (Davoei Zone) to the Hawskerense Subzone (Spinatum Zone), hence spanning the Lower to Upper Pliensbachian boundary. Slight westwards extension of the north-western corner of the site expands the stratigraphical range upwards to include the top beds of the Scalpay Sandstone Formation, the Portree Shale Formation (not exposed) and the Raasay Ironstone Formation. The top bed of the Scalpay Sandstone Formation (exposed at [NG 5987 3793]) can be dated to the basal Toarcian Tenuicostatum Zone. The Portree Shale and Raasay Ironstone formations have not been dated at this locality, but elsewhere have been dated by Howarth (1992) to the Lower Toarcian Serpentinum Zone.

A detailed measured section of the Scalpay Sandstone Formation was given by Howarth (1956) and the succession summarized in (Figure 8.15) is based largely on this, with the addition of some supplementary information. The bed numbers are those of Howarth's (1956) composite succession for Raasay, based on a different locality for beds up to Bed 25. Bed 13 forms the rocky intertidal foreshore and consists of interbedded silty and calcareous fine-grained sandstones exhibiting small-scale (1–2 m) cyclicity. Fossils are uncommon, generally fragmentary, and dominated by infaunal bivalves, but *Aegoceras* sp., indicating the Capricornus Subzone, has been observed. Beds 14–18 were identified by Howarth (1956) as useful marker beds for correlation with localities farther north (see Hallaig Shore and Cadha Carnach GCR site reports). They include two characteristic fissile, laminated micaceous shales crowded with crushed bivalves, especially *Camptonectes* and *Plicatula,* but no ammonites. They are exposed in a small outcrop directly below the second crag of the dig about 200 m south of the bay, at the junction between the beach and the grassy talus slope just above normal high-tide level. The sandstones of beds 19–20, overlying the marker beds, are not well exposed though Howarth (1956) recorded *Oistoceras* sp. of the Figulinum Subzone. Better outcrops occur farther south below An Leac [NG 5999 3745] where calcareous doggers in the lower part of the bed yielded *Androgynoceras brevilobatum* (Howarth, 1956), indicating the Capricornus Subzone. No evidence for the Figulinum Subzone has been found at this latter locality. Bed 21 forms the lower, accessible, part of the lower cliff below An Leac. It consists of thickly bedded silty sandstones and micaceous silty shales that are sparsely fossiliferous with only *Pholadomya* in life position, and *Amaltheus stokesi* indicating the Stokesi Subzone. Small channels cut into the silty sandstones are filled with sandy limestone and crinoid debris. Farther north this bed is covered by talus. The outcrop of Bed 22, sandy micaceous shales and thinly bedded sandstones with *Amaltheus subnodosus* and *A. margaritatus,* indicating the Subnodosus Subzone, is separated from the main northern cliff by a talus slope (gap, Bed 23). The foot of this cliff is formed by Bed 24, of similar lithology, suggesting continuity of facies, with *Amauroceras ferrugineum* (Subnodosus Subzone). Bed 25 is of similar lithology to the underlying beds but with a greater proportion of large calcareous nodules. The sediment is intensely bioturbated, and fossils, including bivalves and pockets of crinoid debris, are concentrated in lenses in the nodules. Ammonites recorded by Howarth (1956) included *Amauroceras ferrugineum, Amaltheus margaritatus* and *Amaltheus gibbosus,* the latter characteristic of the Gibbosus Subzone. Beds 26 and 27 are cleaner, more massive, sandstones with scattered large calcareous doggers and smaller fossiliferous nodules and together form a ledge and overhang in the cliff Bioturbation is intense, with individual trace fossils (including *Thalassinoides*) sometimes recognizable. Ammonites reported by Howarth (1956) are *Amauroceras ferrugineum, Amaltheus gibbosus* and *Amaltheus laevigatus,* with *Amaltheus margaritatus in* the lower part. These are characteristic of the Gibbosus Subzone.

The overlying beds, 27–36, are not accessible in the main cliff, but can be reached by scrambling up the steep gully and grassy slope beside the northern end of the cliff [NG 5993 3799]. However fallen blocks on the talus slope and foreshore can usually be identified to source. Bed 28 is a hard massive sandstone with rows of large calcareous doggers and patches crowded with fossils, usually in nodules which may occur in the sandstone or in doggers. These contain some bivalves but more especially abundant brachiopods, frequently in nests dominated by *Tetrarhynchia tetrahedra* and *Homoeorhynchia acuta* (*see* Ager, 1956a), together with *Pleuroceras solare* of the Apyrenum Subzone. Bed 30 is a distinctive black-weathering bed of hard sandy limestones and calcareous sandstones with common scattered chamosite ooliths, interbedded with black micaceous shales, and containing abundant fossils. Scattered chamosite ooliths are common. These include numerous large *Pseudopecten equivalvis* and *Gryphaea gigantea* together with *Plicatula spinosa, Pholadomya ambigua* and other bivalves. Ammonites include *Pleuroceras solare, Pleuroceras salebrosum* and *Pleuroceras birdi* of the Apyrenum Subzone. The thin beds 31–35 tend to form a ledge and are more muddy and only locally calcareous, with large *Gryphaea gigantea.* The main upper part of the cliff is formed by a thick apparently homogeneous massive fine-grained sandstone (Bed 36) at this locality, but traced laterally to the south can be seen to weather into more thinly bedded units with some cross-bedding and occasional large calcareous doggers. Fossils are extremely rare, but Howarth (1956) recorded *Pleuroceras spinatum* of the Hawskerense Subzone.

Above the main cliff there is an extensive dip-slope (at [NG 5992 3790]) formed by Bed 37, a thinly bedded, more calcareous and argillaceous sandstone with *Pleuroceras spinatum* (Hawskerense Subzone). Bed 37 again crops out at the base of a low cliff [NG 5987 3793] across a gully marking the position of a small fault (Figure 8.13). It is overlain by a massive brown-weathering sandstone (Bed 38), which is similar to Bed 36 and is capped by thinly bedded sandstones of Bed 39. The latter apparently are decalcified and, in places, red-weathering and ferruginous. This top bed of the Scalpay Sandstone Formation contains *Dactylioceras* spp., indicative of the Tenuicostatum Zone, but preservation is not good enough for more precise determination of species and age.

Above the low cliff there is the dip-slope of the top of the Scalpay Sandstone Formation, followed by a ledge that marks the position of the Portree Shale Formation. This is not exposed, but the thickness is estimated at 3 m.

The overlying Raasay Ironstone Formation is exposed in a small excavation (at [NG 5983 3794]) made to test the quality of the ironstone, which is here crinoidal with chamosite mud and ooliths. A thin shale near the top has yielded small unidentified rhynchonellids. No ammonites have been found here, though elsewhere on Raasay they indicate a Serpentinum Zone age (Howarth, 1992). Immediately overlying the Raasay Ironstone Formation are the basal beds of the Dun Caan Shale Member of the Bearreraig Sandstone Formation, described in the Middle Jurassic GCR volume (Cox and Sumbler, 2002). These contain *Pleydellia* spp. and are dated to the uppermost Toarcian Aalensis Zone.

Interpretation

Although the Scalpay Sandstone Formation is named after the Isle of Scalpay, to the south of Raasay, only part of the formation actually crops out there. This GCR locality south of Rubha na' Leac on Raasay provides a more suitable type section, though it has yet to be formally defined. The top of the formation is seen (see above) but not the base, so that a supplementary type section for the base of the formation needs to be defined in the Hallaig Shore GCR site 2 km to the NNW The outcrops within the limits of the GCR site as shown on (Figure 8.13) are entirely within the Scalpay Sandstone

Formation, and this section should be regarded as the primary type section of that formation. However, extending the area of the site slightly enables inclusion of not only the top of the Scalpay Sandstone Formation, but also the Portree Shale Formation (not exposed) and the Raasay Ironstone Formation. It also links this site geographically and stratigraphically with the Middle Jurassic Beinn na Leac GCR site (Cox and Sumbler, 2002).

By far the most important information about the ages and correlations of the Scalpay Sandstone Formation comes from Howarth (1956). This is much more detailed than the information given in Lee (1920) and has yet to be superseded by more recent studies. The ammonites listed in (Figure 8.15), and the positions of the zonal and subzonal boundaries are based largely on those in Howarth (1956), though with some modifications and additions. Dating of Bed 13 to the Capricornus Subzone (Lataecosta Subzone of Howarth, 1956) can be confirmed by a field identification, by M.J. Oates, of a specimen of *Aegoceras* sp.. According to Phelps (1985) *Oistoceras* is confined to the Figulinum Subzone, so that the position of the Figulinum–Capricornus subzonal boundary has been adjusted slightly downwards in (Figure 8.15) from that shown by Howarth (1956). Material collected by Nicol Morton from An Leac and from loose blocks confirms Howarth's records for the Stokesi to Apyrenum subzones. In-situ specimens of *Pleuroceras spinatum* have also been recorded in Bed 37 (not studied by Howarth) from the Hawskerense Subzone and *Dactylioceras* spp. from near the top of Bed 39 in the Tenuicostatum Zone (subzone uncertain), confirming Lee's (1920) conclusion that the Pliensbachian–Toarcian boundary lies within the top of the Scalpay Sandstone Formation.

In terms of facies and depositional environment the Scalpay Sandstone Formation at this locality shows three overall coarsening-up cycles from siltstones to fine-grained sandstones:

1. beds 13 to 20 in the Capricornus to Figulinum subzones, with possible brief anoxic events in beds 15 and 17;
2. beds 21 to 29 in the Stokesi through to Subnodosus and Gibbosus subzones to the lower part of the Apyrenum Subzone.
3. beds 30 to 39 in the upper part of the Apyrenum Subzone through the Hawskerense Subzone to the Tenuicostatum Zone (subzone not identified).

Within several of the beds (e.g. Bed 13) smaller-scale (1–2 m) coarsening-up silty shale to sandstone cycles can also be recognized, though no detailed descriptions have been published.

In general the Scalpay Sandstone Formation was deposited in an environment of normal marine salinity, as indicated by the presence of stenohaline fossils, within a basin into which there was an apparently continuous input of terrigenous sediment from the hinterland. The main exception may have been during deposition of Bed 30, which is unusually fossiliferous and contains chamosite ooliths, perhaps indicating relative condensation and reduced terrigenous input. Sediment was re-distributed from presumed deltaic sources by marine currents and finer-grained parts of the formation were deposited in an environment below normal wave-base. The occurrence of small channels (e.g. In Bed 21) suggests that the sea floor was, at times, above storm wave-base. Cross-bedding can be observed in some places in the sandstone units, notably in Bed 36, suggesting the influence of tidal currents.

Above the Scalpay Sandstone Formation on Raasay there is evidence of an abrupt deepening event, defined as a sequence boundary by Morton (1989), to the black shales of the Portree Shale Formation, dated by Howarth (1992) as Exaratum Subzone. It is likely that part of the Tenuicostatum Zone is represented by a hiatus, though this remains unproven. The Portree Shale Formation forms a grassy ledge at this locality and does not crop out, so that no information can be given other than its estimated thickness of 3 m.

The shales pass up into the Raasay Ironstone Formation, representing another coarsening-up cycle. The age of the ironstone, previously placed in the Bifrons Zone, was revised by Howarth (1992) to the top of the Exaratum Subzone of the Serpentinum Zone. The main interest of this locality for the Raasay Ironstone Formation is the lateral facies change compared with the type section of the formation in central Raasay, 3 km to the south-west. At the main opencast mine in central Raasay the formation consists of thinly bedded and cross-bedded chamosite oolites with ammonites and belemnites, deposited in a shallow marine environment above wave-base (see Morton and Hudson, 1995). On Beinn na Leac it passes into largely crinoidal limestone with a chamositic mud matrix and scattered ooliths deposited below wave-base. The thickness increases slightly from 2.40 m to 2.74 m. The presence of *Pleydellia* spp. in the basal beds of the Dun Caan Shale Member, indicating the uppermost Toarcian Aalensis Zone, is evidence for a major hiatus with most of the Toarcian succession missing above the Raasay Ironstone Formation.

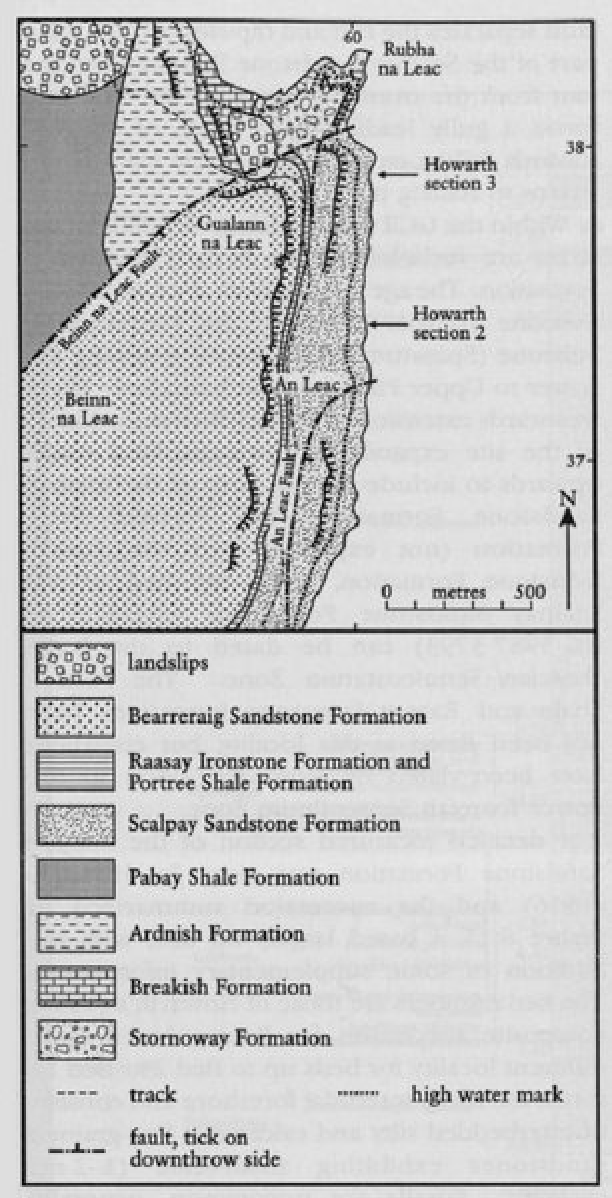
Conclusions

The cliffs and foreshore south of Rubha na' Leac furnish the best section in the Hebrides through most of the Scalpay Sandstone Formation, while to the west outcrops of overlying strata occur. The succession, in the upper part of the Lower Pliensbachian and the Upper Pliensbachian sequence, is complete at subzonal level and thick, especially in the Hawskerense Subzone. However, although fossils are reasonably common, they are discontinuously distributed through the succession, so that precise positions of zonal and subzonal boundaries are uncertain. The site is of great value as an example of Lower Jurassic shallow marine siliciclastic facies, contrasting markedly with the other classic correlative successions of the Dorset and Yorkshire coasts. The succession is typically representative of an early Jurassic subsiding basin sufficiently near to a land area for sedimentation to be almost entirely siliclastic. The outcrops and large fallen blocks provide excellent illustrations of shallow marine silt to fine-sand deposition just below or above wave-base, with intense bioturbation being pervasive.

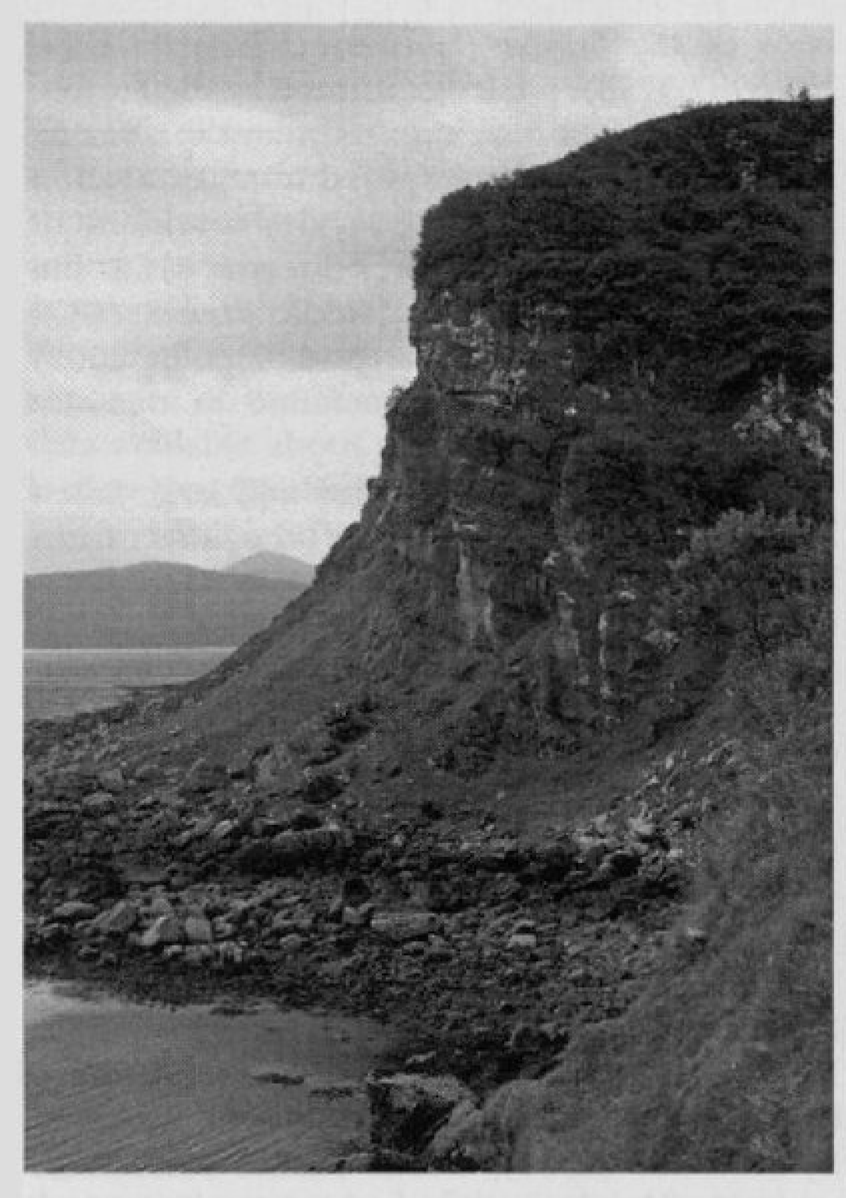
From a palaeontological perspective the most striking feature is the abundance of large bivalves, and especially of *Pseudopecten equivalvis,* together with *Gryphaea gigantea* (both epifaunal), and infaunal bivalves such as *Pleuromya costata* and *Pholmiomya ambigua,* often in life position (see Hallam, 1967a, for a more detailed faunal list). The site is of both national and international significance for its ammonite and brachiopod faunas in particular. It was demonstrated by Howarth (1958) to be of great importance for the biostratigraphy, evolution, taxonomy and palaeobiogeography of the ammonite family Amaltheidae, which dominates the Upper Pliensbachian Substage of Britain. Examples of evolution documented here include the *Amaltheus margaritatus to Amaltheus laevigatus* lineage, and *Amaltheus gibbosus* through *Pleuroceras transiens to Pleuroceras solare.* Brachiopods are also abundant in some beds, usually occurring in large numbers in 'nests'. *Tetrarhynchia tetrahedra* and *Homoeorhynchia acuta* are dominant, but other significant species include *Grandirhynchia grandis* and Zeilleria *quadrifida.* The palaeobiogeographical significance of these was discussed by Ager (1956a), who recognized a distinctive Hebrides Province for Spinatum Zone brachiopods.

Immediately west of the northern limit of the GCR site as defined, the stratigraphical relationships of the Scalpay Sandstone Formation to the overlying Jurassic up to Lower Bajocian succession can be seen. The Pliensbachian–Toarcian boundary can be identified but the characteristic ammonite faunas are separated by 4 m of unfossiliferous strata.

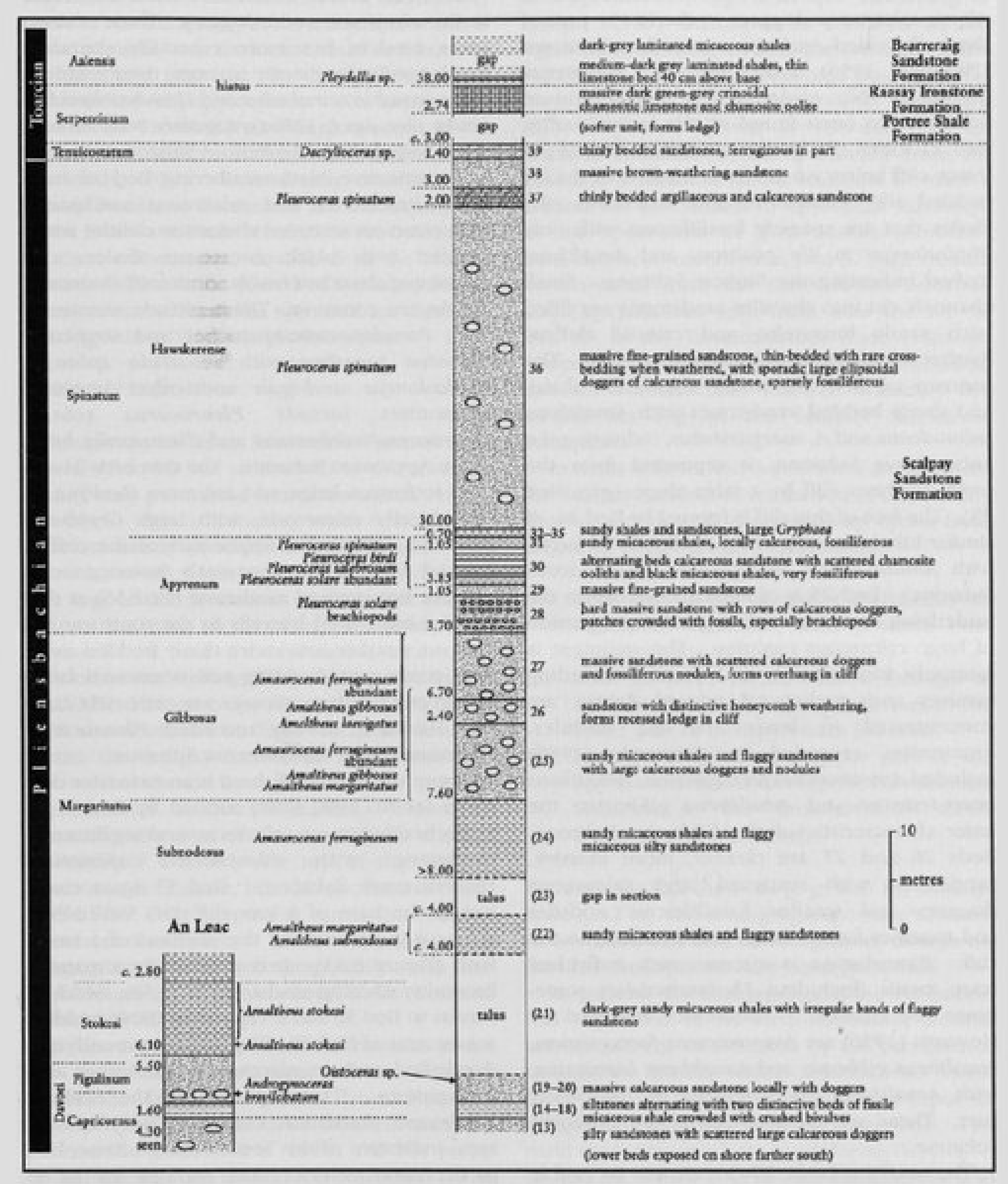
References



(Figure 8.13) Geological map of the northern part of Beinn na Leac and Rubha na' Leac area, showing the main topographic features and localities described in text. The boundary of the notified GCR site is also shown.



(Figure 8.14) Scalpay Sandstone Formation exposed in the cliff at Rubha na' Leac, Raasay. (Photo: N. Morton.)



(Figure 8.15) Succession through the Scalpay Sandstone Formation, Portree Shale Formation (not exposed) and Raasay Ironstone Formation in the shore, cliffs and hillside south and south-west of Rubha na' Leac and the north-east corner of Beinn na Leac, partly modified from Howarth (1956). Bed numbers for the Scalpay Sandstone Formation are those of Howarth's composite measured succession, continued upwards, in brackets where this was based on other localities on Raasay.