Boreraig to Carn Dearg, Loch Eishort, Isle of Skye, Highland

[NG 599 155]–[NG 622 164]

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Introduction

Boreraig was a small settlement, abandoned at the time of the (late 18th to early 19th century) 'Highland Clearances'. The shoreline below the degraded walls of the old blackhouses and the cliffs (Dun Boreraig) and hillside (Beinn Bhuldhe) above have been carved from a complete sequence of rocks of the lower Lias Group, and the Breakish, Ardnish and Pabay Shale formations, although exposure is more limited than in other localities, such as Applecross and around Broadford, where less complete sequences are present. The Loch Eishort cliffs have been largely ignored by previous workers. Arkell (1933) stated that the cliffs here are thermally metamorphosed by Tertiary igneous activity although this is not actually the case. A composite section can be effectively measured from separate outcrops at Boreraig.

The geology of this area of Skye was investigated in the mid-19th century by Geikie (1858) with brief descriptions of some of the Lias Group fossils by Wright (in Geikie, 1858). Further details were published by Peach *et al.* (1910), including a summary section of the Pabay Shale Formation of the Loch Eishort area. A measured section of the lower part of the succession here, traditionally termed the 'Broadford Beds' but now referred to the Breakish and Ardnish formations, was published by Hallam (1959). The work of Oates (1976) formed the basis of the detailed sections published by Hesselbo *et al.* (1998), with amendments to the lithostratigraphical nomenclature and boundaries of the latter based on the comments of Morton (1999a), as outlined in the beginning of this chapter. A brief review and summary log of the site appeared in Hesselbo and Jenkyns (1998) and in Hesselbo and Coe (2000). Hesselbo *et al.* (1998) assigned separate sequences of bed numbers to their Broadford Formation (32 beds), lower Pabay Shale and Hallaig Sandstone Member (71 beds), and the remainder of the Pabay Shale and the Suisnish Sandstone Member (87 beds). These correspond closely to the Breakish, Ardnish and Pabay Shale formations of the present account and the bed numbers are assigned here appropriate prefixes (B, A and P respectively) to distinguish them. Thus the full succession is numbered here as beds B1–B32, A1–A71 and P1–P87 (see (Figure 8.18)). Oates (1976) and Hesselbo *et al.* (1998) established that the Raricostatum Zone here is exceptionally thick and that the site may be suitable for designation as the type locality for the Pabay Shale Formation.

The entire Loch Eishort section is free from any significant structural complication, and along its length only a gentle south-westerly dip is evident. This brings the Suisnish Sandstone Member to shore level at Rubha Suisnish, where it has been worked for stone in historical time, and in which is eroded a large sea-cave.

Access to Loch Eishort is not practically difficult, but it is a long walk from the nearest road at either the head of Loch Slapin, or Heaste. A reasonable footpath is present from Suisnish down the cliff to the foreshore, passing over a prominent picrite dyke of the Tertiary Skye volcanic centre. Tides, in general, are not a factor in accessibility, except for the promontory with the best Obtusum Zone outcrop.

Description

A small marine inlet obscures the base of the Breakish Formation, which overlies red-beds of presumed Triassic or earliest Jurassic age. The succeeding section can be divided into three decametre-scale cycles of peloidal limestone and sandstone. The middle cycle may be a faulted repetition of the lower cycle but, owing to incomplete exposure, this cannot be verified although the successions within each cycle are sufficiently different as to suggest this is unlikely. Although fossil debris is abundant in the Breakish Formation, no ammonites have been found at this site. Keystone vugs and early vadose cement fabrics have been identified in some of the lower limestone beds, with examples from Bed B3 being figured by Hesselbo and Coe (2000). Two fine-grained quartz sandstone beds (B11 and B18) show hummocky cross-stratification.

The actual contact of the Breakish and Ardnish formations is obscured but Hallam (1959) noted the presence of scattered pebbles at the top of his Bed 7 (Bed B32 of this account). At the base of the Ardnish Formation, behind the obvious waterfall where Allt na Peighinn descends to the beach at Boreraig [NG 623 163], a more argillaceous sequence with thin mudstone beds and an abundance of *Gryphaea arcuata* (Bed 8 of Hallam, 1959; Bed A1 of this account) shows a marked similarity to classic Blue Lias Formation facies, such as seen at the Allt Leacach GCR site. The lower part of the Ardnish Formation is a little over 35 m thick here and is dominated by mudstones and argillaceous, micaceous, sandstones that become coarser and more massive upwards. This part of the succession is well exposed along the foreshore and low cliffs of Dun Boreraig, although it is suspected that significant repetition of the succession by extensional faulting may have caused its thickness to be overestimated by Hallam (1959). Both mudstones and sandstones are thoroughly bioturbated with a fully marine fauna including bivalves, brachiopods and ammonites. Hallam (1959) recorded *Arnioceras* aff. *semicostatum* throughout the Ardnish Formation with *Coroniceras lyra* in the lower two-thirds and *Pararnioceras* aff. *parthenope* in the upper third (Hesselbo *et al.,* 1998).

The upper part of the Ardnish Formation forms a distinct lithostratigraphical unit, the Hallaig Sandstone Member, which is just over 45 m thick at this site. It is similar to the underlying beds, but less argillaceous and continues an upward trend to more clean-washed sandstones. Nowhere is its base exposed in the area but a topographic depression at the appropriate level suggests more easily weathered and eroded, possibly muddier, sediments up to 10 m thick. The member comprises well-cemented, fine- to medium-grained sandstone. Hesselbo *et al.* (1998) recognized three cycles grading from thin siltstones and intensely bioturbated muddy sandstones at the base up into strongly cross-bedded sandstones at the top. The bases of the middle and upper cycles are each marked by a thin, poorly sorted sandstone with ferruginous cement and abundant marine fossils. *Arnioceras* sp. is recorded from the lower of these (Bed A50). The top of the member is capped by about 5 m of thinly interbedded coarse sandstone and mudstone, with mud-chip intraclasts and symmetrical ripple marks. Other than the *Arnioceras* sp. already referred to, only *Caenisites* (= *Euasteroceras* of Hallam, 1959) and *Microderoceras* (Oates, 1976) have been recorded from the member although the exact horizon of these is unknown.

An erosion surface at the top of the Hallaig Sandstone Member marks the boundary with the succeeding Pabay Shale Formation, of which about 220 m is exposed at this site. About 10 m of well-bioturbated sandy mudstones, coarsening upwards into a flaggy, very fine sandstone, are seen above the contact and are particularly well-exposed on the promontory, referred to as 'Obtusum Promontory' in Hesselbo *et al.* (1998), about 1.5 km west of the Boreraig settlement. This part of the succession has yielded an abundant ammonite fauna including *Asteroceras stellare, Promicroceras planicosta* and *Xipheroceras* sp., while an ex-situ specimen of *Eparietites* was found above the Obtusum Promontory.

This is succeeded by an unexposed interval, above which the remaining Pabay Shale Formation is present in the cliffs and hillside above the coast between Boreraig and the promontory. Exposure of the upper part is confined to unvegetated patches on the steep hillside and in the bed of Allt Cul an Duin [NG 612 164]–[NG 611 165]. The lowest 13 m (Bed P10) consists of dark-grey, laminated, micaceous mudstones yielding *Oxynoticeras oxynotum* and, near the top, occasional *Bifericeras bifer.* Above an erosion surface at the top of Bed P10 the next approximately 145 m of the succession, which forms the main mass of characteristically grey, crumbling cliff exposure along western Loch Eishort, shows a clear division into three coarsening-upward cycles. These become thicker and coarser towards the top, culminating in the 85 m-thick Suisnish Sandstone Member (beds P30-P64), for which the Loch Eishort section is the type locality. Ammonites, mainly various echioceratid taxa and *Eoderoceras,* occur sporadically throughout this part of the succession. Their stratigraphical distribution was summarized by Hesselbo *et al.* (1998), although none have been recovered from the upper 50 m of the Suisnish Sandstone Member, above Bed P47. A noteworthy marker is an abundance of *Orthechioceras* in a thin bed near the base of the Aplanatum Subzone.

The Suisnish Sandstone Member is succeeded by more than 40 m of medium-grey shale with calcareous and sideritic nodules. Marine molluscs, particularly belemnites and ammonites, are common. Ex-situ ammonite finds from isolated shale outcrops on the hillside below the top of Beinn Bhuidhe include *Apoderoceras* sp., *Platypleuroceras caprarium* and *Uptonia jamesoni,* with the latter also recorded from the Allt Cull an Duin stream section.

A small outcrop of sandstone marks the top of Beinn Bhuidhe and, on the basis of its appearance and lithology only, is assumed to be Scalpay Sandstone Formation (Upper Pliensbachian).

Interpretation

The lowest part of the succession at this site is poorly dated. No ammonites have been recovered from the Breakish Formation here but evidence from other areas of Skye, and from Applecross, indicates that assignment to the Angulata and Bucklandi zones is probable. This suggests that the red-beds immediately below may be lower Hettangian in age although there is no confirmatory evidence for this. At the north-east end of Loch Slapin, a short distance from Boreraig, the lowest Jurassic beds are demonstrably of Sinemurian age, probably Semicostatum Zone, and rest unconformably upon a brecciated, karstic surface of eroded Lower Palaeozoic Durness Limestone (Farris *et al.,* 1999). The Boreraig section itself undoubtedly represents an earlier initiation of Jurassic sedimentation but, nonetheless, is probably still an intermediate stage in progradation up the ramp that culminated at the Loch Slapin exposure, or at a higher elevation as yet unknown. In the succeeding Ardnish Formation the Lyra Subzone is confirmed by the presence of the index species, *Coroniceras lyra.* The remaining subzones of the Semicostatum Zone are unproven but may perhaps be present in the lower part of the Hallaig Sandstone Member and an unexposed 10 m gap beneath. However, ex-situ *Caenisites* and *Microderoceras indicate a* Turneri Zone age for at least part of the Hallaig Sandstone Member. There is clearly a non-sequence above this since the abundant ammonite fauna from the succeeding beds indicate the SteBare and Denotatus subzones, with no evidence for the Obtusum Subzone. The Oxynotum Subzone, indicated by the index species and by *Bifericeras bifer,* is succeeded by a characteristic sequence of Raricostatum Zone ammonite faunas indicating the presence of all four subzones up to the top of the Suisnish Sandstone Member. *Crucilobiceras* indicates the Densinodulum Subzone; *Echioceras* spp. the Raricostatum Subzone; *Leptechioceras* the Macdonnelli Subzone; and *Paltechioceras aplanatum, P. oosteri* and *P. aureolum* the Aplanatum Subzone. Precisely locating the subzonal boundaries is not possible with the available information, particularly in the Suisnish Sandstone Member which, apart from the normally Aplanatum Subzone ammonite *Eoderoceras,* lacks any other diagnostic forms.

Apoderoceras occurs just above the Suisnish Sandstone Member, indicating a position low in the Taylori Subzone. By analogy with the successively thinner Suisnish Sandstone Member sections to the north, on Pabay and Raasay, it is probable that the Jamesoni Zone boundary coincides more-or-less with the gradational top of this sandstone. *Platypleuroceras* occurs at several levels around 20 m higher and indicates the Polymorphus Subzone. The remainder of the Jamesoni Zone and the Ibex Zone probably occupies the 60–70 m of obscured strata between the highest exposed beds (Bed P87) and the Scalpay Sandstone Member outcrop at the top of Beinn Bhuidhe.

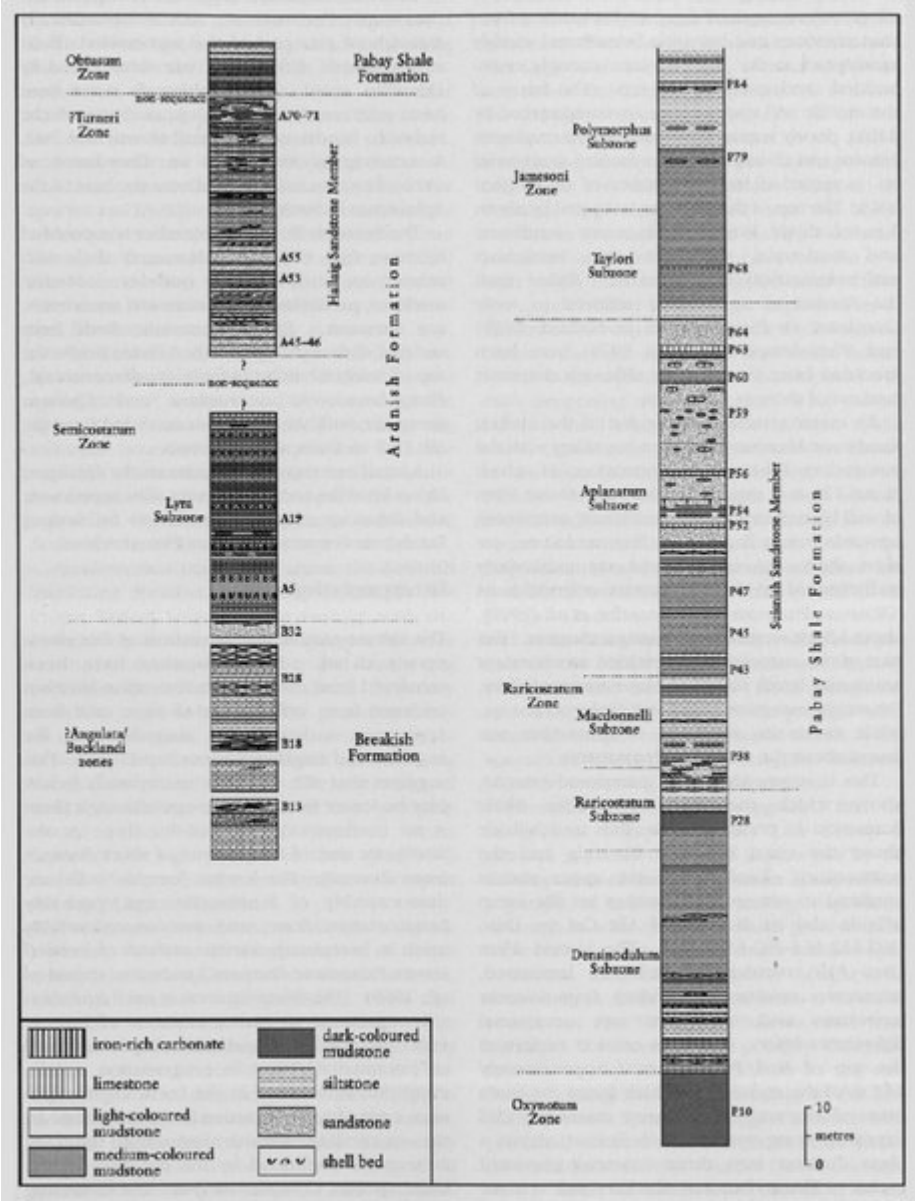
The succession exposed at this site is significant for the overall interpretation of facies changes in the Lias Group of the Hebrides Basin, although there is little published work that is specific to the site. Near the base, in the Breakish Formation, keystone vugs and early vadose cement fabrics identified in some limestone beds were considered by Searl (1989) as evidence of deposition in a littoral environment. A little higher in the succession hummocky cross-stratification is seen in two fine-grained quartz sandstone beds (beds 11 and 18), indicating deposition in shallow marine conditions influenced by storm waves. The change from the deanwashed sandstones of the Breakish Formation to the somewhat muddier sandstones of the succeeding Ardnish Formation are a further indication of increasing depth below wave-base. The larger-scale sedimentary architecture of the succession has been interpreted as evidence for transgressive–regressive cycles of at least regional extent, with Hesselbo *et al.* (1998) recognizing three main cycles corresponding broadly to the Hallaig Sandstone Member, the Suisnish Sandstone Member, and the Scalpa Sandstone Formation. The Hallaig Sandstone Member has been interpreted as estuarine or at least tidally influenced (Hesselbo *et al.,* 1998). Each cycle within it has been explained as an upward-shallowing sequence while the ferruginous bases, with their ammonites and other marine fossils, mark sediment starvation associated with each deepening event. The extent of erosion beneath the Hallaig Sandstone Member at this site is significantly greater here than on Raasay, at the type locality of the Hallaig Sandstone Member. There the ammonite faunas beneath the Hallaig Sandstone Member extend up into the upper Semicostatum Zone, certainly confirming Scipionianum and Resupinatum subzones and possibly the overlying 'Rimed Zone as well. In the Suisnish Sandstone Member the sediment is finer and sedimentary structures less well-developed than in the earlier Hallaig Sandstone Member, which Hesselbo and Jenkyns (1998) interpreted as evidence for deposition of the younger sandstone in deeper water. Marine fossils occur sporadically throughout the Suisnish Sandstone Member, indicating marine deposition.

Hesselbo *et al.* (1998) suggested that the exceptional thickness of the Lias Group in general, superbly illustrated at this site by the development of the Raricostatum Zone, reflects a period of active rifting during deposition, although to what extent the faults present today were active in early Jurassic times remains open to debate. The sediment itself is thought to be derived both from the west, from a Lewisian source on the Hebrides Platform, and from Moinian, Torridonian and possibly Dalradian sources on the Scottish landmass to the east. Marked changes in clay mineralogy at the base of the Ardnish Formation suggest a switch from proximal, smectite-rich sources to more distant illite and kaolinite-rich sources (Amiri-Garoussi, 1977), either as a result of drowning of the irregular basement as the transgression proceeded or as a consequence of exhaustion of the original sources.

Conclusions

The combined exposures at this GCR site afford an almost continuous Hettangian through to Lower Pliensbachian sequence. It is noteworthy for the splendid exposures of the Pabay Shale Formation, with the development of major sandstone units highlighting the large-scale cyclicity of the succession. The Raricostatum Zone, within the Pabay Shale Formation, is substantially thicker at this site than at any other in Britain.

References



(Figure 8.18) Composite section through the Lias Group exposed at the Boreraig to Cam Dearg GCR site, Loch Eishon. After Hesselbo et al. (1998).