Aird na h-Iolaire, Isle of Mull, Argyll and Bute

[NM 404 287]

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Introduction

The sections at the Aird na h-Iolaire GCR site expose a succession from late Triassic terrestrial facies, through the quasi-marine Penarth Group, into the fully marine basal Jurassic Blue Lias Formation facies. As such it is one of only two occurrences of basal Jurassic marine deposits known in Scotland. This is a key site in palaeogeographical reconstructions and for correlation with Lower Jurassic sections in southern Britain. Proven basal Jurassic (lower Hettangian Planorbis Zone) and uppermost Triassic (Norian–Rhaetian) marine sediments are recorded in western Scotland from only two areas; in the Central Ring Complex of the Isle of Arran in south-west Scotland (but see Cope *et al.*, 1980a), and in the south-western part of the Isle of Mull. Only the latter is geographically part of the main area of the Hebridean Jurassic System; palaeogeographically the Arran outcrops may have closer links to Northern Ireland than to the Hebrides Basin. The significance of the Aird na h-Iolaire GCR site in the British Lower Jurassic sequence is that it represents the most northerly outcrop known of the transition between uppermost Triassic and basal Jurassic marine strata, with Planorbis Zone ammonites. This is graphically illustrated by Hesselbo *et al.* (1998). Although the Planorbis Zone has been assumed to be present elsewhere, such as in Applecross (Hallam, 1959), this remains unproven and generally the lowest proven ammonite zone within the Hebridean region north of Mull is the Angulata Zone.

Most of the Isle of Mull is geologically dominated by Palaeocene igneous rocks, including a thick pile of plateau basalt lavas. Exceptions are the Ross of Mull Peninsula and the area around Loch Don in the south and south-east respectively. Elsewhere there are, in places, narrow strips of Mesozoic and older rocks which can be seen along the coast below the basalts. One such area is the Ardmeanach Peninsula, including the Aird na h-Iolaire GCR site (Figure 8.16). Here, between Rubha na h-Uahma [NM 402 279] and Gribun [NM 454 351], Triassic and Lower Jurassic sediments, resting unconformably on Moine schists and overlain unconformably by Upper Cretaceous sediments, occur along the coast below a high cliff of the Palaeocene volcanic rocks. However, most Jurassic outcrops are obscured by landslips from the basalt scarp or are covered by scree and there are few in-situ sections.

The Triassic succession in this area comprises two formations. The Stornoway Formation, consisting of conglomerates overlain by sandstones with calcretes (cornstones), rests unconformably on an uneven surface of Moine Schists. The unfossiliferous red-beds of the Stornoway Formation are overlain by pale-coloured calcareous sandstones, dark sandy limestones and thin layers of black shale containing marine bivalves, including '*Chlamys*' *valoniensis* and *Rhaetavicula contorta.* These beds are classified in the Penarth Group and, together with a locality on the edge of the Central Ring Complex of Arran, provide the only proof of marine Rhaetian in Scotland. Other localities such as Loch Aline (Morvern) have different bivalve faunas and are of uncertain age.

The Lower Jurassic sediments, classified by Oates (1976, 1978) as part of the Blue Lias Formation, can be seen in *situ* in only two areas on the Ardmeanach Peninsula of Mull (Figure 8.16), at the Aird na h-Iolaire GCR site [NM 403 287] and in Allt na Teangaidh east of Balmeanach Farm, Gribun [NM 451 333]. This account will deal with both areas, but concentrate on the defined GCR site at the former locality, because it is the more completely known even though it is much more difficult to access in, aptly named, 'The Wilderness'. The descriptions are based on the [British] Geological Survey memoir (Lee and Bailey, 1925), a PhD thesis (Oates, 1976) and information provided by Michael Oates, Gert Bloos and Geoff Warrington.

The lithostratigraphical terminology used here follows that in Cope *et al.* (1980a), which included use of Penarth Group for the 'Rhaetic' and Blue Lias Formation for the Lower Lias (following Oates 1976, 1978), but with Stornoway Formation used for the rest of the so-called Trias 'New Red Sandstone' following Morton and Hudson (1995).

Access to Aird na h-Iolaire by walking is best achieved by following a footpath westwards from Tavool House [NM 439 271] but remaining above the sea-cliff past the fossil trees and Rubha na h-Uamha to regain the shore south of Aird na h-Iolaire (M. Oates, pers. comm.).

Description

The outcrops of the Lower Jurassic sediments at the Aird na h-Iolaire GCR site are usually obscured by scree and landslipped material where the high scarp of the Palaeocene lavas has slipped on the soft Mesozoic sediments beneath. Oates (1976) identified two episodes of scree formation, with the earlier scree including, in addition to basalt, blocks of Mesozoic sedimentary rocks which included, in places, Blue Lias Formation limestone and shale with the

Hettangian ammonite *Psiloceras* or with lower Sinemurian *Gryphaea arcuata,* together with Upper Cretaceous greensand, white sandstone and silicified chalk (see Lee and Bailey, 1925; Oates, 1976). The younger scree contains only basaltic material.

At Aird na h-Iolaire, apparently in-situ Lower Jurassic sediments crop out on the foreshore and in a low cliff at the foot of the scree slope on both sides of the point [NM 402 288]. The beds are almost horizontal but the sections are not continuous and do not show completely the stratigraphical relationships with older or younger strata. An alternative, though less likely, possibility is that the outcrops may be a more coherent part of the larger Aird na h-Iolaire landslip.

This area of Mesozoic sediments is bounded to the north by a NW–SE-trending fault which cuts the west coast of the Ardmeanach Peninsula at Uamh nan Calmon [NM 405 293] and the south coast near Tavool House [NM 439 271] (Figure 8.16). North of the fault the Palaeocene basalts rest on a thin development (*c.* 3 m) of the Stornoway Formation which lies uncon-formably on Moine Schists. Upper Cretaceous sediments are not mapped by the [British] Geological Survey until 3 km to the north-east (at [NM 434 313]), near where they overstep the Penarth Group southwards to rest directly on the Stornoway Formation (Figure 8.16). Therefore, the Uamh nan Calmon Fault must have a significant pre-Palaeocene downthrow to the south-east. The overstep by the Upper Cretaceous sediments on both sides of the fault, and comparisons with the Camasunary and related faults in the Skye area, suggests that the main movement is likely to be of a pre-Late Cretaceous age (Morton, 1992b). Although mapped by the [British] Geological Survey as cutting the Palaeocene lavas, there is evidence neither for significant displacement of these nor of a topographic feature south-west of Creach Bheinn. By contrast several NNW–SSE faults (Figure 8.16) do displace the lavas and are associated with topographic features.

A coherent stratigraphical succession for the Aird na h-Iolaire area is possible only for short sections in the lower part of the Mesozoic sequence. However, the overall succession here can be reconstructed based on information shown on the [British] Geological Survey map (Sheet 43, Iona) and published by Lee and Bailey (1925).

Paleocene:	basalts (not differentiated here)	
Upper Cretaceous:	silicified chalk (Turanian) white sandstone (?Cenomanian) greensand (?Upper Albian–Cenomanian)	
Lower Jurassic:	Blue Lias limestones and shales with Gryphaea (Sinemurian)	
	Blue Lias shales and limestones with *Psiloceras* and *Liostrea*	*c.* 8 m
Triassic:	Penarth Group sandstones and shales (Rhaetian)	5.80 m
	Stornoway Formation sandstones with conglomerates and cornstones (undated)	*c.* 6 m
		base not seen

There are no coherent sections in the higher beds, so no estimates of thickness can be given. A more detailed lowermost Jurassic succession at Aird na h-Iolaire, based on Oates (1976) and Lee and Bailey (1925), is shown in (Figure 8.17). The strata exposed on the foreshore, partly obscured by mobile beach boulders, are silty bioturbated sandstones (Bed 2) capped by a more calcareous sandstone (Bed 3). These beds are extensively bioturbated but contain only plant remains. Lee and Bailey (1925) recorded 5.8 m of similar strata, with a 0.3 m-thick bed of red mudstone below (Bed 1). The boundary with the overlying beds is obscured by beach debris (Oates, 1976).

In a low cliff at the foot of the scree slope the lowest overlying beds observed are hard calcareous shaly sandstones (beds 5a–c). These become less sandy upwards and pass into alternating soft silty shales and thin argillaceous micritic limestones (beds 5d–j) crowded with *Liostrea hisingeri,* together with poorly preserved other bivalves including *Modiolus hillanus,* in the lower part but with a more diverse fauna, including more variable and more gibbous *Liostrea, Cardinia concinna, Plagiostoma succinta* and *P.* cf. *giganteum,* in the upper part. The thickness indicated by Lee and Bailey (1925; 2.4 m) Is greater than that given by Oates (1976; 1.27 m). Above a soft, brown, silty, micaceous shale are alternating beds of fine-grained, slightly micaceous shales and argillaceous micritic limestone (beds 7–25). The similarity of facies between this part of the succession and the Blue Lias Formation of England and Wales led Oates (1976, 1978) to extend this lithostratigraphical term to part of the Lower Lias of the Hebrides. A detailed measured section for the Blue Lias Formation at Aird na h-Iolaire was given by Oates (1976), and this forms the basis for (Figure 8.17) with the addition of numbers for the individual beds because these can be matched in detail with photographs (figs 2 and 5) in Oates' thesis (1976). The fauna is more diverse, especially near the top of the section in Bed 24 (Figure 8.17), with ammonites including *Psiloceras planorbis* (see below) of the Planorbis Subzone, and bivalves including *Cardinia, Modiolus, Pholadomya, Pinna* and *Plagiostoma.* Oates (1976) also described sandstone channels cutting the shales and limestones and resulting also in disruption of bedding.

Higher Jurassic strata are not seen *in situ* or in stratigraphical continuity with the Hettangian strata. However, Lee and Bailey (1925) recorded fallen blocks in the landslip which suggest the presence of two higher units:

1. grey shales and limestones with *Psiloceras, Liostrea hisingeri* and a 'gryphaeid form' of *Liostrea,* of lower Hettangian age;
2. limestones with typical *Gryphaea arcuata, Plagiostoma giganteum* and *Unicardium cardioides,* interpreted as from low in the Sinemurian Stage.

No evidence has yet been found for the presence of Hettangian strata higher than the Planorbis Zone.

From the cliff above Caisteal Sloc nam Ban (at [NM 435 317]) northwards into the Gribun area and Inch Kenneth, the Stornoway Formation increases dramatically in thickness and the Penarth Group re-appears below the Upper Cretaceous sediments and Palaeocene lavas. In the Gribun area there is an extensive raised beach area underlain mainly by the Stornoway Formation. East of the Balmeanach Farm, in Allt na Teangaidh where the slope begins to steepen [NM 452 332], the Stornoway Formation is overlain by the Penarth Group and black shales of the Lower Jurassic Series. The latter were not described by the [British] Geological Survey but descriptions are given by Oates (1976). This small area of Jurassic sediments does not appear to extend north or south of the Allt na Teangaidh valley.

The Gribun area shows better Triassic sections, both in the Stornoway Formation and the Penarth Group, than are seen at Aird na h-Iolaire. In the latter Manson (in Lee and Bailey, 1925) recorded fish scales and bivalves typical of the 'zone of *Rhaetavicula contorta*', i.e. Rhaetian. There appear to be significant differences between the Rhaetian strata here compared with Aird na h-Iolaire, but details of these are outside the scope of this review. The top of the Rhaetian and the overlying Jurassic were described by the [British] Geological Survey as obscured. However, Oates (1976) described small exposures of Blue Lias Formation facies (confirmed by G. Warrington, pers. comm.) in the banks of the Allt na Teangaidh. The section is not as useful as that at Aird na h-Iolaire, so that only additional facies or faunas at Gribun are commented on here. Oates (1976) described one facies not seen at Aird na h-Iolaire. This is a bed, 0.8 m thick, of light-grey, laminated shales which contain a rich, but low-diversity, bivalve fauna dominated by small, up to *c.* 7 mm in length, specimens of *Modiolus* sp. associated with *Lingula.* The *Modiolus* were interpreted as dwarfed and the fauna as possibly indicating an interval or reduced salinity. The stratigraphical relations of this bed to the Blue Lias Formation of the Planorbis Subzone at Aird na h-Iolaire is uncertain. From an outcrop stratigraphically higher than the laminated

shales, Oates (1976, 1978) figured a specimen of *Caloceras* ? *Johnstoni,* indicating the presence of the Johnstoni Subzone, and hence evidence for faunas younger than the Planorbis Subzone of Aird na h-Iolaire.

Interpretation

The unfossiliferous conglomeratic and sandy 'red-beds' of the Stornoway Formation, at the base of the Mesozoic succession in the Hebrides, are everywhere undated by direct evidence. Other than the palaeomagnetic evidence in the Stornoway area used by Storetvedt and Steel (1977) to correlate these beds with the 'New Red Sandstone', rather than the Old Red Sandstone or Torridonian, only their conformable position below dated Lower Jurassic strata tentatively supports assignment to the Upper Triassic sequence (Morton, 1989). In Skye (Morton, 1999b) the top of the formation is thought to be Hettangian in age, but in the Ardmeanach area of Mull it is overlain by dated Rhaetian and basal Hettangian strata.

Transitional beds between the clearly continental Stornoway Formation and the clearly marine Lower Jurassic (Blue Lias Formation or Breakish Formation) sediments are widespread in the Hebrides. Those in the Ardmeanach Peninsula of Mull differ in two main aspects. The first is that the fauna, dominated by bivalves, includes species such as '*Chlamys*' *valoniensis* and *Rhaetavicula contorta,* which are typical of the Penarth Group of England and Wales. The second is that they are overlain by dated basal Jurassic sediments of the Planorbis Subzone. Similar strata elsewhere in the Hebrides, even in Morvern, tend to be more sandy and have a different bivalve fauna. In some areas at least, they may be of Hettangian age (Morton, 1999b).

Overlying the 'Ostrea Beds' at Aird na h-Iolaire is a 5.80 m-thick succession of interbedded shales and limestones (Figure 8.17) with a more diverse bivalve fauna and, more significantly, ammonites. This was placed in the Blue Lias Formation by Oates (1976, 1978) and correlated with the Pre-Planorbis Beds of, England and Wales (see also Hesselbo *et al.,* 1998). The ammonites occur throughout but Oates (1976, 1978) allocated all of his material to one species *Psiloceras planorbis,* index fossil of the basal Jurassic Planorbis Subzone of the Planorbis Zone.

For the [British] Geological Survey, Manson (in Lee and Bailey 1925) carried out bed-by-bed sampling. The ammonites were submitted to S.S. Buckman who identified several species of *Psiloceras* reported (in Lee and Bailey, 1925) as 'indicat[ing] a zonal succession with tachygenesis of wider umbilication'. Gert Bloos (pers. comm., February 2001) has suggested that, if the identifications can be confirmed, the detailed succession in the Planorbis Subzone of Mull could be one of the most complete in Britain. Further work on the British Geological Survey and Michael Oates' collections, preferably with collection of new material, is required.

The equivalent strata do not appear to be well exposed in the Allt na Teangaidh section, from where Oates (1976) figured a specimen of *Caloceras ? johnstoni* indicating the presence of the Johnstoni Subzone, the upper subzone of the Planorbis Zone. The facies, fauna and possible palaeoenvironmental significance of the bed with dwarfed *Modiolus* from lower in the section were compared by Oates (1976) with an interval in the Johnstoni Subzone of the Stowell Park Borehole in Gloucestershire.

The Triassic to Lower Jurassic succession exposed here represents a clear palaeoenvironmental transition from terrestrial to marine. The basal beds are locally derived breccias deposited by flash-floods near an alluvial fan setting. The overlying conglomerates include lenticles of cross-bedded pebbly sandstones and were deposited in a braided fluvial environment. Some pebbles in this unit are of more distant origin and include clasts of Durness Limestone from a considerable distance to the west (Lee and Bailey, 1925). In the Gribun and Inch Kenneth area the upper part of the formation is dominated by pale-coloured calcite-cemented sandstones, with frequent development of calcretes (cornstones). The formation varies enormously in thickness on the Ardmeanach Peninsula, as elsewhere in Mull and the Hebrides, from over 60 m at Inch Kenneth, opposite Gribun, to 3 m south of Gribun. It was deposited in a terrestrial alluvial fan to braided floodplain environment in a predominantly semi-arid climate which resulted in evaporation of groundwater to form the subsoil calcretes (Steel, 1974a,b).

The sandstones in the lower part of the Penarth Group here, especially at Aird na h-Iolaire, are hard, grey, micaceous calcareous sandstones with silty shales. The absence of fossils other than plant remains, and the extensive bioturbation,

suggests a marginal-marine environment. The succeeding sandy limestones and shales with pyrite and abundant *Liostrea bisingeri* are overlain by beds with a different and more diverse bivalve fauna. Oates (1976) compared these beds with the Pre-Planorbis Beds of England and Wales and both are classified here as the 'Ostrea Beds'. They record the latest Triassic marine transgression across this area, as in England and Wales. At Allt na Teangaidh the shales and limestones are thicker (Manson in Lee and Bailey 1925, recorded 15 beds) and have a more diverse fauna of Rhaetian bivalves and fish scales. There appear to be significant differences of detail between the Allt na Teangaidh and Aird na h-Iolaire sections, although both environments were marine and below wave-base.

The Blue Lias Formation at this locality was described by Oates as his 'Blue Lias Facies Type 1', characterized by a low carbonate content and fine-grained mud sediment. The limestones are argillaceous with mostly sharp, planar bedding surfaces. The shales are softer, dark in colour with small detrital mica flakes and strongly compacted, though not laminated. Differential compaction is evident (Oates, 1976). Fossils are unevenly distributed through the sediment, but generally more abundant in the limestones, especially the uppermost limestone of Bed 24. Ammonites of one or more species of *Psiloceras,* including *P. planorbis,* were reported both by Lee and Bailey (1925) and Oates (1976) as occurring throughout; in the limestones they are preserved with the body chambers filled with sediment and uncrushed but the phragmocones hollow and crushed. The bivalves are mostly disarticulated but unbroken and include infaunal and epifaunal elements such as *Cardinia, Pholadomya, Modiolus* and *Plagiostoma.* The semi-infaunal genus *Pinna* occurs at several levels, but always preserved parallel to bedding. In addition fragments of indeterminate pectinid bivalves, cidaroid radioles, crinoid ossicles, the ostracod *Ogmaconcha* and lignite fragments are reported. The disarticulation of the bivalves and absence of lamination suggest extensive bioturbation of the sediment, though no recognizable trace fossils have been identified. Deposition was clearly below wave-base in a fully marine environment, but not in anoxic conditions. Depth of depositional environment and distance from shore cannot be deduced solely from the nature of the limestone–mudstone interbeds. However, these interbeds are cut by two small sandstone-filled channels eroded into the shale (Oates, 1976). The sandstones are immature and glauconitic and have longitudinal flute casts at their base. Disruption of the limestone–mudstone beds is interpreted by Oates as due to contemporaneous local deposition of more porous sand subsequently influencing carbonate deposition, rather than a product of compaction effects. The field evidence indicates that the channels are aligned east–west and they may represent tidal washout structures associated with rip currents (Oates, pers. comm.). Such an interpretation implies that deposition was not in deep water and not far from the shore, in a restricted tidally influenced basin.

Strata in the Allt na Teangaidh section at Gribun are less clearly exposed so that few comparisons can be made. However, Oates (1976) described light-grey laminated shales with apparently dwarfed *Modiolus* which are unlike any of the shales in the Aird na h-Iolaire section. It is possible that they are younger in age aohnstoni Subzone). Oates' (1976) suggestion of local near-shore development of a lagoonal environment with slightly reduced salinity would be consistent with the suggestion above of a restricted basin.

Overall, the presence of marine basal Jurassic and quasi-marine Penarth Group strata on Mull contrasts with the situation on Skye and Applecross to the north, where the lowest ammonite-bearing strata can be assigned to the Angulata Zone. It suggests that these northern areas were emergent during late Triassic and earliest Jurassic times, while the presence there of calcareous sandstones with coral-bearing horizons suggests shallower-water deposition in late Hettangian and early Sinemurian times, in contrast with the more typical Blue Lias Formation facies farther south.

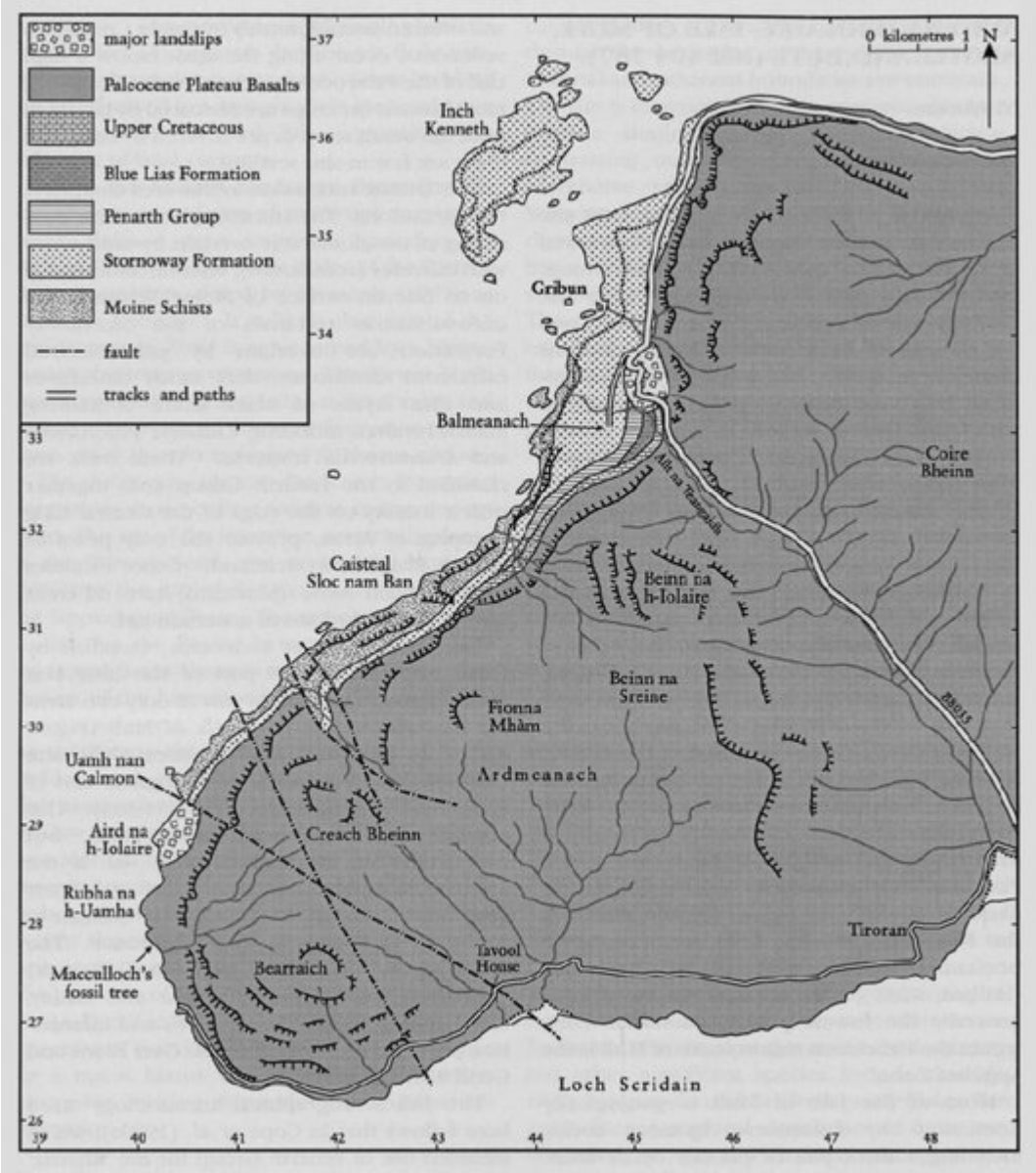
Conclusions

The greatest significance of the Aird na h-Iolaire GCR site is in being almost the only outcrop in Scotland known to show a good fossiliferous section through basal Jurassic sediments with lowermost Hettangian, Planorbis Subzone, ammonites. The detailed ammonite succession merits further investigation. In the wider context of the Ardmeanach Peninsula (i.e. taking account also of the outcrops farther north around Gribun) the area also demonstrates evidence for:

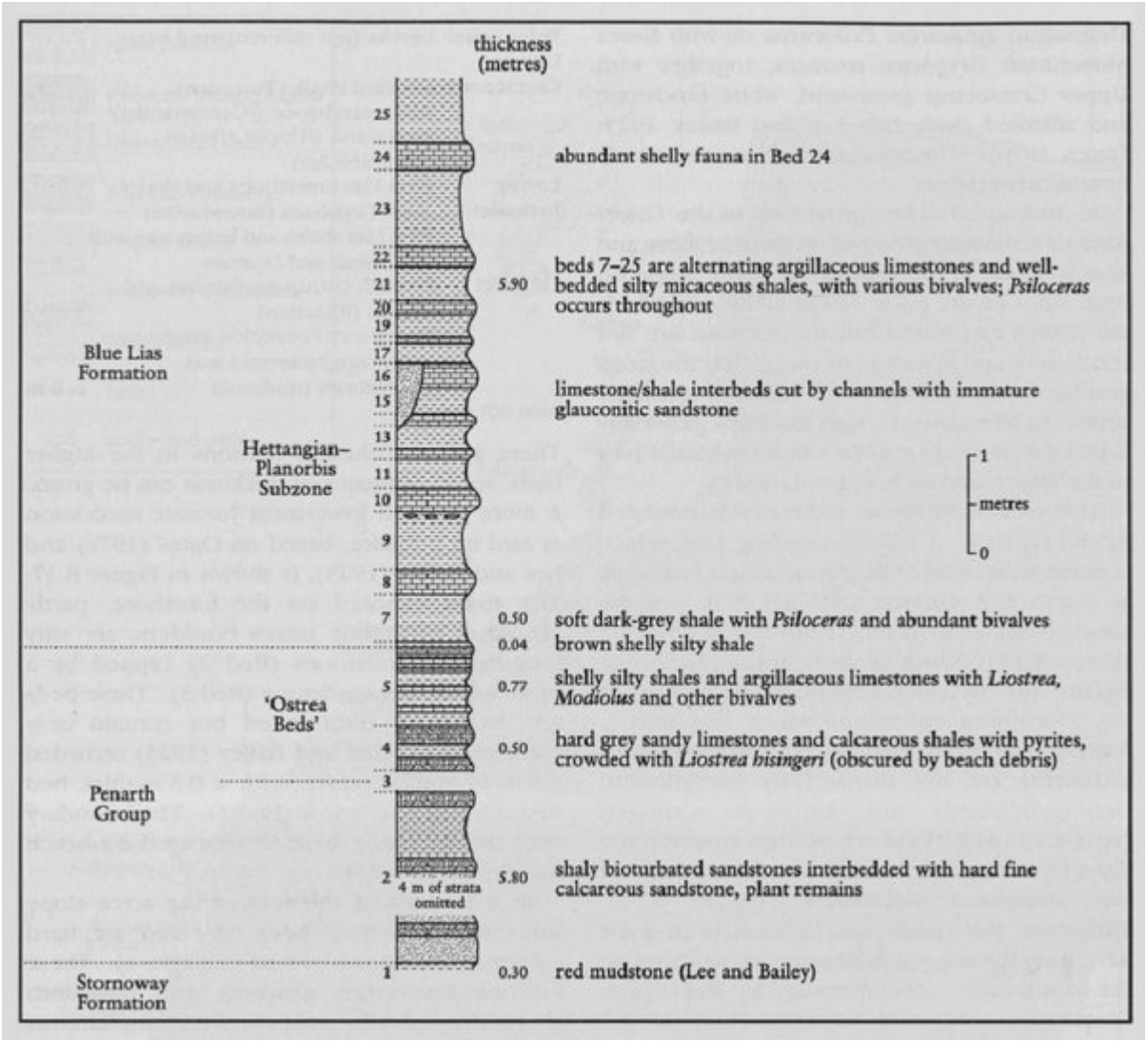
1. Differential subsidence with stratigraphical thickening and lateral facies change during late Triassic times, both in the Stornoway Formation and in the Penarth Group.

2. Late Triassic (Rhaetian) transgression into the southern part (at least) of the Hebrides Basin resulting in deposition of marine Rhaetian sediments that can be dated biostratigraphically in the black shales and limestone of the Penarth Group.
3. Evidence that the Blue Lias Formation sediments, normally interpreted as deposited in an offshore environment, were in this area deposited in a more restricted basin where the shoreline of the Scottish landmass was not far distant.
4. The NW–SE Uamh nan Calmon Fault in the south-western part of the Ardmeanach Peninsula is a Mesozoic fault with pre-Late Cretaceous movement. The contrasts of succession and facies in the Rhaetian and Hettangian sediments between Aird na h-Iolaire and Gribun may suggest that earlier phases of movement could also have occurred.

References



(Figure 8.16) Simplified geology and topography map of the western part of the Ardmeanach Peninsula, western Mull. The two main localities discussed, Aird na h-Iolaire and Allt na Teangaidh, Gribun, are indicated.



(Figure 8.17) Uppermost Triassic and lowermost Jurassic measured succession just south of Aird na h-Iolaire, based mainly on Oates (1976) with additional data from Lee and Bailey (1925) and Oates (1976). The bed numbering is added here for reference.