
Ob Lusa to Ardnish Coast, Isle of Skye, Highland

[NG 701 248]–[NG 676 245]

N. Morton

Introduction

The Ob Lusa to Ardnish Coast GCR site lies on the foreshore on the eastern side of Broadford Bay on the Isle of Skye. Here an extensive low-lying area is underlain by Lower Jurassic sediments, including the Ardnish Peninsula, the crofting townships of Waterloo, Lower and Upper Breakish (part), and extending east to the Isle of Skye airfield and Ob Lusa (Figure 8.3). This GCR site is probably the best-known Lias section in the Hebrides Basin. It exposes one of the most extensive and readily accessible sections through the Hettangian and Lower Sinemurian succession of the region. It includes the type locality for the carbonate-dominated Breakish Formation, with its remarkable coral beds, and the more clastic-dominated Ardnish Formation, contrasting markedly with the correlative Blue Lias Formation developed across much of Britain. The Ob Lusa Coral Bed represents the only extensive development in the British Lias of *isastraeid* corals.

The Jurassic rocks in central Skye are folded into a broad syncline and anticline, of Tertiary age, but to the north and north-east these folds die out and on either side of Broadford Bay the rocks show the simple north-westward tilting which is typical of most of the Hebridean Jurassic sequence. The low dips and extensive coastal outcrops expose large bedding surface areas that provide excellent opportunities to study the typical facies and faunas of the Lower Lias of the northern Hebrides. These include coral beds and oolitic ironstones as well as a variety of carbonates and siliciclastic sediments, some of which are richly fossiliferous. The best outcrops, giving almost continuous successions through more than 75 m of Hettangian (Angulata Zone) to Lower Sinemurian (Semicostatum Zone) strata occur in and adjacent to the Ob Lusa to Ardnish Coast GCR site, on the east side of Broadford Bay, between Ob Lusa [NG 701 248] and the Ardnish Peninsula ([NG 676 245] for GCR site, but extending south-west to Waterloo [NG 660 235] (Figure 8.3).

The Lower Lias of the Broadford area of central Skye has a long history of investigation, most notably by Judd (1878) and the [British] Geological Survey (Peach *et al.*, 1910). More recent accounts with detailed measured sections include those by Hallam (1959), Sean (1992, 1994), Morton and Hudson (1995) and Hesselbo *et al.* (1998). The outcrops in this area are the most easily accessible Jurassic outcrops in the Hebrides. They are also the most frequently studied, by generations of geologists at all levels of experience - amateurs and tourists on holiday, students on field classes and professional geologists on field studies. An excursion guide is given by Morton and Hudson (1995).

Broadford is the type area of the Broadford Beds, the lithostratigraphical name introduced by Woodward (in Peach *et al.*, 1910) for the lowest marine Jurassic succession in the Hebrides. More recent revisions of the lithostratigraphical nomenclature by Oates (1978), Hesselbo *et al.* (1998, 1999) and Morton (1999a,b) are discussed below. The GCR site includes the type section of the carbonate-dominated Breakish Formation, the lowest part of the marine Lower Lias in this area. Named after the township of Breakish, the type section is defined as the headland on the west side of Ob Lusa with the base at [NG 6998 2492] and the top at [NG 6972 2512] (Morton 1999b). The succeeding strata are clastic-dominated and crop out extensively on the Ardnish Peninsula, particularly in the coastal areas. It is not yet formally defined but is termed here the 'Ardnish Formation'. The base is seen in a small inlet on the south side of the peninsula [NG 6796 2422] but the top is not seen in the peninsula.

Description

The Broadford area is part of one of the Hebrides tilted fault-blocks, formed during early Cretaceous times (Morton, 1992b), and the beds dip at low angles generally of less than 10° to the north-west. The outcrop is cut by numerous small faults of Palaeogene age, most with a north-west–south-east trend and a downthrow of only a few metres to the north-east. Numerous minor intrusions include dolerite sills, sometimes intruded along particular stratal surfaces, and

dolerite and felsite dyke-complexes, sometimes associated with the minor faults. These cause only very local baking of the sediments, but in addition to the effects of burial diagenesis (Searl, 1994) the area is close enough to the Palaeogene plutonic centre of central Skye to have suffered slight thermal metamorphism (Lewis *et al.*, 1992).

Detailed measured sections through the Jurassic succession at the site are given by Morton and Hudson (1995) and by Hesselbo *et al.* (1998). Though differing in detail of individual beds, most can be reconciled as shown in (Figure 8.4) and (Figure 8.5). The succession, traditionally classified as 'Broadford Beds', always divided into two units, is now formally recognized as two formations.

The lower, carbonate-dominated, unit, the Breakish Formation, was variously termed the 'infra-Lias' by Judd (1878), the 'Lower Broadford Beds' by Hallam (1959), and the 'Broadford Formation' (in a more restricted sense) by Hesselbo *et al.* (1998). In the light of subsequent discussion it was re-named as the 'Breakish Formation' in its present sense, by Morton (1999b). The best section (Figure 8.4) lies on the west side of Ob Lusa where the unit is 34 m thick, but the succession can be correlated in detail across to the Ashaig Burn and Breakish (Figure 8.3). The base is seen only at Ob Lusa (between beds 1 and 2 of Morton and Hudson, 1995): and is not exposed elsewhere. The Breakish Formation contains several distinctive beds which form useful marker horizons. The Ob Lusa Coral Bed (Bed 6 of Morton and Hudson, 1995; Bed 2 of Hesselbo *et al.*, 1998) contains numerous subspherical colonies of the compact colonial coral *Heterastraea murchisoni*, many of them *in situ*, together with bivalves, especially *Liostrea* and various pectinids, and gastropods. However, the coral bed has suffered severely from over-collecting in recent years and little *in situ* material can now be seen (MacFadyen, 2001). The overlying beds show hummocky cross-stratification and a wave-sorted shell bed with *Cardinia*. Oates (1976) found the only ammonite recorded *in situ* in these beds, a *Schlotheimia* sp. about 3 m below the top. It indicates a late Hettangian, Angulata Zone, age. Near the top of the Breakish Formation is the Ob Breakish Coral Bed (Bed 12 of Morton and Hudson, 1995; Bed 14 of Hesselbo *et al.*, 1998). It contains thicket-like colonies of the loosely branching coral *Thecosmilia martini* at Ob Breakish, but at Ob Lusa has passed laterally into a cross-bedded shelly limestone with rare coral fragments. Shales and limestones overlie the Ob Breakish Coral Bed but are not well exposed at either Ob Lusa or in the Ob Breakish inlet, with a dolerite sill intruded at this level at both localities. The top of the Breakish Formation is characterized by a thick calcareous quartzitic sandstone, cross-bedded in places, which forms the headland west of Ob Lusa and a prominent scarp on the north side of Ob Breakish. The top 1.5 m becomes conglomeratic, with mainly quartz pebbles.

The upper, clastic-dominated unit is the Ardnish Formation, comprising shales, siltstones and sandstones which characteristically are highly micaceous and ferruginous. It crops out extensively in the intertidal zone and small islands of the Ardnish Peninsula, but numerous small faults make reconstruction of a complete sequence difficult. Estimates of the total thickness, excluding the top beds (Bed 31 of Morton and Hudson, 1995), range from 36 m (Hesselbo *et al.*, 1998) to 42 m (Morton and Hudson, 1995). This unit was re-classified as part of an extended Pabay Shale Formation by Hesselbo *et al.* (1998), but an alternative classification, as the Ardnish Formation', was suggested in discussion of this paper by Morton (1999a, and reply by Hesselbo *et al.*, 1999) and is being adopted here and for the revision of the British Geological Survey 1:50 000-scale maps. To reflect this change in nomenclature bed numbers on (Figure 8.5) have been revised from those given in Morton and Hudson (1995).

In a small inlet on the south side of the Ardnish Peninsula [NG 6796 2422] outcrops of the basal beds of highly micaceous silty shales vary according to the state of the beach. Hesselbo *et al.* (1998) recorded a gap of 5–6 m (plus their Bed 1), but on different occasions this has been much less (beds 1 and 2 with a smaller gap). The facies change to highly micaceous sediments, and the incoming of *Gryphaea arcuata*, marks the base of the Ardnish Formation. However, dating of this boundary to the basal Sinemurian Bucklandi Zone (after Hallam, 1959) or to the Semicostatum Zone is uncertain. The overlying beds 4 to 7 (Figure 8.5) contain numerous fossils. In addition to *Gryphaea arcuata*, the calcareous silty sandstone pavements contain frequent very large *Coronkeras lyra* of the Lyra Subzone, Semicostatum Zone. Two beds of red-weathering oolitic ironstone contain berthierine ooids and a rich fauna including the ammonites *Coroniceras* and *Arnioceras*, the small rhynchonellid *Piarorhynchia juvenis*, and numerous bivalves including *Chlamys calva* and *Plagiostoma giganteum*. The higher, and thicker, of these ironstones (Bed 7 of the Ardnish Formation) is known as the Ardnish Ironstone'. Above the ironstone are numerous coarsening-up shale–siltstone–sandstone cycles extending through some 10 m of the succession. Large *Coroniceras* occur in the lower part, while small phosphatic nodules and phosphatized body chambers of *Arnioceras* are common, together with *Gryphaea* and other bivalves and

trace fossils. Both Morton and Hudson (1995) and Hesselbo *et al.* (1998) recorded a gap in the succession. This is presumed to correspond to an interval of shales, but higher parts of the measured sections are more difficult to reconcile, presumably because of problems of correlating across the numerous small faults in the absence of useful marker beds. The facies remain similar, with micaceous siltstones and sandstones containing ammonites mostly preserved as body-chamber moulds. *Agassiceras* and *Euagassiceras* replace *Arnioceras* as the most common, and indicate higher subzones within the Semicostatum Zone. Bed 13 (Figure 8.5), subdivided into their beds 12 to 25 by Hesselbo *et al.* (1998), forms a prominent scarp striking towards the most northerly point of the peninsula. Details of the highest beds cropping out in the intertidal zone to the north-west are not recorded in either of the measured sections, but the youngest ammonites recorded still belong to the Semicostatum Zone.

Interpretation

Lithostratigraphical subdivision of the traditional Broadford Beds into two units is now accepted by consensus by those who have worked on this part of the Hebridean Jurassic sequence in recent years, with the lower unit being re-named the 'Breakish Formation' (Morton, 1999b). However, lithostratigraphical classification of the upper unit, as part of an enlarged and revised Pabay Shale Formation (Hesselbo *et al.*, 1998) or as a separate Ardnish Formation is not yet agreed. The latter is used here and has been adopted for the revision of the British Geological Survey maps.

The age of the succession and correlation with other sites has been discussed by Morton (1999b). Trueman (1942) concluded, largely on the basis of the bivalve faunas, that the Ob Lusa Coral Bed and overlying strata up to the Ob Breakish Coral Bed belonged to the Angulata Zone. The *Schlotheimia* found 3 m below the Ob Breakish Coral Bed (Oates, 1976) at least partly confirm this. The two coral beds are useful marker beds that can be correlated to Applecross, where Lee (1920) recorded *Schlotheimia* cf. *montana*, indicating the Angulata Zone, from near the level of the Ob Lusa Coral Bed. Although neither coral bed can be recognized at Hallaig on Raasay, an oolite marker bed below the Ob Lusa Coral Bed at Applecross is present at Hallaig though not in the Broadford area. These marker bed correlations support the interpretation that the base of the Breakish Formation in the Broadford area falls within the Angulata Zone, and hence is younger than the base of the formation at Applecross and Hallaig. Consequently the upper part of the continental red-bed facies (Stornoway Formation) in the Broadford area is interpreted as Jurassic in age.

The sandstones above the Ob Breakish Coral Bed in Applecross yielded a *Coroniceras coronaries* to Lee (1920), since re-identified as *Coroniceras caesar*, a form characteristic of the middle part of the Conybeari Subzone (Morton, 1999b). Consequently, the upper part of the Breakish Formation in Ob Lusa and Ob Breakish is also interpreted as belonging to the Bucklandi Zone. However, the precise position of the Hettangian–Sinemurian boundary remains uncertain. The Breakish Formation can be traced south-westwards from Ob Lusa towards Heaste and Loch Eishort, with both coral beds recognized though the sandstones become generally coarser grained.

In the succeeding Ardnish Formation ammonites are fairly common throughout the sequence. However, most frequent are small- to medium-sized body chambers of *Arnioceras* which are of only limited biostratigraphical value. Hence, although the whole of the formation exposed in the Ardnish Peninsula can be assigned to the Semicostatum Zone, the precise positions of the base of the zone and of subzonal boundaries remain less certain. Beds 3–6 are characterized by common large (> 35 cm diameter) *Coroniceras lyra* (Lyra Subzone). A large (> 40 cm diameter) specimen of *Agassiceras superbum* was found in Bed 12 on the north coast of Ardnish, indicating the Scipionianum Subzone, while *Euagassiceras* occurs in the upper part of Bed 13 and above and indicate the Sauzeanum Subzone. Elsewhere in Skye (Loch Eishort) and on Raasay (Hallaig) the Ardnish Formation, as used here (cf. Hesselbo *et al.*, 1998), encompasses younger strata, including the Hallaig Sandstone Member, which range up to the Turneri Zone.

The Breakish Formation in the Ob Lusa to Ardnish Coast area consists of limestones and clean (non-muddy) sandstones, with only subordinate shales. They are interpreted as having been deposited in generally shallow marine, near-shore environments with varying input of siliciclastic sand from adjacent land areas. This produced pure carbonates, especially the coral beds, when siliciclastic input was low, and quartz sandstones or sandy limestones when siliciclastic input was higher. Most beds contain stenohaline fossils, such as bivalves, gastropods and echinoderms, as well as the corals, indicating deposition in fully marine conditions. Cross-bedding in some beds, notably the top sandstone and the

Ob Breakish Coral Bed at Ob Lusa, indicate deposition by marine tidal currents. Hummocky cross-stratification, indicative of the influence of storms, occurs in the beds above the Ob Lusa Coral Bed.

A characteristic feature of most of the succeeding Ardnish Formation is the almost ubiquitous occurrence of detrital mica. Lithologies range from micaceous shales through siltstones to sandstones, which tend to be muddy rather than the purer quartz sandstones of the Breakish Formation. The two formations provide a classic example of the contrasts between Hallam's (1975) ferruginous and calcareous facies associations. Berthierine ('chamosite') oolites occur in several beds in the lower part of the succession (Searl, 1992) and are sufficiently abundant in two of these towards the base of the formation for them to be termed 'ironstones'. At several levels metre-scale coarsening-up cycles occur.

Fossils occur throughout but are abundant only in some beds, with layers rich in *Gryphaea arcuata* being especially characteristic. The faunas consistently include stenohaline groups such as ammonites and echinoderms indicating deposition in normal marine salinity. The sediments were deposited in an offshore shelf environment below or close to wave-base. Because the upper part of the succession is missing, the upward change to sandstones is less fully developed in Ardnish than elsewhere in Skye or Raasay.

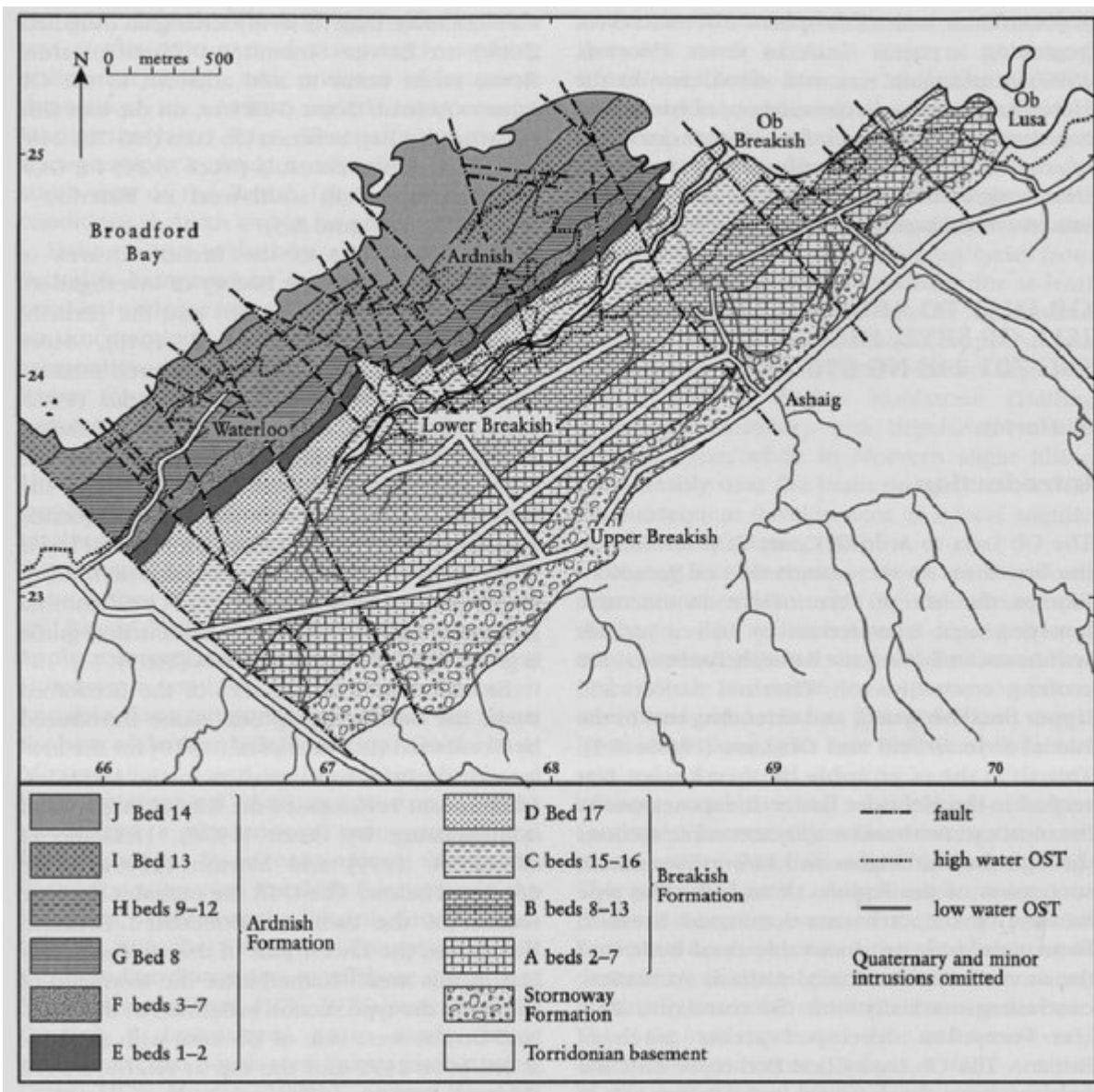
Conclusions

The Ob Lusa to Ardnish Coast GCR site includes the foreshore parts of two main areas of outcrop separated by the Isle of Skye airstrip (construction of which obscured some outcrops between). The two areas are complementary in showing different parts of the Hettangian to lower Sinemurian succession in the classical lacks of the northern Hebrides Lower Lias.

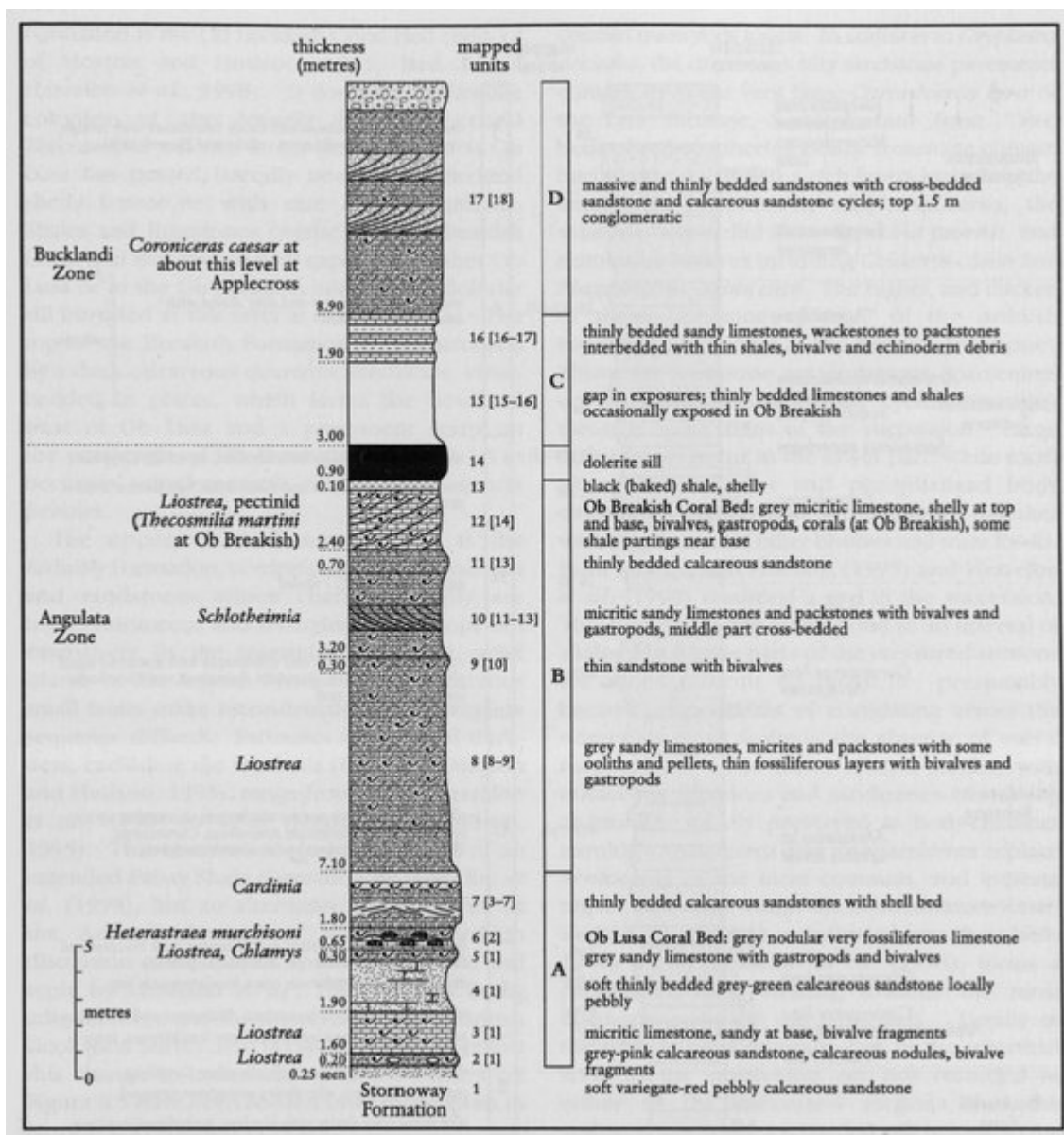
Ob Lusa and the headland to the west shows the best and most accessible section of Hettangian to basal Sinemurian sediments in the Hebrides, and is the type locality of the Breakish Formation (formerly the 'Lower Broadford Beds'). Sedimentological interest lies in the mixing and alternation of shallow marine carbonates of various types and quartzose sandstones. Of greatest palaeontological interest is the Ob Lusa Coral Bed, with subspherical colonies, mostly 10 cm to 25 cm in diameter, of *Heterastraea murchisoni*. The upper part of the Breakish Formation is discontinuously exposed on both sides of Ob Breakish south of the Ardnish Peninsula. Outcrops of the Ob Breakish Coral Bed, with large masses of the branching colonial coral *Thecosmilia martini*, occur at high-water mark below the eastern end of Lower Breakish.

The Ardnish Peninsula, and especially the intertidal and supratidal shore zone and small islands at the eastern end included in the GCR site, shows very extensive outcrops of the lower Sinemurian Semicostatum Zone in the Ardnish Formation (formerly the 'Upper Broadford Beds'). The broad flat rocky platforms enable study of large areas of bedding plane in the micaceous silty shales, siltstones and silty sandstones. The Ardnish Ironstone and a lower, thinner bed are very fossiliferous iron-bearing oolites. Fossils include numerous ammonites, especially large *Coroniceras* in the lower part, and *Arnioceras* and *Agassiceras* in the upper part, together with epifaunal and infaunal bivalves, layers with abundant *Gryphaea*, and brachiopods locally.

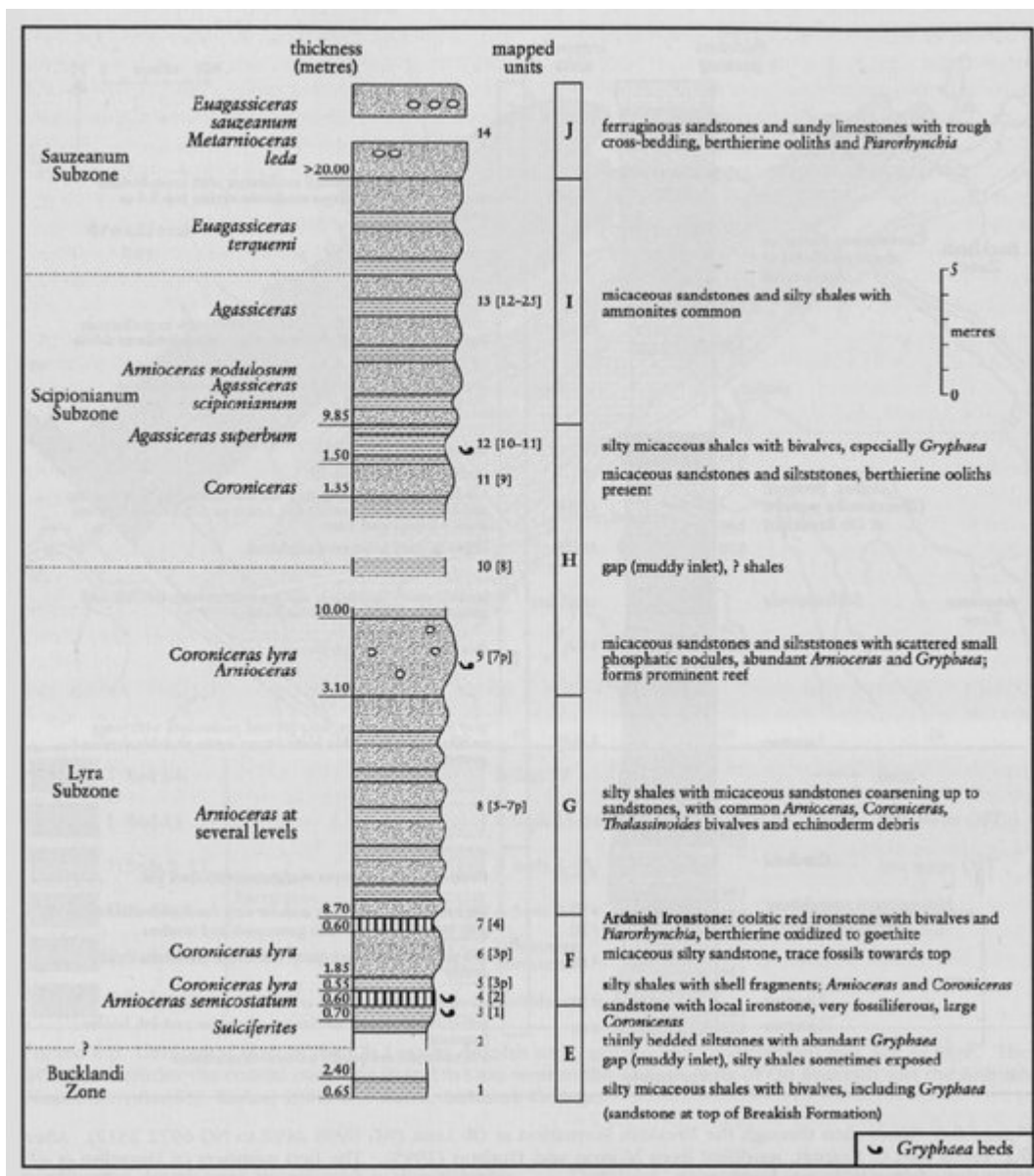
[References](#)



(Figure 8.3) Geological map of the Ob Lusa to Ardnish area, eastern part of Broadford Bay, Isle of Skye. The GCR site includes the coastal outcrops from Ob Lusa west to the eastern parts of Ob Breakish and the Ardnish Peninsula. After D.J. Taylor, 1981, BSc thesis, Birkbeck College.



(Figure 8.4) Succession through the Breakish Formation at Ob Lusa [NG 6998 2492] to [NG 6972 2512]. After D.J. Taylor and C. Cointet, modified from Morton and Hudson (1995). The bed numbers of Hesselbo et al. (1998) are shown in square brackets.



(Figure 8.5) Succession in the Ardnish Formation in the Ardnish Peninsula. After D.J. Taylor and C. Cointet, modified from Morton and Hudson (1995). Bed numbers have been revised to start the base of the Ardnish Formation as Bed 1 (= Bed 18 of Morton and Hudson, 1995). The bed numbers of Hesselbo et al. (1998) are shown in square brackets.