

Bajocian (Jurassic) stratigraphy in Skye, Western Scotland

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SYNOPSIS

Revised lithostratigraphical terminology for the subdivisions of the Bearreraig Sandstone Formation in Skye and Raasay is proposed. The sequence of Bajocian ammonite faunas in Trotternish, Skye is summarised. Lower Bajocian zones and subzones recognised are: Discites, Laeviuscula (with subzones Ovalis (?) and Laeviuscula), Sauzei (with subzones Sauzei and Hebridica), and Humphriesianum (with subzones Cycloides, Humphriesianum and Blagdeni (?)). The Hebridica Subzone is proposed for strata with *D. pinguis* (Roemer), *D. hebridica* Morton and associated ammonites, which seem to fall between the Sauzei and Humphriesianum Zones as usually recognised.

INTRODUCTION

The occurrence of Bajocian ammonites in western Scotland has long been known, particularly as a result of Buckman's identifications of faunas collected by the Geological Survey, published in the North-East Skye (Lee 1920) and Mull (Lee and Bailey 1925) memoirs, and summarised by Lee and Pringle (1932). More recent work is by Anderson and Dunham (1966) and Morton (1965). Further collecting, particularly in the Bearreraig Sandstone along the east coast of the Trotternish Peninsula (North-East Skye), has added to our knowledge of the Bajocian ammonite fauna in the area (Morton 1971a, 1972, 1975), and it would seem useful to summarise the stratigraphical results. The biostratigraphy is based mainly on collections made since 1965, including some made after my 1975 paper went to press, but major revisions of previously listed faunas are indicated.

LITHOSTRATIGRAPHY

Two independent investigations of the Bajocian (and Aalenian) rocks of North-East Skye by Morton (Morton and Hudson 1964; Morton 1965) and Anderson (Anderson and Dunham 1966) have resulted in there being two sets of lithostratigraphical terms available. I propose the use of a combination of the two sets, with some modifications, to give lithostratigraphical terminology in accordance with the code proposed by Harland *et al.* (1972). For details of lithology see Morton (1965, pp. 194–201).

The Bearreraig Sandstone Formation, named (as a 'Series' in the old sense) and defined by Morton and Hudson (1964, p. 532) and Morton (1965, p. 190) [= Inferior Oolite Sandstone of Anderson and Dunham 1966, p. 9] can be divided into six members

in the Trotternish Peninsula, Skye:

- (vi) Garantiana Clay (2 m) named by Buckman (*in* Lee 1920) [= Garantiana Clay and Sandstone of Anderson and Dunham (1966, p. 12)]. The best exposure is probably that at Storab's Grave in Raasay.

— sharp junction —

- (v) Rigg Sandstone (18 m to >90 m) named by Anderson and Dunham (1966, p. 12) [= Upper Sandstones of Morton and Hudson (1964, p. 532)], including at top Berreraig Grit of Anderson and Dunham (1966) [= Calcareous Grit of Lee (1920)]. The base is seen beside the pipeline at the top of the cliff overlooking the power station at Berreraig, but the type section is along the shore between Rigg and Inver Tote (see Morton 1965, fig. 1 for locality details).

— rapidly transitional junction —

- (iv) Holm Sandstone (36 m) named by Anderson and Dunham (1966, p. 12) [= Massive Sandstones of Morton and Hudson (1964)]. The base is seen along the foot of the high cliff between Holm and Berreraig and at the foot of the main waterfall in the Berreraig Burn. The type section is on the east bank and behind the main waterfall of the Berreraig Burn.

— transitional junction —

- (iii) Udairn Shales (72 m) named by Anderson and Dunham (1966, p. 12) [= Shaly Sandstones of Morton and Hudson (1964)]. The base and lowermost part are best seen just above the low cliff between Berreraig and Holm, but the main part is best seen in the Berreraig Burn section below the main waterfall.

— sharp junction —

- (ii) Ollach Sandstone (16 m) named by Anderson and Dunham (1966, p. 12) but redefined to exclude the lower part [= Lower Sandstones of Morton and Hudson (1964, p. 532)]. The base is now defined below the lowest Murchisonae Zone ammonite bed [= Black Bed of Berreraig of Buckman (*in* Lee 1920, p. 75)], and is seen in the type section along the low cliff just south of Berreraig.

— transitional diachronous junction —

- (i) Dun Caan Shales (12 m in Trotternish) named by Buckman (*in* Lee 1920) [= Fiurnean Shales and lower part of Ollach Sandstone of Anderson and Dunham (1966, pp. 10 and 12)]. The Dun Caan Shales are underlain by the Raasay Ironstone

and the junction, which is sharp, is seen at various localities in Raasay. The type section indicated by Buckman was east of Dun Caan on Raasay (see also Morton 1965, fig. 7, p. 206). The top of the Dun Caan Shales is diachronous between Bearreraig (Murchisonae Zone) and Raasay (Opalinum Zone at north-east corner of Beinn na Leac).

In Raasay only the Garantiana Clay and the Dun Caan Shales can be recognised. The Dun Caan Shales are overlain by the Beinn na Leac Sandstone named herein [= Calcareous Sandstones of Morton (1965, p. 202) and including the Main Ammonite Bed of Raasay named by Buckman (*in* Lee 1920, p. 65)] with type section at the north-eastern corner of Beinn na Leac (see Morton 1965, p. 206 for details). The Beinn na Leac Sandstone is overlain by the Raasay Sandstone, named by Buckman (*in* Lee 1920, p. 65). The base is best seen east of Loch na Mna and at the north-eastern corner of Beinn na Leac, but the only complete section is east of Dun Caan.

In Strathaird only the Garantiana Clay can be recognised. It is underlain by the Druim an Fhuarain Sandstones named by Morton (1965, p. 209) [including Basal Limestone of Morton (1965, p. 209)]. The base is seen at Faoilean and below Dun Liath, and the type section is between Faoilean and Capach.

The Aalenian-Bajocian boundary at Bearreraig lies approximately 17 m above the base of the Udairn Shales, with Aalenian ammonites (Graphoceratidae) occurring in the lower part and in the two underlying members. There is also lateral change of facies southwards in the Bearreraig Sandstone Formation, especially in Raasay and Strathaird, into cross-stratified sandstones and calcarenites in which ammonites are extremely rare.

BIOSTRATIGRAPHY

The zonal scheme for most of the Bajocian Stage is reasonably well established, and even some of the subzones can be widely recognised. Zonation of the lower part, the Sauzei and former Sowerbyi Zones, has been reviewed by Parsons (1974) and the zonal scheme proposed by him is used herein with one modification.

The sequence of faunas found in the Trotternish Peninsula in Skye (with conclusions as to zonal or subzonal position) is as follows (see also Fig. 1 and Table 1). Detailed discussion of the stratigraphical occurrence of individual species will be found in my systematic papers.

1. Approximately 17 m above the base of the Udairn Shales at the lowest exposure in the Bearreraig Burn *Euhoploceras* (*Euhoploceras*)? *dominans* (Buckman) and *E. (E.) marginata* (Buckman) were found. Both species were first described by Buckman (1887-1907) from the fossil bed at Bradford Abbas in Dorset and could be from either the Concavum Zone (Aalenian) or Discites Zone (see also Barker and Torrens 1971, Parsons 1974, pp. 170-171). A fragment of the graphoceratid *Hyperlioceras* sp. from 1-2 m higher, is characteristic of the Discites Zone (see Morton 1971b), so that the *Euhoploceras* specimens come from either the Discites Zone or very near the top of the Concavum Zone.

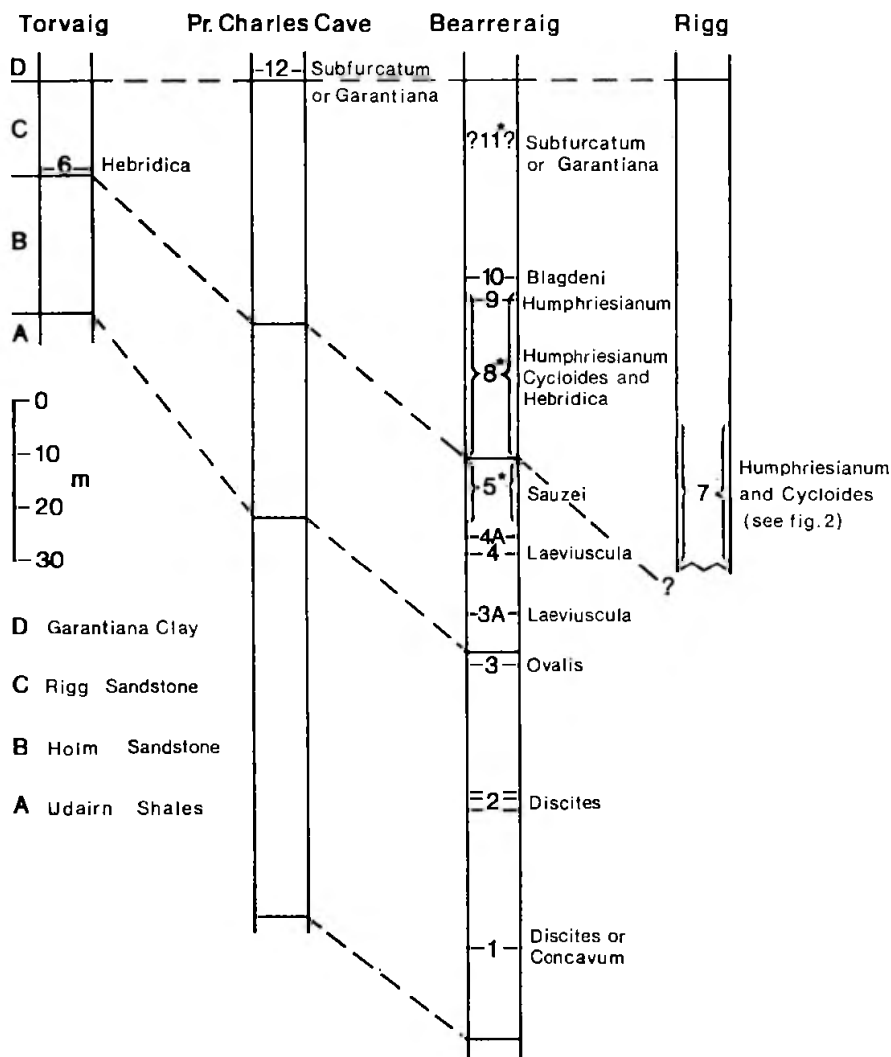


FIG. 1. Stratigraphical relationships of Bajocian ammonite faunas from Trotternish, Isle of Skye. The numbers refer to the sequence of faunas as described in the text, the precise stratigraphical positions of those marked with asterisks are uncertain.

- The middle part of the Udairn Shales contains very few ammonites, but *Euhoploceras* (*E.*) sp. (? cf. *costatum* (Buckman)) has been found 26 m and *E. (E.)* sp. (? cf. *modestum* (Buckman)) 27 m and 29 m below the top of the Udairn Shales in Bearreraig Burn. This fauna is again comparable with that from the Bradford Abbas fossil bed and probably belongs to the Discites Zone since *Hyperlioceras* occurs lower.
- The top 2–3 m of the Udairn Shales contain more numerous ammonites, both in the Bearreraig Burn section and especially at the foot of the high cliff 400 m south of Bearreraig (300 m north of Holm)—*Euhoploceras* (*Fissiloboceras*) *fissilobatum*

(Waagen) (common), *Euhoploceras* (E.) sp. (? cf. *adicrum* (Waagen)), *Shirbuirnia trigonalis* Buckman, *S. stephani* (Buckman), *Witchellia* sp., *Emileia* (E.) aff. *catamorphia* Buckman (more involute). *E. (Fissiloboceras)* and *Shirbuirnia* are found in the basal part of the Sandford Lane fossil bed according to Buckman (1910, pp. 92-3; 1920, pl. 181A,B), placed in the Laeviuscula Zone and Subzone by Parsons (1974, p. 168). However similar forms range down into the Ovalis Subzone. The fossils are not conclusive, but this fauna occurs 20 m below a definite Laeviuscula Subzone fauna (4) and may be from the Ovalis Subzone of the Laeviuscula Zone.

- 3A. Approximately 29 m below the top of the Holm Sandstone (9 m above fauna 3) in the east bank of the Berreraig Burn below the main waterfall were found *Euhoploceras* (E.) *alternata* (Buckman), *Witchellia* cf. *sutneri* (Branco), *Pelekodites aurifer* (Buckman) and *Euhoploceras* sp. indet. This fauna is certainly from the Laeviuscula Zone, probably the Laeviuscula Subzone since *P. aurifer* (Buckman) comes from the upper part of the zone at Osborne Wood, Dorset (Parsons 1974, p. 167).
4. At the ledge behind the main waterfall in the Berreraig Burn, 11 m above the preceding fauna i.e. 18 m below the top of the Holm Sandstone, an abundant fauna of ammonites includes *Witchellia* aff. *rubra* (Buckman), *W.* aff. *laeviuscula* (Sowerby), *W.* aff. *romanoides* (Douville), *Pelekodites zurcheri* (Douville), *P. macer* (Buckman), *P. minimus* (Hiltermann), *Sonninia* (S.) *corrugata* (Sowerby), *Emileia* (*Otoites*) sp. nov. At the same stratigraphical level, on the east bank of the burn *Sonninia* (S.) *corrugata* (Sowerby), *S.* (S.) sp. indet. and *Pelekodites* sp. indet. were found. This fauna, particularly the abundant *Witchellia* aff. *rubra* (Buckman), is characteristic of the "*Witchellia hemera*" of Buckman—the Laeviuscula Zone and Subzone (Parsons 1974, p. 168; see also Mousterde *et al.* 1971, pp. 10-11; Pavia and Sturani 1968, p. 311; Westermann 1967, pp. 159-160).
- 4A. At a level 3 m above that of fauna 4, some 15 m below the top of the Holm Sandstone, 10 m east of the gully on the eastern side of the main waterfall in the Berreraig Burn, were found *Sonninia* (*Papilliceras*) *arenata* (Quenstedt), *S.* (*P.*) sp. indet., *S.* (*Sonninia*) ? *corrugata* (Sowerby), *S.* (S.) sp. indet., *Pelekodites macer* (Buckman), *P.* sp. indet. and *Strigoceras* ? *languidum* (Buckman). In the absence of *S.* (*P.*) *mesacantha* and typical Sauzei Zone *Sonninia* (see also below) this fauna is assigned to the Laeviuscula Zone and Subzone.

All the above faunas were collected *in situ* at Berreraig so that their stratigraphical sequence is clear. Unfortunately the sequence of higher faunas is less certain, partly because they were collected at separate localities (Torvaig, Berreraig, Rigg) and partly because they were collected from loose blocks fallen from the cliffs at Berreraig. In both cases the necessary stratigraphical extrapolation introduces an element of uncertainty into the statement of sequence. This is especially the case for specimens from Rudha Sughar on the north side of Berreraig Bay, where the faunas can be recognised as coming from either the top 10-12 m of the Holm Sandstone or the basal 25-30 m of the Rigg Sandstone.

5. In the blocks from the top 10–12 m of the Holm Sandstone (and therefore above faunas 4 and 4A) at Rudha Sughar were found *Sonninia* (S.) cf. *sowerbyi* (Sowerby), *S.* (S.) cf. *propinquans* (Bayle), *S.* (S.) *corrugata* (Sowerby), *S.* (*Papilliceras*) *arenata* (Quenstedt), *S.* (*P.*) *mesacantha* (Waagen), *S.* (*P.*) sp. indet., *Pelekodites macer* (Buckman), *P. minimus* (Hiltermann), *Witchellia* aff. *rubra* (Buckman), *Strigoceras bessinum* Brasil and *Emileia* (E.) sp., Anderson and Dunham (1966, p. 16) recorded ammonites (revised determinations included in the above list) as from the upper half of the Udairn Shales, but these beds are not exposed at this locality. Of the species listed, "typical" compressed alticarinatate *Sonninia* of the *sowerbyi* and *propinquans* types and *S.* (*P.*) *mesacantha* are widely recorded as characteristic of the Sauzei Zone (for example Pavia and Sturani 1968, p. 311; Mouterde *et al.* 1971, p. 11; Parsons 1974, pp. 158–159). *S.* (*P.*) *arenata* is recorded from the Laeviuscula Zone, but Oechsle (1958, p. 102) states that the type specimen comes from the Blaukalke (Sauzei Zone). Presumably *arenata*, together with *corrugata* and *Pelekodites*, occurs in both Laeviuscula and Sauzei Zones. The *Witchellia* specimen is from a separate block and may be from a slightly lower stratigraphical level. On balance it would seem that, while a small part of this fauna may be from the Laeviuscula Zone, there are enough characteristic elements to indicate that this fauna is mainly from the Sauzei Zone and Subzone.
6. At Torvaig, near Portree, a dark calcareous sandstone bed overlies a massive light-coloured sandstone similar to the Holm Sandstone at Bearreraig and Prince Charles' Cave, and is taken to be the base of the Rigg Sandstone at Torvaig. The ammonite fauna (partly revision of that listed in Morton 1965, p. 198) includes *Stephanoceras* (S.) *nodosum* (Quenstedt), *S.* (S.) aff. *nodosum* and aff. *macrum* (Quenstedt), *S.* (*Normannites*) *nodosum* (Westermann), *S.* (N.) sp. indet., *Emileia* (*Otoites*) sp. indet., *Chondroceras gervillii* (Sowerby), ? *C. evolvens* (Waagen), *Lissoceras oolithicum* (d'Orbigny), *Strigoceras* cf. *compressum* (Etheridge), *Dorsetensia pinguis* (Roemer), *D. hannoverana* (Hiltermann), *D. hebridica* Morton, "*Sonninia*" aff. *furticarinata* (Quenstedt). This fauna (with especially abundant *D. pinguis*) is known elsewhere mainly from the "Pinguis-Schichten" of northern Germany, described by Hiltermann (1939), Westermann (1954), Huf (1968) and others. In previous papers I followed German authors in placing strata with this fauna in the lower part of the Humphriesianum Zone. They were placed in a Frechi Subzone by Westermann (1967, p. 123) but this name was strongly criticised by Sturani (1971, p. 50). The Pinguis-Schichten of northern Germany have never been adequately dated, although there is a characteristic fauna now known to occur also in Skye. In Skye this fauna has been found well-preserved and *in situ* only at Torvaig—the equivalent beds at Bearreraig are either inaccessible or have not so far yielded ammonites. Stratigraphical placing of the fauna between fauna 5 at Bearreraig (listed above), which is characteristic of the Sauzei Zone, and fauna 7 at Rigg (see below), characteristic of the lower part of the Humphriesianum Zone, is therefore dependent on correlation between Torvaig, Bearreraig and Rigg. Some specimens of *D. pinguis* (Roemer)

have been found in loose blocks from the lower part of the Rigg Sandstone at Berreraig, so that there is fairly clear evidence that the *D. pinguis* fauna occurs above the Sauzei Zone fauna. Evidence in Skye for its occurrence below the Humphriesianum Zone fauna (*D. romani* and associated species) remains circumstantial. Fortunately in northern Germany, especially at Bethel and Gerzen, the *D. pinguis* fauna has been shown to be stratigraphically below the Humphriesianum Zone *D. romani* fauna by Huf (1968, pp. 14, 16). The evidence in Skye and northern Germany now shows the existence of strata with a characteristic fauna between the Humphriesianum Zone and Sauzei Zones as normally defined. According to widely accepted stratigraphical practice this should be inserted as a new subzone at the top of the Sauzei Zone. *Pinguis* cannot be used for this subzone because of:

- (i) inadequate and inaccurate original definition of a *Pinguis* Zone below the Sauzei Zone in southern Germany by Dorn (1935, p. 75, p. 120);
- (ii) subsequent apparent misidentification of Dorn's *Pinguis* Zone by Huf (1968) and Westermann (1967);

(iii) the unsatisfactory nature of the type material of *pinguis*, preserved only as nuclei. I propose (see also Morton 1975, p. 42) the name *Hebridica* for this subzone, using as index the other characteristic species in the Skye fauna—*Dorsetensia hebridica* Morton. In Skye two subzones of the Sauzei Zone can now be recognised—a lower Sauzei Subzone (fauna 5) and an upper *Hebridica* Subzone (fauna 6). In England the upper subzone cannot yet be generally recognised. One contributory reason is that above preserved Sauzei Zone there is a stratigraphical gap as a result of widespread erosion—the overlying beds belong to the Humphriesianum Zone or, more normally, topmost Garantiana Zone. Possible exceptions are in the "South Main Road" quarry at Dundry where Parsons (1974, p. 174) records *hebridica* (as ? *Witchellia*) from the upper part of the Sauzei Zone, and at Sandford Lane (op. cit., p. 166).

7. The lower part of the Rigg Sandstone is exposed at sea level on the shore below Rigg, 4 km north of Berreraig, and it is possible to collect faunas *in situ*. Unfortunately the base is below sea level, but probably not more than 5–10 m below the lowest exposed bed. If the base of the Rigg Sandstone is properly correlated then the ammonites from Rigg are younger than those from Torvaig. The faunas found at Rigg, and their stratigraphical sequence are summarised in Figure 2. They are typical of those found in the lower part of the Humphriesianum Zone of several parts of north-west Europe and two subzones—*Cycloides* and *Humphriesianum*—can be recognised.
8. The loose blocks from the Rigg Sandstone at Rudha Sughar, Berreraig, come from the basal 30 m or so, and may therefore include the lateral equivalents of both the previous faunas (at Torvaig and Rigg). Ammonites found include *Oppelia* (*O.*) ? *subradiata* (Sowerby), *Stephanoceras* (*St.*) *mutabile* (Quenstedt), *S.* (*S.*) aff. *brodiaei* (Sowerby), *S.* (*S.*) aff. *nodosum* and aff. *macrum* (Quenstedt), *S.* (*S.*) aff. *triplex* Weisert, *S.* (*S.*) *pyritosum* (Quenstedt), *S.* (*Normannites*) ? *orbignyi* (Buckman),

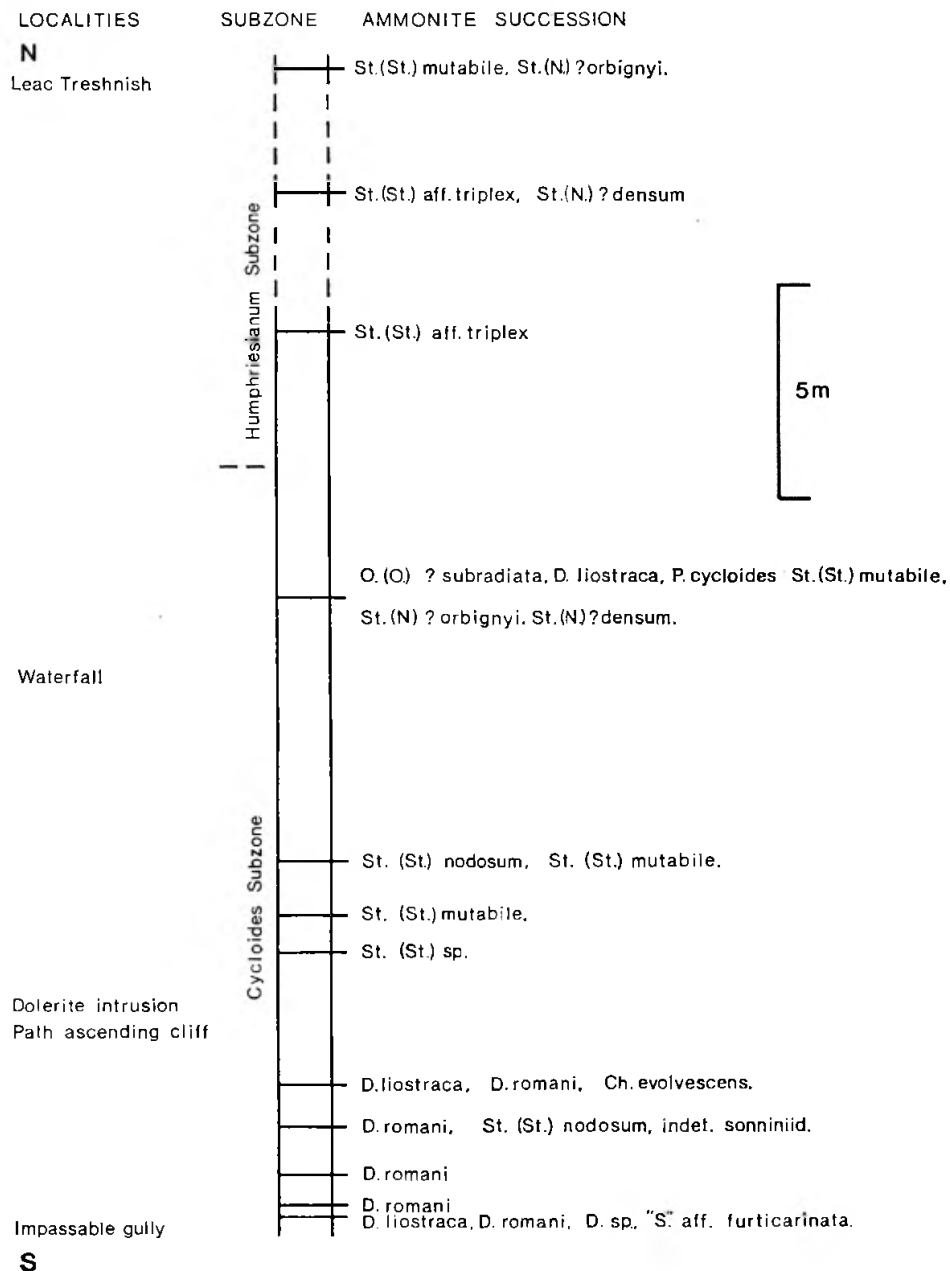


FIG. 2. Ammonite succession in the lower part of the Rigg Sandstone at Rigg, Trotternish, Isle of Skye. Some geographical reference points along the Rigg shore are shown on the left.

Dorsetensia liostraca Buckman, *D. romani* (Oppel), *D. pinguis* (Roemer), "*Sonninia*" aff. *furticarinata* (Quenstedt). It would seem that the fauna includes representatives from the Hebridica Subzone, and from the Cycloides and Humphriesianum Subzones of the Humphriesianum Zone.

9. In the pipeline cutting at Bearreraig, some 30 m above the base of the Rigg Sandstone, were found *Stephanoceras* (*S.*) *pyritosum* (Quenstedt), *S.* (*S.*) aff. *triplex* Weisert and *S.* (*Normannites*) sp., presumably in the Humphriesianum Subzone of the Humphriesianum Zone.
10. Also in the Bearreraig pipeline cutting, 4 m above fauna 9, a single specimen of *Teloceras* (*T.*) *blagdeni* (Sowerby) was found. This species is indicative of the Blagdeni Subzone, the upper subzone of the Humphriesianum Zone, but one specimen alone is not conclusive.

In the Rigg Sandstone four zones or subzones can therefore be recognised. The characteristic or common species are:

- (iv) Blagdeni Subzone :—*Teloceras* (*T.*) *blagdeni* (Sowerby);
- (iii) Humphriesianum Subzone—*Stephanoceras* (*S.*) aff. *triplex* Weisert, *S.* (*S.*) *pyritosum* (Quenstedt), *S.* (*S.*) *mutabile* (Quenstedt);
- (ii) Cycloides Subzone—*Poecilomorphus cycloides* (d'Orbigny), *Dorsetensia liostraca* Buckman, *D. romani* (Oppel), "*Sonninia*" aff. *furticarinata* (Quenstedt), *Stephanoceras* (*S.*) *mutabile* (Quenstedt), *S.* (*S.*) *nodosum* (Quenstedt), *Chondroceras evolvenscens* (Waagen);
- (i) Hebridica Subzone—*Dorsetensia pinguis* (Roemer), *D. hannoverana* (Hiltermann), *D. hebridica* Morton, "*Sonninia*" aff. *furticarinata* (Quenstedt), *Stephanoceras* (*S.*) *nodosum* (Quenstedt), *S.* (*Normannites*) *nodosum* (Westermann), *Chondroceras gervillii* (Sowerby).

TABLE 1

SUBSTAGES	ZONES	SUBZONES
Upper Bajocian	Garantiana or Subfurcatum	Blagdeni (?)
	Humphriesianum	Humphriesianum
		Cycloides
		Hebridica
Lower Bajocian	Sauzei	Sauzei
		Laeviuscula
	Laeviuscula	Ovalis (?)
	Discites	

11. A single specimen similar to those identified earlier (Morton 1971a, p. 287) as *Garantiana* (G.) ? *baculata* (Quenstedt) was found by Dr. J. K. Wright in a loose block of sandy chamositic ironstone at Berreraig, presumably from somewhere in the upper part of the Rigg Sandstone (see also discussion of fauna 12).
12. In the *Garantiana* Clay above Prince Charles' Cave was found an ammonite thought to be *Garantiana* (G.) ? *baculata* (Quenstedt) from the Subfurcatum Zone (Morton 1971a, p. 269) or *Pseudogarantiana dichotoma* (Bentz) from the lower part of the *Garantiana* Zone (Pavia 1973, p. 110). The specimens available at present are probably inadequate for proof of identity and age more precisely than early Upper Bajocian.

The zones and subzones which can be recognised in Skye are shown in Table 1.

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