Hallaig Shore, Isle of Raasay, Highland

[NG 588 396]–[NG 591 390]

N. Morton

Introduction

The Hallaig Shore GCR site is the finest of the very few exposures to show the transition from the Pabay Shale Formation into the Scalpay Sandstone Formation, a part of the succession almost never exposed in the Hebrides. The site is of key importance for dating the apparently diachronous junction between the two formations. The ammonite succession is well documented and enables detailed correlations to be made with the predominantly argillaceous Pliensbachian successions in southern England.

The area immediately north of the abandoned crofting township of Hallaig on the Isle of Raasay, including the Hallaig Shore GCR site (Figure 8.6), is underlain by a large rotational landslip. This consists mainly of the thick sandstones of the (Aalenian–Bajocian) Bearreraig Sandstone Formation and the (Pliensbachian–basal Toarcian) Scalpay Sandstone Formation. Decollement is in the lower part of the (Sinemurian–lower Pliensbachian) Pabay Shale Formation, which has been squeezed out so that the apparent thickness of this part of the formation is much reduced. The sole of the landslip lies on the top sandstone bed (Sinemurian Turneri Zone) of the Hallaig Sandstone Member of the Ardnish Formation, which forms the top of the cliff north of Hallaig waterfall [NG 5940 3870] and a scarp feature across the beach 200 m to the north [NG 5926 3887]. Locally, very small masses of in-situ basal Pabay Shale Formation (Sinemurian Oxynotum Zone) can be observed on top of the sandstone.

In the southern part of the landslip, around Hallaig township and Creag nan Cadhaig, it is not possible to establish a coherent stratigraphy and a chaotic arrangement of small blocks is apparent in the few outcrops. The eastern edge of this part of the landslip, along the northern part of the Hallaig Burn, the top of the cliff north of the waterfall and on the shore to the north is still active and subject to erosion. Elsewhere, it is more stable and there is no evidence of significant movement in historical times; for example, the enclosure wall and foundations of the former crofts remain largely intact.

In the northern part of the landslip the various parts of the succession have generally maintained their cohesion and relative stratigraphical positions, although displaced from their original positions and rotated through some 25° (see below). Consequently the upper part of the Pabay Shale Formation exposed on the shore [NG 5907 3909], dips WNW beneath the Scalpay Sandstone Formation, which forms the lower cliff overlooking the shore [NG 5883 3952] southwards to north of Creag nan Cadhaig [NG 5890 3907]. The Bearreraig Sandstone Formation forms the higher scarp, to the west of a broad ledge interpreted to mark the position of the Portree Shale and Raasay Ironstone formations. On the western edge of the landslip it is possible locally to identify the Garantiana Clay Member and Cullaidh Shale Formation and map part of the Great Estuarine Group (Figure 8.6).

A description of the outcrops and lithologies, with a surprisingly brief faunal list, was given by Lee (1920). A more detailed measured succession was described by Howarth (1956) and further information about the ammonite succession was given by Phelps (1985). The sedimentary log by Hesselbo *et al.* (1998) is a composite of this site and that at the Cadha Carnach GCR site located 1 km to the north.

Lithologies throughout the succession vary between micaceous silty shales and sandstones, frequently with calcareous nodules or doggers, and some calcareous beds. Some beds are reasonably fossiliferous, with ammonites, bivalves and brachiopods dominant, though the distributions are usually discontinuous stratigraphically, so that precise positions of zonal or subzonal boundaries can rarely be defined.

Description

The most important outcrops within the Hallaig Shore GCR site are in the intertidal part of the shore north of Hallaig. The first outcrops north of the top of the Hallaig Sandstone Member (at [NG 5926 3885]) are of fossiliferous dark shales, with numerous red-weathering calcareous nodules, comprising the main part of the Pabay Shale Formation. They are strongly affected by faulting and shearing in the base of the landslip so that their thickness is reduced and bedding is not preserved. Hence these outcrops are not stratigraphically useful. The southern edge of the GCR site (Figure 8.6) lies within this belt of deformed shales.

The first coherent beds, dipping at 40° to WSW, crop out in a small headland [NG 5914 3906] 260 m farther north and comprise dark-grey to black micaceous shales with calcareous nodules. The discrepancy of the dip and NNW–SSE strike here, compared with the regional strike and outcrops to the north, suggest that this outcrop is a separate landslipped block which is not in stratigraphical continuity with the main section described below.

The main section within the GCR site is 120 m farther north along the shore, extending some 400 m from [NG 5904 3916] northwards to [NG 5888 3958]. The dip of the beds over this section is consistently close to 30° to the west and the strike close to north–south. Although the dip is significantly steeper than the regional dip (12° to 15° at Hallaig waterfall, for example), due to rotation during landslipping, there is stratigraphical continuity throughout the section, and the succession shown in (Figure 8.7) does not include any structural breaks. The sediments are medium- to dark-grey micaceous shales with red-weathering calcareous nodules, gradually coarsening-up into muddy sandstones with calcareous lenticles and doggers.

The outcrops along the shore are separated, by a narrow emerged ('raised') beach platform, from the low cliff formed by the upper part of the Scalpay Sandstone Formation. The main part of this cliff is formed by massive sandstones (Bed 36 of Howarth, 1956, in the Rubha na' Leac GCR succession) but other beds can also be identified; for example, sandstones with doggers and with bands containing *Pseudopecten equivalvis* (Howarth's beds 28 to 30) near the southern end of the cliff. Some further rotational landslipping of certain blocks is indicated by higher dips, up to 40°, but the unbroken nature of the cliff line suggests that these movements are minor. Although this cliff lies within the GCR site, these strata have not been included in the measured succession (Figure 8.7).

The oldest strata seen within the GCR site are sheared black micaceous shales containing Raricostatum Zone *Echioceras* spp. and other fossils. However, these outcrops are not stratigraphically useful and undeformed strata of this part of the Pabay Shale Formation are exposed elsewhere on Raasay, notably in the Allt Fearns section 3 km to the south. Higher parts of the Pabay Shale Formation crop out in the small headland near the southern boundary of the GCR site, though they are also seen in the Allt Fearns section. No detailed measured succession is available and it is not at present possible to establish precise stratigraphical relationships with higher parts of the succession, described below. However, these outcrops are noteworthy because they are richly fossiliferous, yielding ammonites (*Polymorphites* cf. *angusta,* eoderoceratids and echioceratids), bivalves (including *Gryphaea mccullochi, Hippopodium ponderosum* and *Pleuromya costata*) and brachiopods (including *Spiriferina pinguis* and *Rimirhynchia anglica*). It appears that both Raricostatum and Jamesoni zone faunas may be present and that this outcrop represents strata below the described section. The position of the Sinemurian–Pliensbachian boundary remains to be established.

The main section, for which the site has been included in the GCR, is on the foreshore just to the north, though separated by a structural break. A detailed measured section re-drawn from data in Howarth (1956), Phelps (1985) and Hesselbo *et al.* (1998) is given in (Figure 8.7). Note that only the upper part of Bed 1, which is about 12 m thick, is shown. Beds 1 and 2 are dark-grey micaceous, slightly silty, shales with nodules and lenticles of red-weathering, dark-grey to black, argillaceous limestone. Some of the nodules were formed at a very early stage of diagenesis, before compaction, while others appear to be later septarian nodules. Ammonites recorded by Howarth (1956), Oates (1976) and Phelps (1985) include Jamesoni Zone *Uptonia* and *Platypleuroceras* in Bed 1, Ibex Zone *Acanthopleuroceras* and *Tragophylloceras* in Bed 2. Bed 3 is a 7.62 m-thick succession of micaceous shales with thin lenticles of calcareous sandstone. Comminuted shell debris, mostly bivalve, occurs but no ammonites have been identified.

The base of the Scalpay Sandstone Formation was placed by Howarth (1956) at the first continuous sandstone, Bed 4. In such a transitional situation any lithostratigraphical boundary is arbitrary, so that Howarth's definition is accepted here, as it was by Hesselbo *et al.* (1998) even though elsewhere in the Hebrides it may be placed at biostratigraphically higher

levels. Beds 5 to 10 vary between silty micaceous shales and muddy sandstones, with elongate calcareous doggers and thin beds of calcareous sandstone. Recognizable fossils are uncommon other than poorly preserved infaunal bivalves (*?Pholadomya* and *Pleuromya*), but bioturbation is pervasive. Exceptions are nodules with *Piarorhynchia* in Bed 5 and *Tetrarhynchia* in Bed 9, while parts of Bed 10 contain large specimens of *Gryphaea gigantea.* The position of the Valdani–Luridum subzonal boundary is uncertain. Silty shales characterize the upper part of Howarth's Bed 10 as well as Bed 11. Howarth (1956) listed *Androgynoceras maculatum* from Bed 11 but Phelps (1985) recorded specimens of *Beaniceras* transitional between *crassum* and *luridum* from this level, placing these beds in the Luridum Subzone (Ibex Zone) rather than Maculatum Subzone (Davoei Zone). Beds 12 and 13 show a return to mainly muddy sandstones with thin beds and doggers of calcareous sandstone and only minor silty shales. Phelps (1985) recorded *Androgynoceras* from Bed 13 and placed the base of the Maculatum Subzone (and Davoei Zone) in Bed 12. Feldmann *et al.* (2002) described a new species of crustacean, *Pseudoglyphea foersteri,* from a fallen block of fossiliferous Scalpay Sandstone Formation also containing *Aegoceras* cf. *brevilobatum* indicative of the Capricornus Subzone.

Near the top of the shore section Howarth (1956) identified a sequence of thin beds of calcareous sandstones and fissile micaceous shales. These dark fissile shales are crowded with crushed bivalves and are unusually distinctive within the otherwise homogeneous silty shale to muddy sandstone facies of the Scalpay Sandstone Formation. They are of great importance as marker beds, providing a lithostratigraphical correlation between this and other sections of the Scalpay Sandstone Formation on Raasay. The overlying sandstones of the main part of the Scalpay Sandstone Formation crop out in the low cliff overlooking the shore. However, these beds are better exposed elsewhere. As noted above, identification of the succession with beds seen south of Rubha na' Leac is usually straightforward.

Interpretation

Within the Hallaig Shore GCR site itself only the upper part of the Pabay Shale Formation can be observed in stratigraphical succession, though undisturbed sections through the middle and lower parts of the Pabay Shale Formation can be seen farther south, in the Hallaig Burn and its tributaries south of Hallaig, and more especially in the classic Allt Fearns section 3 km to the south. Of the overlying Scalpay Sandstone Formation only the lowest 40 m is discussed here. Better sections through the main part of the formation can be found to the north (see Cadha Carnach GCR site report) and the south (see Rubha na' Leac GCR site report).

Ammonites occur only sporadically through the succession here and hence uncertainty surrounds some parts of the biostratigraphy. The southernmost shore outcrops in the GCR site consist of sheared shales with *Echioceras* and *Eoderoceras* of the Raricostatum Zone. In contrast to the succession in Allt Fearns Burn, where the four subzones of the Raricostatum Zone can be readily identified (Getty, 1973; Morton and Hudson, 1995), the thickness here has been greatly reduced by landslipping.

The lowest stratigraphically coherent block of Pabay Shale Formation in the small headland [NG 5914 3906] has not been measured in detail so that the succession of faunas is not known. However, ammonites recorded include *Polymorphites* cf. *angusta,* deroceratids and echioceratids suggesting that both the Raricostatum and Jamesoni zones may be present. A thin sandstone bed seen at about the zonal boundary in Allt Fearns has not been observed here.

The main section to the north exposes about 23 m of the uppermost part of the Pabay Shale Formation. In the upper part of Bed 1 *Uptonia* is abundant, including *U. Jamesoni* and *U. angusta* (Howarth, 1956) indicating the Jamesoni Subzone, while *Platypleuroceras brevispina may* come from slightly lower (Oates, 1976), indicating the Brevispina Subzone. Bed 2 contains *Acanthopleuroceras* sp. and *Pagophylloceras loscombi* of the Valdani Subzone, so that the Jamesoni–Ibex zonal boundary is placed between beds 1 and 2. However, in the absence of diagnostic ammonites the position of the Masseanum Subzone here is unknown. The top 7.6 m of the Pabay Shale Formation (Bed 3) has not yielded any ammonites but is presumed to be still in the Valdani Subzone.

The lower part of the Scalpay Sandstone Formation contains very few ammonites so that the ages of most beds and the positions of zonal and subzonal boundaries are poorly constrained. The base of the formation, and strata up to Bed 8, are placed in the Valdani Subzone, with *Piarorhynchia* cf. *deffneri* in Bed 5. Phelps (1985) recorded *Liparoceras cheltiense* from this level and indicated Valdani Subzone (his fig. 3), although elsewhere (his fig. 9) he indicates the

range of this species as extending into the lower part of the Luridum Subzone. The Valdani–Luridum subzonal boundary is tentatively placed in Bed 8, below the occurrence of *Tetrarhynchia dunrobinensis* in Bed 9. Phelps' (1985) record of specimens of *Beaniceras* transitional between *crassum* and *luridum is* consistent with a position in the middle–upper part of the Luridum Subzone (see his fig. 9). The Ibex–Davoei zonal (Luridum–Maculatum subzone) boundary is interpolated between the *Beaniceras* specimens in Bed 11 and *Androgynoceras in* Bed 13. The ammonite from this level was identified by Phelps (1985) as transitional between A. *sparsicosta* and *A. maculatum,* which is in the middle of the Maculatum Subzone. *Androgynoceras* ranges up into the base of the Capricornus Subzone (Phelps, 1985) so that the marker beds 14 to 18 may be close to the Maculatum–Capricornus subzonal boundary. Phelps (1985) recorded *Aegoceras capricornus* (Capricornus Subzone) from the lower part of Bed 19.

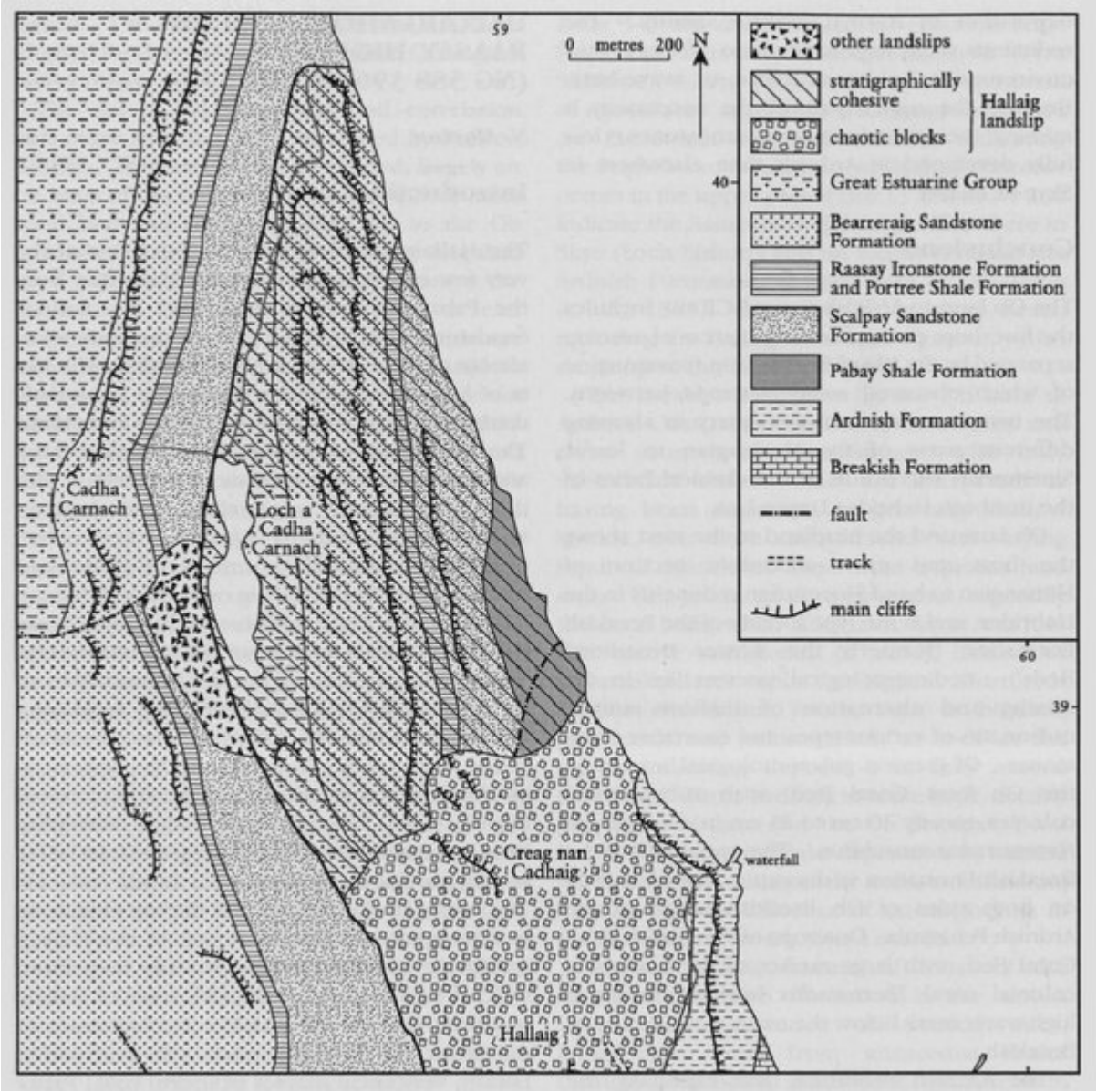
The overall succession at this site shows a gradual coarsening-up from uniformly micaceous silty shales typical of the Pabay Shale Formation into silty and muddy fine-grained sandstones of the Scalpay Sandstone Formation. Placing a lithostratigraphical boundary is arbitrary, and Howarth's (1956) unambiguous definition of the Scalpay Sandstone Formation as beginning with Bed 4 at this locality is accepted here.

The Pabay Shale Formation was deposited in normal marine conditions below wave-base. The abundance of detrital mica as flakes 2–3 mm across in this part of the formation suggests that transport from a nearby hinterland, identified from other evidence as the Scottish Highlands to the east, occurred via rivers and then tidal currents. However, there is no evidence for these inferred tidal currents having affected the sea floor depositional environment. By contrast, the occurrence of lenses of sand and comminuted shell-debris in Bed 3, presumably deposited in channels, indicates that the depositional environment shallowed to near or slightly above storm wave-base. Through the lower part of the Scalpay Sandstone Formation there is comparatively little lithological variation other than relatively subtle changes between muddy fine sandstone and silty mudstone. The most striking aspect of the lithology is the number of calcite-cemented beds and doggers, most formed late during diagenesis. The depositional environment was normal marine, close to or slightly above wave-base. Large fragments of driftwood suggest that the coastline and hinterland were not very distant.

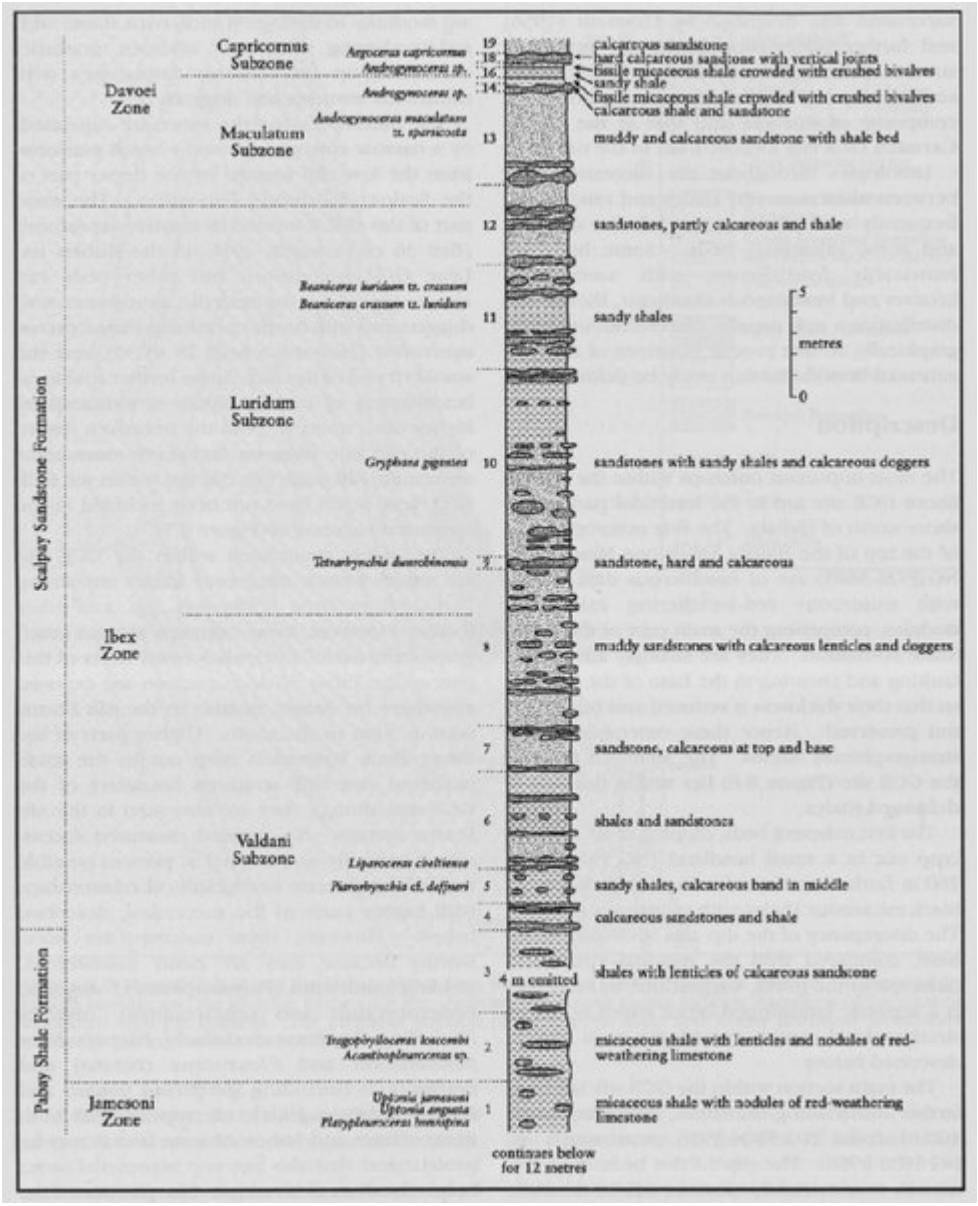
Conclusions

The most significant feature of the Hallaig Shore GCR site is in providing the only good section of the transition between the Pabay Shale and Scalpay Sandstone formations known in the northern part of the Hebrides Basin. In this section the base of the Scalpay Sandstone Formation is taken, following Howarth (1956), at the base of the first sandstone bed in a gradual coarsening-up sequence. This occurs in the Lower Pliensbachian Valdani Subzone of the Ibex Zone. This contrasts with the situation in Carsaig Bay (Isle of Mull) where there is a similar gradual coarsening-up but the base of the Scalpay Sandstone Formation is taken at an abrupt erosional base of a more massive sandstone (Oates, 1976) in the Upper Pliensbachian Subnodosus Subzone of the Margaritatus Zone. From a palaeontological point of view the main interest of this section lies in the lower part, in which a good succession of ammonites from the upper part of the Jamesoni Zone and the lower part of the Ibex Zone can be established. A structurally separate section of a lower part of the Pabay Shale Formation is also exposed within the GCR site. This fossiliferous succession may span parts of the Raricostatum and Jamesoni zones, and, therefore, possibly the Sinemurian–Pliensbachian boundary.

References



(Figure 8.6) Map of Hallaig and the Hallaig Shore area, showing the main topographic features, the limits of the Hallaig landslip and the location of the GCR site. Selected dip arrows shown indicate the effects of the rotation associated with the landslip. The probable position of the Portree Shale and Raasay Ironstone formations, which are not exposed, is interpolated.



(Figure 8.7) Detailed succession of the uppermost Pabay Shale Formation and lower Scalpay Sandstone Formation, together with records of ammonites and some other key fossils. Bed numbers are those of Howarth (1956), on whose work this figure is mainly based, with additional information from Hesselbo et al. (1998) and Phelps (1985). Note that Bed 3 is 4 m thicker than shown here. The boundary between the Pabay Shale and Scalpay Sandstone formations is transitional but taken at the base of Bed 4. Beds 14 to 18 are distinctive marker beds allowing correlation with other sections on Raasay, including the GCR sites at Rubha na' Leac 1.5 km to the south, and Cadha Carnach 1 km to the north.