Elgol–Glen Scaladal, Isle of Skye

[NG 517 136]–[NG 519 154], [NG 520 159]–[NG 520 168]

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Introduction

The coastline from Port na Cullaidh to north of Glen Scaladal (Figure 6.15), on the west coast of Strathaird, southern Skye, exposes a virtually continuous section through the Great Estuarine Group together with the overlying Carn Mor Sandstone Member (Staffin Bay Formation) of Early Callovian age (see North Elgol Coast GCR site report, this volume). The exposure is interrupted for about 500 m to the west of Carn Mor by the Carn Mor landslip. The beds dip gently WNW so that, except for some repetition due to folding in the northern part of the exposure, the succession youngs from south to north. The exposures here include the type sections of the Elgol Sandstone Formation, and type/reference sections for the Cullaidh Shale and Kilmaluag formations. The cliffs are unstable and dangerous, especially below Carn Mor.

Description

The sections have been described by Morton and Hudson (1995) on which the following notes are largely based, together with additional information from Harris and Hudson (1980), Andrews (1985), Harris (1989, 1992) and Andrews and Walton (1990). The sections were also included in earlier field guides by Hudson and Morton (1969) and Bell and Harris (1986).

Elgol to Carn Mor

The oldest strata, belonging to the Cullaidh Shale Formation, are exposed in a mobile storm beach immediately in front of Elgol school. The exposure [NG 517 137], normally of 1–2 m of dark shale intruded by thin, irregular, basaltic sills, varies with the state of the beach. The shale contains abundant cycloid and ctenoid fish (probably *leptolepisyscales,* and a sparse invertebrate fauna of gastropods (*Viviparus?* and tiny indeterminate specimens), bivalves (*Praemytilus?*) and rare conchostracans (*Euestheria* cf. *trotternishensis* Chen and Hudson, and *Neopolygrapta* sp.; Chen and Hudson, 1991). The base of the formation is not seen.

Exposure of the overlying Elgol Sandstone Formation ((Figure 6.16) and (Figure 6.17)) is nearly continuous from the Cullaidh Shale Formation exposure in front of the school (see above) to the base of the overhanging cliff, on the north side of Port na Cullaidh, which is formed by the higher beds of the Elgol Sandstone Formation. The boundary with the underlying Cullaidh Shale Formation is transitional; the shales become progressively more silty and, about 30 m south of the cliff, thin, bioturbated, shaly sandstone beds appear. Black, micaceous shales are intercalated with successively thicker, shaly sandstones that become progressively more intensively bioturbated upwards, culminating in shaly, fine-grained sands with pyrite nodules and a restricted assemblage of trace fossils, mainly *Planolites* (Harris, 1989). The sands gradually increase in proportion and thickness; first, and forming the main part of the cliff, there are white, fine- to medium-grained, pure, non-calcareous sandstones with well-developed honeycomb weathering under the overhang and with thin, lenticular, coarse-grained sand units. These are followed by moderately well-sorted, medium- to coarse-grained sandstones with large-scale (5 m amplitude), low-angle inclined surfaces dipping at between 4° and 7° to the south-east (these beds are seen in the N–S-trending cliff behind the school). These surfaces commonly have weak basal scours and show low-amplitude (less than 0.10 m) trough and tabular cross-stratification and complex palaeo-current flow directions. *Monocraterion* and indistinct *Thalassinoides?* burrows occur intermittently. Coarse- and very coarse-grained sands with granule and pebble lenses complete the sequence. These show trough and tabular cross-bed sets in the lower part with planar lamination preserved between numerous scour surfaces; in the upper part, there are two trough cross-stratified cosets capped by medium-grained sands with poorly defined planar-lamination. Moulds of large bivalves (probably *Unio*) in life orientation are seen on the surface of dipping slabs of the top sandstone exposed in front of a ruined cottage to the north of the main outcrop. The total thickness of the formation, which forms a distinct scarp traceable for *c.* 7 km to the north-west, is here 22 m.

The overlying Lealt Shale Formation is exposed in the next bay [NG 516 140]–[NG 516 144] to the north of the headland. It is predominantly argillaceous with numerous thin, mainly biosparite limestones, and yields an abundant, but restricted, fauna of bivalves, gastropods, ostracods and conchostracans. Its sharp contact with the coarse top of the Elgol Sandstone Formation is displaced by small faults. About 1 m above the base, there is a 0.30 m-thick bed of fine-grained sandstone, 0.30 m above which, the shales have yielded a well-preserved, fusainized fragment of the dipterid fern *Hausmannia* sp. This lower part of the Lealt Shale Formation (the Kildonnan Member) is dominated by the mytilid bivalve *Praemytilus strathairdensis* (Anderson and Cox). The upper part of the member, capped by a stromatolite bed, is exposed a few metres south of a small vent breccia outcrop that is conspicuous in the cliff but does not extend across the shore. These highest shales of the Kildonnan Member contain a fauna of *Praemyti–Unio, Neomiodon,* neritid and probable ellobiid gastropods, *Darwinula* and conchostracans, succeeded (in Bed 13 of (Figure 6.18)) by a completely different fauna dominated by *Placunopsis socialis* and *Cuspidaria ibbetsoni.* The domal stromatolite (Bed 14), which caps the member, is 0.20 m thick and, in thin section, shows pseudomorphs after gypsum. The basal shales of the overlying Lonfearn Member, which is almost continuously exposed from here to a steep and projecting part of the cliff formed by a dyke complex, contain a fauna that also includes *Cuspidaria* as well as *Isognomon, Neomiodon* and *?Viviparus*. Above this, the member comprises alternations of dark shales and thin limestones, some of which are ooidal. Numerous, thin, basaltic sills and dykes intrude the succession and some of the shales are blackened by metamorphism. The bivalve *Neomiodon* forms shell plasters, and *Viviparus* and *Unio* occur in some beds. Conchostracans, including *Skyestheria intermedia* Chen and Hudson, occur abundantly, as well as ostracods including *Darwinula.* In the highest part of the Lonfearn Member, the limestones are again biosparites with *Neomiodon* shells, and this bivalve and *Viviparus* dominate the fauna. The shales become increasingly silty upwards and the boundary with the overlying Valtos Sandstone Formation is gradational. A detailed, bed-numbered, measured section through the Leak Shale Formation and the lowest part of the Valtos Sandstone Formation exposed on the foreshore [NG 515 140]–[NG 516 147] is included in Morton and Hudson (1995) based on data supplied by J.E. Andrews.

The lower 6 m of the Valtos Sandstone Formation (Figure 6.19) seen here consist of sandy limestones, intensely bioturbated, calcareous, silty, fine-grained sandstones, and 0.05–0.30 m-thick calcilutites, interbedded with thin dark shales. The calcilutites are finely laminated, probably 'algal'-bound, and with prominent, complex, desiccation cracks. The sandy limestones contain *Neomiodon* valves, and large, probably crustacean, burrows; other trace fossils include *Planolites* and *Lockeia.* The overlying beds comprise a thin, dark shale, and then a group of coarsely sandy limestones, some with loaded ?slumps at their base; these form a prominent stack. The top is faulted against the overlying Duntulm Formation so that the upper part of the Valtos Sandstone Formation and the lower part of the Duntulm Formation are not visible in this section. The latter formation is seen in the foreshore north of the Valtos Sandstone Formation exposures [NG 516 145] and in the cliff behind, but exposure is poor and cut by numerous small intrusions and small faults (Andrews and Walton, 1990, fig. 18). A graphic section, based on Andrews and Walton (1990) and Morton and Hudson (1995), is shown in (Figure 6.20). The characteristic oyster limestones are well developed, as well as four horizons of variably developed nodular and stromatolitic algal limestone. Beds 10–29 of Andrews and Walton (1990) are best seen in the cliff, and beds 29–48, including the transition with the overlying Kilmaluag Formation, on the foreshore but, according to Andrews and Walton (1990), the algal limestone recognized by Anderson (1948) is easily located above the first thick oyster-rich limestone seen on the foreshore (Bed 20 of (Figure 6.20)). The base of that formation has been taken above the last oyster limestone, although for about 4 m beneath it, limestones are predominantly argillaceous micrites such as characterize the Kilmaluag Formation.

The lower part of the Kilmaluag Formation consists of ostracod-rich mudstone–argillaceous limestone alternations, with frequent horizons of desiccation cracks and intra-formational mud-clast conglomerates. The basal beds (Figure 6.21) are exposed on the foreshore [NG 516 146]–[NG 517 147] where a stromatolite bed has been recorded by Andrews (1986). Exposures are discontinuous across a small embayment and in the cliffs behind. The uppermost beds of the formation are exposed at, and north of, a small point with a waterfall and several dykes (Andrews, 1985). These comprise the so-called 'Breccia Beds' (dolomites with desiccation features and burrows) and the gradational boundary beds with the Skudiburgh Formation in which limestones with ostracods (including *Theriosynoecum*) and *Viviparus,* are replaced upwards by massive, purple and greenish mudstones that characterize the latter formation. The Skudiburgh Formation is exposed in the core of a syncline, the axis of which corresponds to a gentle embayment in the coastline [NG 517 147]–[NG 518 152]. The lowest 4 m, with well-developed calcrete horizons, are well exposed at the south end of this section but otherwise exposure is poor on the foreshore. The top beds of the formation are exposed at several places along the cliff and also near the cliff path a little farther north, on the south side of the Carn Mor landslip. The Carn Mor Sandstone Member of the Staffin Bay Formation, which abruptly overlies the Skudiburgh Formation, is also exposed along this stretch of coast, and can be examined in fallen blocks on the foreshore. The sandstone is coarse-grained, with pebbles up to 30 mm, and bioturbated. *Thalassinoides* burrows extend down from the sandstone into the underlying mudstone of the Skudiburgh Formation. Clusters of rhynchonellid brachiopods, identified by Sykes (1975) as *Thurmanella acuticosta* Childs, are locally conspicuous in the sandstone, and rare ammonites (*Kepplerites* (*Gowericeras*) *gowerianus* (J. de C. Sowerby) and *Proplanulites koenigi* (J. Sowerby)) also occur. The coarse top of the sandstone, with abundant belemnites, many of them reduced to moulds by a combination of metamorphism and leaching, is well exposed in the cliff section.

Glen Scaladal

The Valtos Sandstone, Duntulm, Kilmaluag and Skudiburgh formations are again exposed north of the Carn Mor landslip, to the north and south of Glen Scaladal.

Alternating fine-grained, calcareous, 0.100.40 m-thick sandstones and 0.05–0.25 m-thick dark shales of the Valtos Sandstone Formation are well exposed in the shore platform and low cliff at [NG 521 160], but the base of the formation is not exposed (Figure 6.19). The shales contain lenses of silt and very fine sand, *Planolites* burrows and *Neomiodon* shell plasters sometimes coated in pyrite. Load casts and detached load-balls occur at the bases of the sandstones. A 1.3 m-thick *Neomiodon* biosparite, with abundant and well-preserved *Viviparus scoticus* Tate, makes a conspicuous karstic outcrop on the shore on the south side of Cladach a'Ghlinne [NG 521 162]. The lowest beds of the overlying Duntulm Formation (beds 1–9 of (Figure 6.20)), including an algal limestone, are exposed in the nearby cliff adjacent to a small cave [NG 521 160]. According to Andrews and Walton (1990), this is the best exposure of that formation in Straithaird. The middle and upper part of the Duntulm Formation must crop out beneath the storm beach at the mouth of Glen Scaladal.

The Kilmaluag Formation is almost completely exposed in the prominent cliff section at the northern end of the GCR site [NG 519 165] and in the foreshore to the south (Figure 6.21). The exposure shows well-preserved sedimentary structures despite being mildly metamorphosed by the nearby Cuillin igneous complex. The lower beds, as farther south, comprise mudstone–argillaceous limestone alternations with frequent horizons of desiccation cracks and intraformational mud-clast conglomerates. These are overlain by distinctive, blue-grey, blue-weathering, hard limestones interbedded with calcareous siltstones and shales; individual limestones have irregular bases and contain bone fragments, *Viviparus* and ostracod valves, the last-named sometimes in rock-forming abundance. Concretions occur in some of the shales. This interval, known as the 'Vertebrate Beds', has yielded mammal and mammal-like reptiles (Savage, 1972; Waldman and Savage, 1972). The overlying Breccia Beds are predominantly dolomitic and weather brownish-yellow. The clasts are more dolomite-rich than the interstitial material and the cuboidal clasts show cryptalgal laminae. Conspicuous pipe-like structures, 4070 mm across and up to 0.5 m deep, cut these breccias and are filled with similar, but finer-grained, material. The Breccia Beds are overlain by a mudstone with calcrete nodules and then by lithologies similar to the underlying Vertebrate Beds. The basal transition to the Skudiburgh Formation, with limestones being replaced upwards by purple and greenish mudstones, is well exposed in the low cliffs at [NG 519 166]. A bed-numbered graphic log of the Kilmaluag Formation here is given by Harris and Hudson (1980, fig. 9) and Morton and Hudson (1995, fig. 23).

Interpretation

According to Harris (1989), the shales of the Cullaidh Shale Formation represent deposition in an enclosed, probably stratified, water body (lagoon). They lack marine macrofauna, and palynofloras have largely been destroyed by Tertiary thermal metamorphism so that palaeosalinities remain uncertain. The boundary with the overlying Elgol Sandstone Formation is transitional and demonstrates the genetic relationship between the two formations, the Elgol Sandstone Formation representing delta-front sandstones, and the upper part of the Cullaidh Shale Formation, pro-delta mudstones.

The Elgol Sandstone Formation in Straithaird forms a coarsening-upwards deltaic sequence, the sedimentology of which has been investigated by Harris (1989) who undertook detailed facies analysis. According to him, the coarsening-upward sandstones clearly represent shoreline progradation in a shallow water body (rootlets occur 5.5 m above the base). The minor fining-upward sequences indicate sediment supply by small channels flowing southwards. The channel sandstones contain fine-grained sediment drapes and probably had fluctuating discharge regimes. These sequences are interpreted by Harris (1989) as minor fluvial-dominated elongate deltas. Rootlets at the top of the sand bodies indicate plant colonization prior to abandonment and subsidence. The delta shoreline sands at the top of the Elgol Sandstone Formation that contain moulds of probable *Unio* demonstrate that by this time the basin probably contained freshwater; these sands probably also record minor wave reworking.

The restricted fauna of the overlying Leah Shale Formation is indicative of generally brackish water but with fluctuating salinities. In particular, the boundary beds of the Kildonnan and Lonfearn members show a change from low- to high-salinity faunas; they include a stromatolite bed with pseudomorphs after gypsum, which indicate hypersalinity. The formation is interpreted as representing deposition in shallow water in near-coastal lagoons (Hudson, 1983; Chen and Hudson, 1991).

According to Harris (1992), the outcrops of the Valtos Sandstone Formation in Straithaird show major thickness and facies variations because they are sited near the margin of the Inner Hebrides Basin. The formation is only about 24 m thick (compared with *c.* 120 m in northern Skye; see Valtos GCR site report, this volume) and the major sand bodies that dominate the formation elsewhere are replaced by shell-debris limestones, desiccation-cracked and burrowed limestones and shales. The mineralogy also differs: the sandstones are quartzose and contain much less feldspar. Heavy-mineral assemblages are garnet-poor, staurolite-rich and ruffle-rich; these probably indicate a significant though indirect input of sediment from the Dalradian rocks of the southern and eastern Highlands (possibly via the Old Red Sandstone, which may have extended into the hinterland of the basin). As elsewhere, pebbles are predominantly of vein quartz. The depositional environment of the Valtos Sandstone Formation is one of lagoonal deltas and interdeltaic lagoon shorelines (Harris, 1992). The characteristics of the limestones near Elgol (facies 5 and 7 of Harris, 1992) are indicative of low subsidence rates and low rates of elastic supply to the area. The desiccation cracks are indicative of periods of sub-aerial emergence of lagoon margin mudflats; the associated sandstones represent lagoon shoreline sand bodies, and the occurrence of *Neomiodon* in the sandy limestones marks brackish-water transgressions.

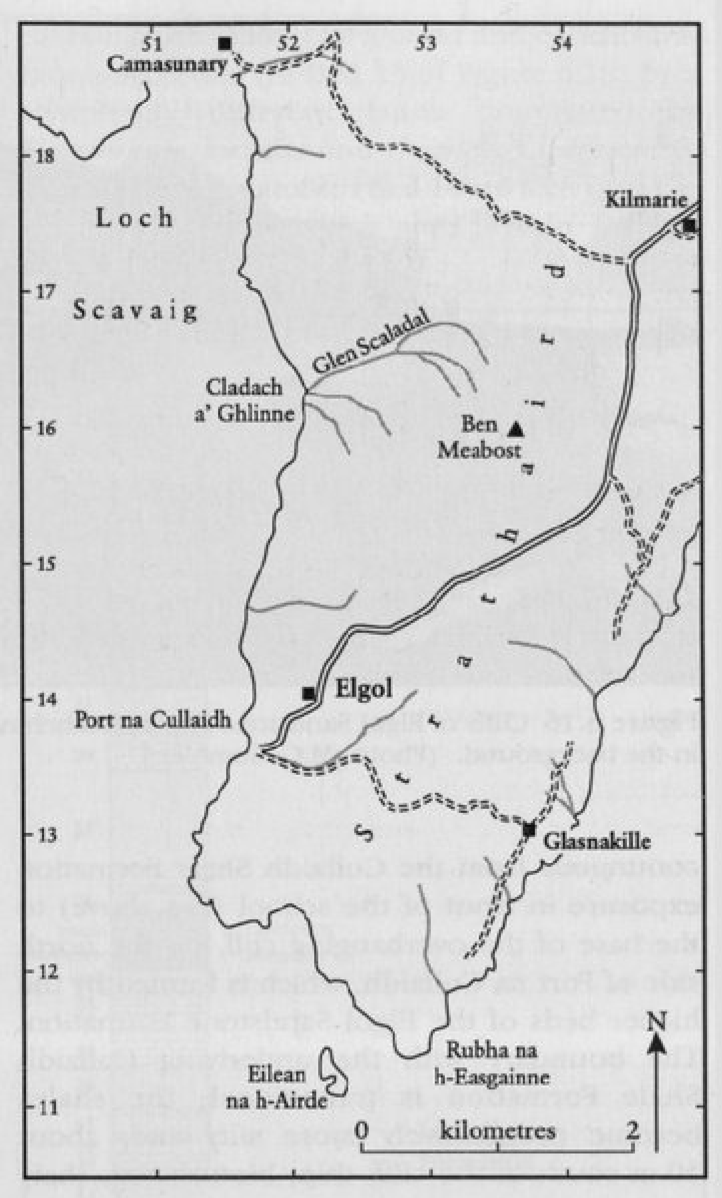
Detailed facies analysis of the Duntulm Formation suggests that it represents shallow lagoonal sediments (Hudson and Harris, 1979; Andrews and Walton, 1990). Most of the succession at the GCR site belongs to their lithofacies 1 ('*Praeexogyra* limestone–shales') and lithofacies 2 ('argillaceous limestones') and the algal limestones constitute their lithofacies 3a (Figure 6.20). According to Andrews and Walton (1990), lithofacies 1 is interpreted as probably representing former shell-banks that have 'fallen apart'; the preservation of articulated valves, and the mudstone matrix, militate against strong current reworking, and they were probably agitated by weak, wind-driven tides in shallow water. The argillaceous beds intercalated between the oyster beds are interpreted as inter-shell-bank muds. The clay minerals and silts were probably deposited in the lagoons as distal suspension detritus from small rivers. The limestones of lithofacies 2 probably represent shallow littoral carbonate–siliciclastic mud deposition. The bivalve faunas are identical to those from the inter-shell-bank muds of lithofacies 1 but colonization by oysters was prevented by the soft, muddy substrate. The impure carbonate muds that these beds represent possibly accumulated in quiet water, leeward of the oyster-shell banks that dampened currents. Lithofacies 2 limestones at the base of the formation indicate the final abandonment of the Valtos Sandstone Formation delta as the 'Duntulm transgression' began (Andrews and Walton, 1990). Grain-rich, chaotically bedded laminae alternating with micritic laminae are interpreted as episodic storm layers. Shallow burrowing bivalves and other burrowing organisms bioturbated the muddy substrates during periods of quiescence. The petrography and palaeoecology of the algal limestones of lithofacies 3a have been studied in great detail (Hudson, 1970; Andrews, 1986); the latter author interpreted them as supralittoral 'algal' stromatolites.

The Kilmaluag Formation exposed here belongs to the 'argillaceous limestone' facies of Andrews (1985). Lamination, which is common in the argillaceous limestones, is in places disrupted and domed suggesting that the beds are stromatolitic. Such domes are indicative of a shallow sublittoral to intralittoral depositional environment, which, for the formation as a whole, is deduced to be ephemeral lagoons, closed from the sea. According to Andrews (1985), the basal beds (1–9) represent a mud-dominated, low-salinity lagoon that alternated between elastic and carbonate mud deposition. The rhythmic alternation of muds and muddy carbonates probably reflects climatic control. Magnesium/calcium ratios probably varied during seasonal climatic changes. Mud-clast conglomerates formed when the lagoon evaporated to leave exposed vast mudflats that dried and cracked. The thicker limestones of the so-called 'Vertebrate Beds' have the lowest magnesium content in the Kilmaluag Formation of Straithaird and, according to Andrews (1985), may represent a wet climatic phase. He envisaged gastropods, ostracods and turtles flourishing while terrestrial vertebrate bone fragments accumulated on the muddy lagoon bed. Courses of desiccation breccias may be lagoon floor lags, reworked from the marginal flats, but the Breccia Beds themselves appear to represent the lagoon-marginal mudflats that existed during prolonged periods of exposure and desiccation. Cryptalga-laminates were cracked and partially reworked, accompanied by penecontemporaneous dolomitization. The upper part of the succession records a return to largely sublittoral, lagoonal environments. The recovery of a specimen of *Unio* (Andrews, 1985) probably indicates non-evaporated freshwater. Calcrete nodules, similar to those in the overlying Skudiburgh Formation, which occur amongst the highest beds of the Kilmaluag Formation, probably record the oscillatory transition from relatively extensive, coastal lagoons to smaller alluvial-plain lagoons, and eventually the coastal plain, terrestrial environments of the Skudiburgh Formation.

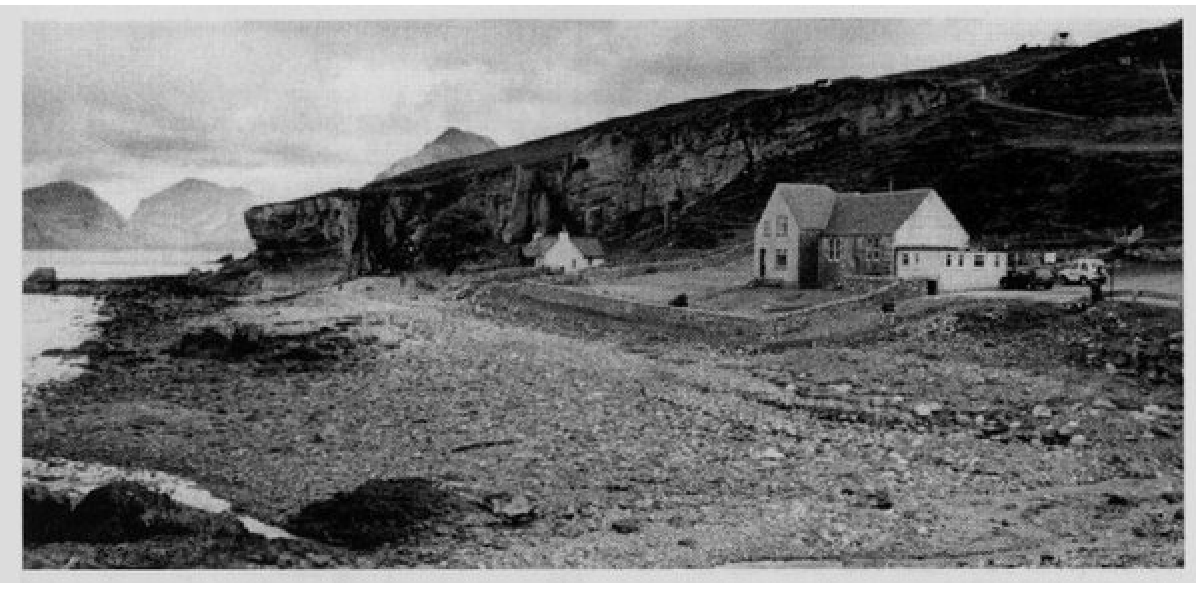
Conclusions

The Elgol–Glen Scaladal GCR site exposes virtually the entire Great Estuarine Group of Straithaird, southern Skye, and is the only site representing that region. It includes the type section of the Elgol Sandstone Formation, and type and reference sections for the Cuillaidh Shale and Kilmaluag formations. Although thermally metamorphosed and intruded by dykes and sills, the succession records all of the characteristic features of the component formations of the group in the Inner Hebrides Basin, which represent a range of coastal lagoonal and deltaic depositional palaeoenvironments (Figure 6.22). The site is therefore an important one for stratigraphy, sedimentology, palaeoecology and palaeogeography.

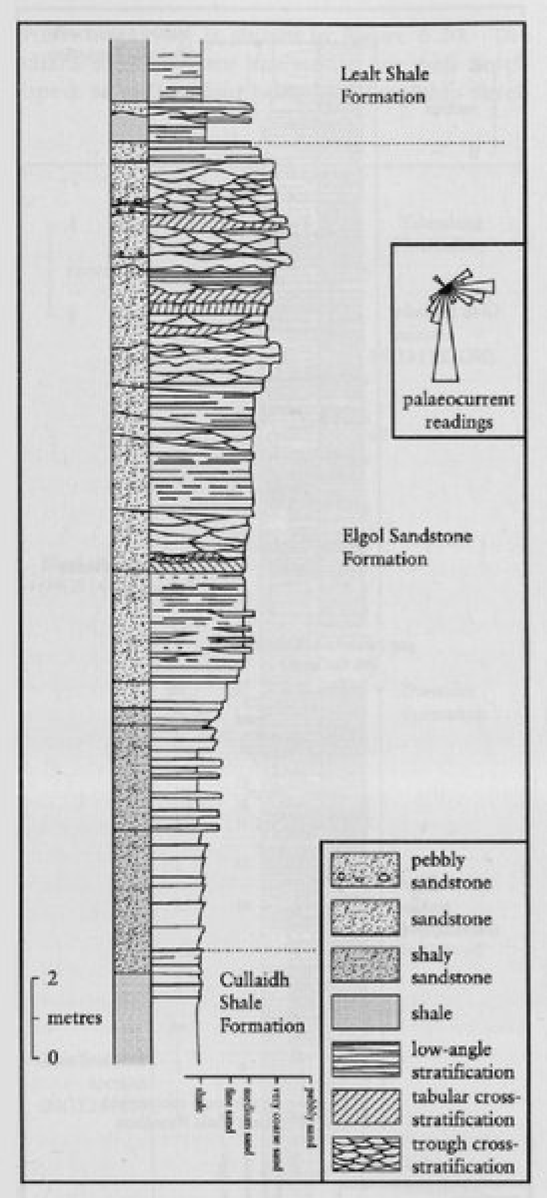
References



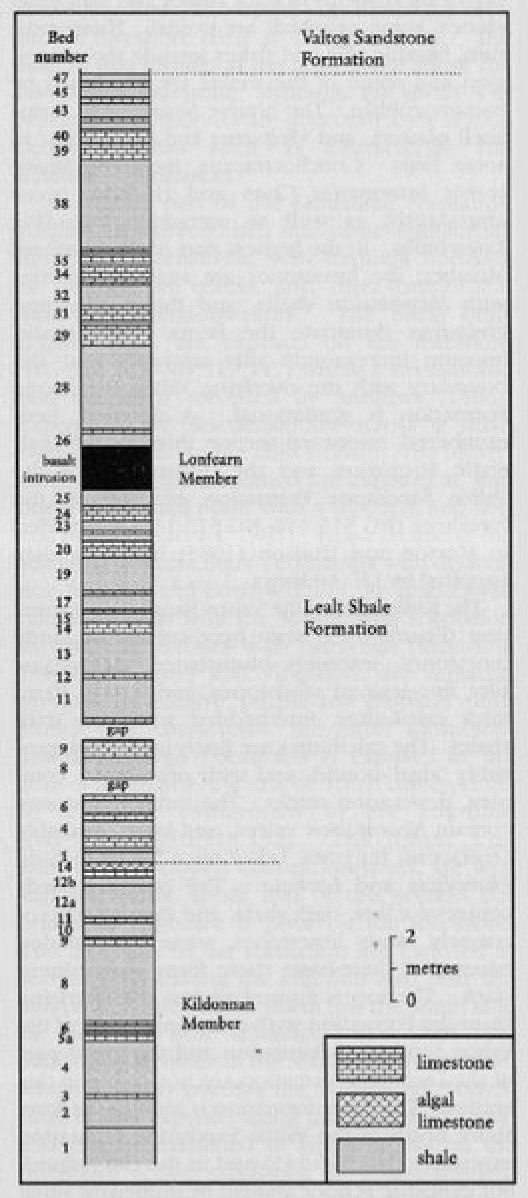
(Figure 6.15) Locality map for the Elgol–Glen Scaladal GCR site.)



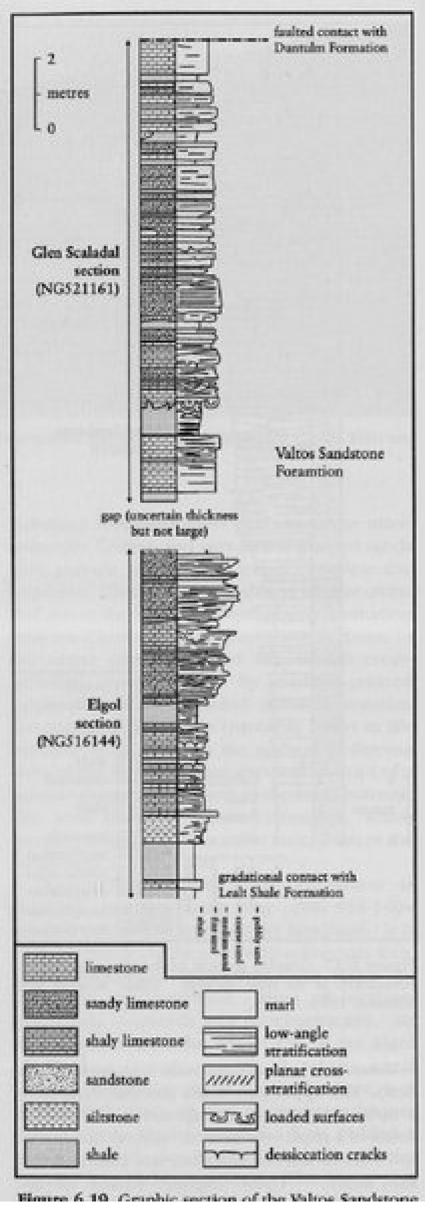
(Figure 6.16) Cliffs of Elgol Sandstone Formation behind the school (centre right) at Elgol. The Cuillin Hills are in the background. (Photo: M.G. Sumbler.))



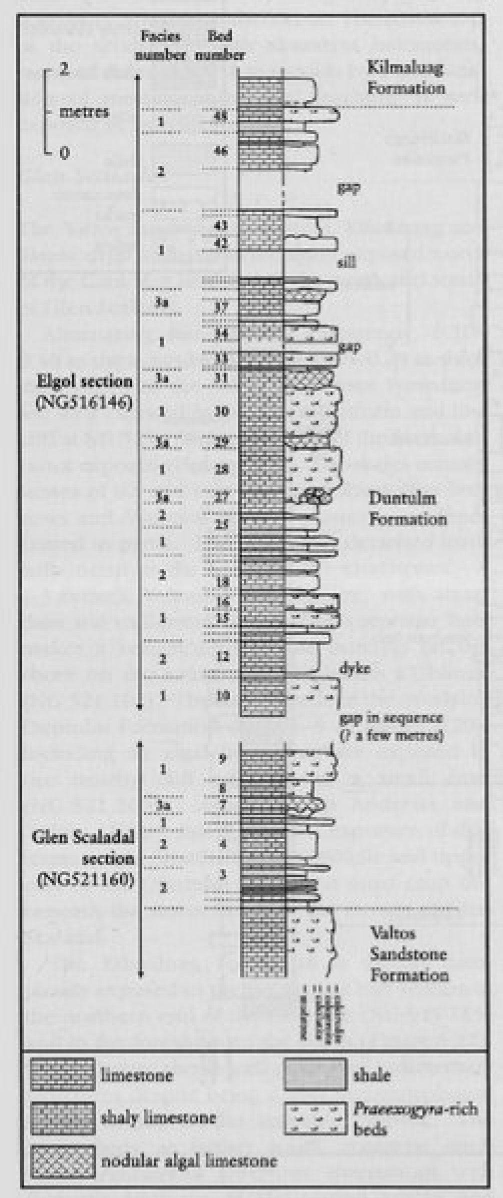
(Figure 6.17) Graphic section of the Elgol Sandstone Formation at its type locality. (After Morton and Hudson, 1995, fig. 19.))



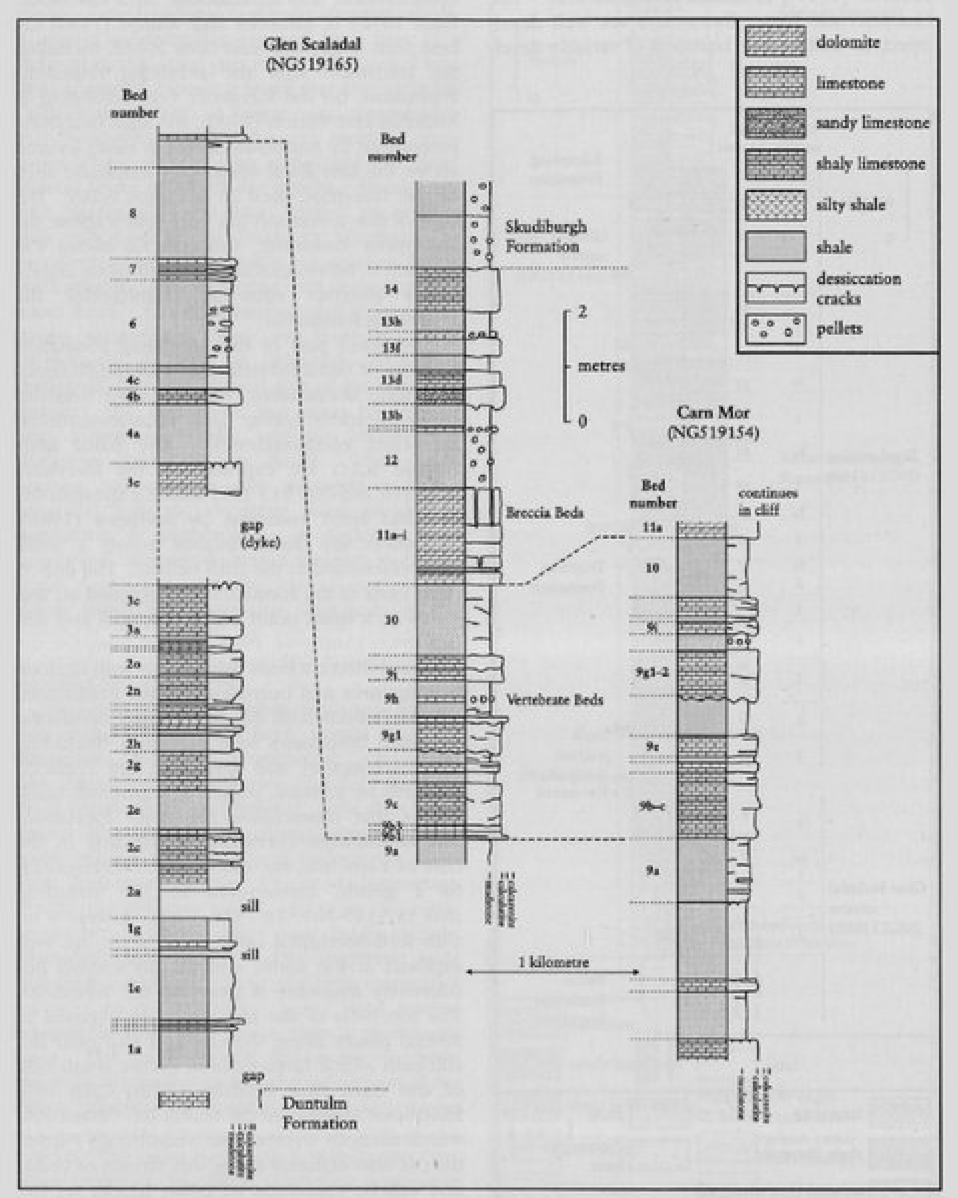
(Figure 6.18) Graphic section of the Leak Shale Formation on the coast north of Elgol, Isle of Skye. (After Wakefield, 1994, fig. 50.) Bed numbers follow Andrews (1984).)



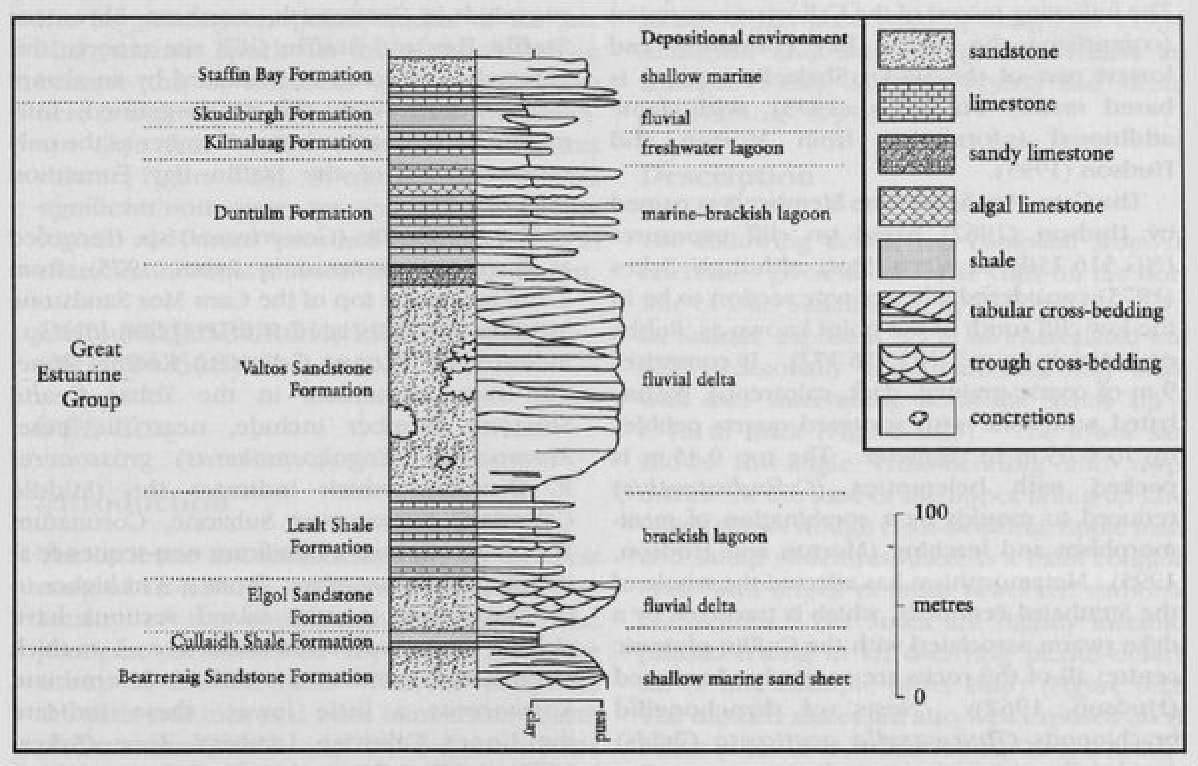
(Figure 6.19) Graphic section of the Valtos Sandstone Formation on the coast north of Elgol, Isle of Skye. (After Morton and Hudson, 1995, fig. 20.))



(Figure 6.20) Composite graphic section of the Duntulm Formation at Elgol–Glen Scaladal. (After Emeleus, 1997, fig. 17.) Bed and facies numbers follow Andrews (1984).)



(Figure 6.21) Graphic section of the Kilmaluag Formation, north of Elgol, Isle of Skye. (After Morton and Hudson, 1995, fig. 23.) Bed numbers follow Andrews (1984).)



(Figure 6.22) Main lithologies, fossils and depositional environments of the Great Estuarine Group of the Inner Hebrides. (After Hudson et al., 1995, fig. 1.))