8 Surnaig Farm, Islay

[NR 396 451]–[NR 403 453]

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8.1 Introduction

Much of the detailed sedimentological history of the Dalradian Supergroup has been deciphered from rocks in the South-west Grampian Highlands (e.g. Anderton, 1985). This is because the tectonic strain and metamorphic grade are relatively low, and hence the original sedimentary structures are preserved. This is superbly illustrated near Surnaig Farm, to the south-east of Lagavulin Bay on the south-east coast of Islay (Figure 2.18), where spectacular sandstone dykes are exposed on the rocky foreshore. The dykes occur in rocks that are assigned to the Laphroaig Quartzite Formation (Easdale Subgroup), which at this locality is at least 260 m thick. Its boundary with the underlying Port Ellen Phyllite Formation is gradational, representing a change from a succession dominated by metamudstones to one dominated by metasandstones. Poor exposure makes the positioning of this boundary somewhat arbitrary. Elsewhere on Islay, the Laphroaig Quartzite is overlain by the conglomeratic basal member of the Ardmore Formation (Crinan Subgroup).

Other rocks that crop out at this locality include sills of metamafic rock. The basal contact of one of these sills is exposed at the west end of Lagavulin Bay [NR 4025 4536]. Here the country rocks are contact metamorphosed (Wilkinson, 1907) but have been little affected by the subsequent regional metamorphism associated with the Grampian Event. There is also a good exposure of a dyke of metamafic rock on the foreshore at [NR 3927 4523].

The Laphroaig Quartzite Formation was first described by Wilkinson (1907). However, the sequence he proposed was upside-down as was later demonstrated by Bailey (1917) and Allison (1933), using sedimentary way-up indicators. The sandstone dykes were first described by Borradaile (1974) who used the angular relationships between the dykes, the cleavage and the bedding to estimate the amount of strain associated with the formation of the Islay Anticline.

8.2 Description

Sandstone dykes are not uncommon in Dalradian metasedimentary rocks (e.g. Smith and Rast, 1958) and have been described from several localities on Islay (Borradaile and Johnson, 1973; Borradaile, 1974). Most are small, being only a few centimetres or so wide and a few tens of centimetres long. However, much larger sedimentary dykes occur within the Laphroaig Quartzite Formation along the south-east coast of Islay. The best exposed and most impressive of these occur at this GCR site in a rocky bay 400 m west-south-west of Lagavulin Bay (Figure 2.18). Here, the largest sedimentary dyke is 0.5 m wide and penetrates 16 m beneath the source bed (outcrop 3 of Borradaile, 1974).

The dykes occur in the middle of the formation and are intruded into beds of metamudstone, which are 2–3 m thick (Figure 2.19). These metamudstone beds are interbedded with metasandstone beds, which vary in thickness from 1 m to a few centimetres and form the source rocks for the sedimentary dykes. However, it is not always clear which metasandstone bodies represent true bedding and which are cross-cutting sedimentary dykes. Some of the metasandstones are original orthoquartzites, whilst others are calcareous. There are also rare metalimestones, but none are more than 2–3 cm thick. This part of the succession is *c.* 30 m thick. Above this, metamudstone beds are much thinner (generally less than 10 cm thick), and the succession is dominated by massive metasandstone beds, which vary between 0.5 and 2 m in thickness. The strike of bedding here is *c.* 280° and the dip is about 30° to the south.

Upwards of thirty sedimentary dykes may be observed here, the majority of which are only a few centimetres thick and 1–5 m long. All lie at an acute angle to the bedding and are both folded and planar. The planar dykes make angles with bedding of around 20° and the long limbs of the folded dykes make higher angles, around 44°, with the bedding (Borradaile, 1974). The largest dyke (mentioned above) is spectacularly folded (Figure 2.19). The folds are close to tight and the cleavage in the host rock metamudstone is axial planar to them. Some of the smaller dykes also show a similar style of folding. There is one clearly exposed example of two planar dykes cross-cutting each other and other examples of dykes forming offshoots from other dykes. All the examples of sedimentary dykes described above occur in a relatively small exposure at [NR 3978 4523].

Locally the sills of metamafic rock, which dip at 20 to 30° to the east-south-east, dominate the landscape as they form prominent ridges. One forms the headland on the western side of Lagavulin Bay. This sill is *c.* 15–20 m thick and retains a relict ophitic igneous texture. Also preserved at the base of the sill, at [NR 4020 4535], are metasedimentary rocks that have been subjected to contact metamorphism and, because of this, have been little affected by the later regional metamorphism. Whereas sills are common, dykes of metamafic rock are rare. There is an unequivocal example of a highly schistose dyke on the foreshore 50 m to the east of the sedimentary dyke locality. It is intruded into rocks that are predominantly quartzitic metasandstones, is 2 m wide, vertical and trends north–south, clearly cross-cutting the metasedimentary rocks.

The rocks here were deformed and metamorphosed up to the greenschist facies during the Grampian Event and the metamudstones have been recrystallized into phyllites. The dominant cleavage is an S1 penetrative cleavage, and it is this cleavage that is axial planar to the folds of the sedimentary dyke described above. The cleavage observed in the meta-igneous dyke is also S1.

8.3 Interpretation

Borradaile (1974) interpreted the metasedimentary dykes as neptunian, that is the infilling with sand of fractures in already consolidated sediment. He used the angular relationships between bedding, cleavage and the dykes to estimate the amount of strain that these rocks were subjected to during the D1 phase of deformation that produced the major Islay Anticline (Roberts and Treagus, 1977c). He concluded that there was 70% shortening normal to the slaty cleavage and extensions of 63 % and 109 % within the plane of the cleavage in the phyllitic rocks. More recently, many sedimentary dykes elsewhere have been interpreted as due to the forceful injection of sand from an unconsolidated source bed into adjacent consolidated beds (Collinson, 1994); and, furthermore, the formation of large sedimentary dykes due to passive infilling of cracks requires the presence nearby of an unconformity or at least the formation of an erosion surface in cohesive sediments. Hence it may be that none of the dykes described here is neptunian in origin.

Neptunian dykes indicate a break in sedimentation and dessication of surface sediments. However, if the dykes resulted from forceful injection, then they might have formed in buried sediments in which liquefied sand was injected into a cohesive host, in this case clay-rich sediment. This process usually requires overpressured pore fluid, which commonly arises from rapid burial of the host sediments, with the formation of sand-filled dykes possibly being triggered by earthquakes (Collinson, 1994).

Dykes of metamafic rock up to 30 m wide have been described from Jura (Graham and Borradaile, 1984) but they are rare on Islay and on the mainland, where sills predominate. Graham and Borradaile made the significant point that on Jura the host rocks are stratigraphically older than those on Islay and the mainland. This suggests that the igneous ‘plumbing system’ here may have followed the model of Francis (1982), where the level of intrusion of sills is constrained by the lithostatic pressure in the country rock and the hydrostatic pressure in the feeder dyke. Intrusion of sills will only occur where the hydrostatic pressure of the magma in the feeder dyke is greater than the lithostatic pressure of the country rocks; the lithostatic pressure directly relates to depth of burial. At the time of intrusion of the sills and dykes, the stratigraphically older rocks on Jura will have been at a greater depth than the Port Ellen Phyllite and Laphroaig Quartzite formations on Islay and, critically, too deep for the intrusion of sills. It is probable that the dyke described above was a feeder dyke for the nearby or higher sills.

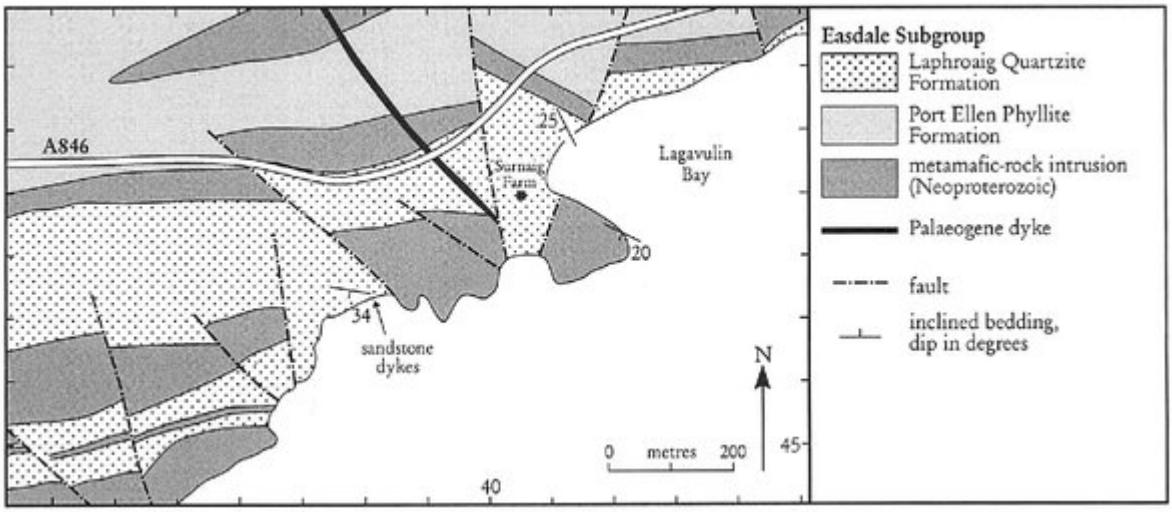
The igneous dykes are important indicators of the extensional stress regime associated with the Dalradian sedimentary basin. The orientation of this dyke is similar to the majority found on Jura and indicates an extension direction approximately east–west.

8.4 Conclusions

Although sedimentary dykes are not uncommon in the Scottish Dalradian, none of the other reported examples are as spectacular as those found at the Surnaig Farm GCR site. In fact these are some of the best examples of sedimentary dykes in Britain and are certainly the best found in deformed rocks. They are most likely to have resulted from interstratal dewatering, as has been proposed here for sandstone dykes at the *Caol Isla* GCR site, but some of the diagnostic features have been obscured or destroyed at Surnaig Farm by subsequent deformation.

The shoreline here also reveals several other intriguing aspects of Dalradian geology, including a fine example of a sill of metamafic rock and, rare for Islay, an unequivocal example of a metamafic-rock dyke. The GCR site, therefore, provides evocative snapshots of the evolution of the Argyll Group, from the sedimentation and igneous activity associated with its early depositional history, to the deformation and metamorphism of these rocks in the subsequent mountain building episode now referred to as the Grampian Event.

References



(Figure 2.18) Map of the area around the Surnaig Farm GCR site, south-east Islay, showing the 'sandstone dykes' locality.

(Figure 2.19) A folded sedimentary dyke (viewed to the west), within the Laphroaig Quartzite Formation, 300 m south-west of Surnaig Farm, south-east Islay [NR 3982 4525]. The dyke is between 40 cm and 50 cm wide and the spirit level (centre) is 5 cm long. (Photo: P.W.G. Tanner.)