10 Ardilistry Bay, Islay

[NR 443 485]–[NR 447 483]

C.A. Bendall

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10.1 Introduction

Along the coastal sections at Ardilistry Bay, 8 km east of Port Ellen in south-east Islay, metamorphosed basic sills account for over half the succession. One of the sills, exposed along the south-east shoreline of the bay [NR 4415 4816]–[NR 4441 4837], is almost certainly unique in the British Isles. This sill is around 12–14 m thick and, towards the base, there is a 3 m-thick layer that consists almost entirely of the amphibole, actinolite. The protolith of this rock was almost certainly a pyroxene-cumulate and the pyroxene has been replaced by actinolite during greenschist-facies metamorphism. Although the mineralogy has changed, the original cumulate texture is retained. The metapyroxenite is overlain by a metamorphosed plagioclase layer approximately 1 m thick, in which albite and epidote have replaced the original plagioclase.

The country rocks around the bay are Dalradian metasedimentary rocks belonging to the Easdale Subgroup of the Argyll Group. These rocks were first described by Wilkinson (1907), and have received relatively little attention since. Wilkinson also provided the most comprehensive description of the Islay sills, although this was rather general and he made no mention of this particular sill. The area was resurveyed by Basahel (1971) and much of the revised 1998 edition of the BGS 1: 50,000 Sheet 19 (South Islay) is based upon his work.

10.2 Description

Two formations crop out at Ardilistry Bay; the Port Ellen Phyllite is poorly exposed, especially inland, but the younger Laphroaig Quartzite is exposed intermittently around the coastline (Figure 2.22). The Port Ellen Phyllite Formation consists mainly of metamudstones with subordinate metasandstones and impure metasandstones. The metasandstones become more common towards the top of the formation, where there is a gradation into the thickly bedded metasandstones with subordinate metamudstones of the Laphroaig Quartzite Formation. This low-lying coastal region is dominated by a series of ridges, parallel to strike, that are formed by sills of resistant metamafic rock (Figure 2.23). Thinner sills are generally schistose but, while their margins may be schistose, many of the thicker sills retain relict igneous textures that are commonly ophitic. The mineral assemblage of the sills is typical of the greenschist facies and consists of chlorite, actinolite, albite, epidote, calcite, quartz and leucoxene.

Among several curious features to be found in these sills, are pods rich in the yellow-green mineral epidote. They are quite conspicuous in some of the thicker sills along the north-east shore of the bay.

The metapyroxenite-bearing sill is found at [NR 4431 4831]. There is good exposure in low cliffs along the shoreline, but it is poorly exposed when traced inland. A schematic section of this sill is presented in (Figure 2.24). The basal part is schistose; little remains of the original igneous texture except for relict phenocrysts, which were probably once calcium-rich plagioclase. These have been pseudomorphed by albite, epidote and calcite during greenschist-facies metamorphism and have been flattened during the deformation that produced the schistosity. Although the base of this schistose unit cannot be observed directly, the unit appears to be no more than about a metre thick, and could represent the original fine-grained basal margin to the sill. Immediately above this is the actinolite-rich layer, which is approximately 3 m thick and consists almost entirely of actinolite pseudomorphs after clinopyroxene. These are mostly euhedral to subhedral, dark olive green crystals some 2–3 mm in size, and they are randomly orientated. In thin section the actinolite is almost colourless, indicating a high Mg/Fe ratio, which has been substantiated by electron-microprobe analyses

(Bendall, 1995). Interstitial to the large actinolites is a fine-grained groundmass of epidote, albite, calcite, leucoxene, rare quartz and acicular actinolite. This layer appears to be fairly homogenous in texture and composition.

Above this layer there is a transition zone that is about a metre thick. Pseudomorphs of albite-epidote after plagioclase occur, and increase in abundance upwards at the expense of the actinolite, until they account for more than 90% of the rock, resulting in what is in essence a meta-anorthosite. The pseudomorphs after plagioclase are larger than the actinolites and are generally between 1 and 2 cm in size. Most appear to be subhedral and are quite rounded. The meta-anorthosite layer is approximately 1 metre thick and grades upwards into a layer of metamafic rock with relict ophitic texture, which is *c*. 2 m thick. About 3.8 m of finer grained schistose metamafic rock makes up the uppermost layer of the sill, and the schistosity increases in intensity upwards; the top 1.5 m is highly schistose. Whereas albite-epidote pseudomorphs still occur above the meta-anorthosite layer, they are less abundant (5–10% of the rock) and smaller (generally less than 1 cm) than at lower levels.

Structurally, these rocks lie on the south-eastern limb of the Islay Anticline and the beds dip and young to the south-east. The metapyroxenite-bearing sill is concordant with bedding, and its top dips at 45° to the south-east. The schistosity also dips to the south-east, but is somewhat steeper, giving a sense of vergence towards the north-west.

10.3 Interpretation

The relict texture defined by the actinolites in the metapyroxenite layer suggests that the igneous protolith to this rock was a clinopyroxene-cumulate. The presence of albite, epidote and calcite, interstitial to the actinolites, suggest that plagioclase was an intercumulus phase. Whole-rock analyses are low in silica (47%) and rich in MgO (19%) (Bendall, 1995). Hence, it is possible that there was some intercumulus olivine, as well as plagioclase. This layer was most likely formed by the early crystallizing phase, clinopyroxene, settling out under the influence of gravity.

Once the clinopyroxene had settled out, it appears that plagioclase was then the main crystallizing phase. The plagioclase too may have settled out to form a cumulate anorthosite layer. However, as plagioclase has a relatively low density, and may not settle out as easily as pyroxene, this layer could have formed through crystallization of plagioclase, without any subsequent movement through the magma, making the protolith to the meta-anorthosite a plagioclase-adcumulate.

The sill is probably associated with the Tayvallich volcanic rocks, which were extruded at around 600 Ma ago (Halliday *et al*., 1989; Dempster *et al.,* 2000). During the mid Ordovician Grampian Event, the sill underwent deformation and greenschist-facies metamorphism along with the country rocks. The sense of vergence to the north-west, shown by the schistosity on bedding, is consistent with it forming during the same (D1) deformation phase that formed the Islay Anticline (Roberts and Treagus, 1977c).

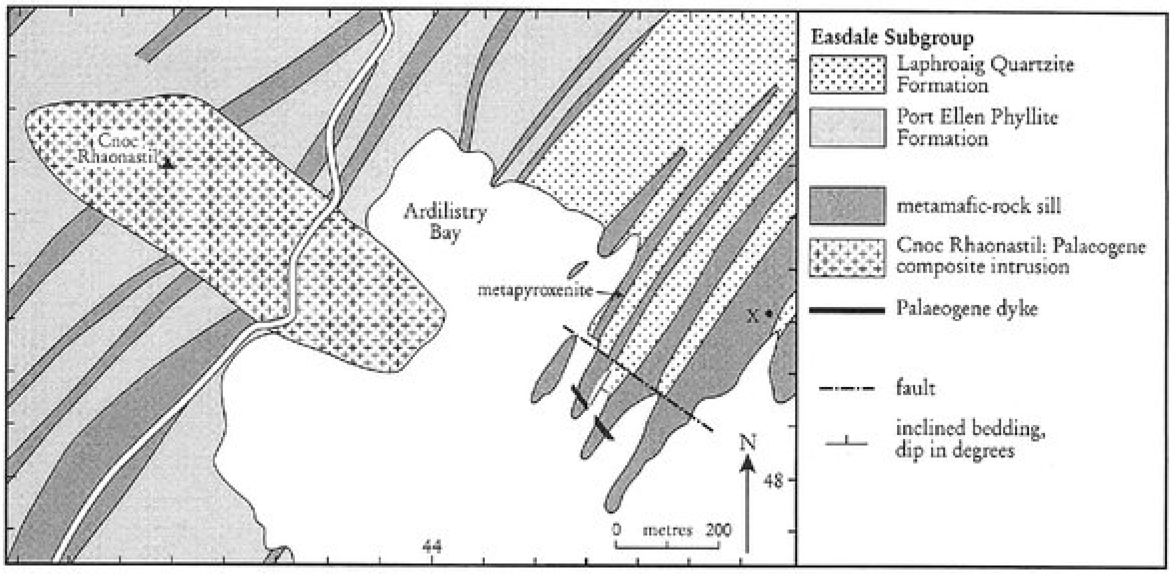
Only the margins of the sill are schistose and the inner part retains the original igneous textures. Work by Skelton *et al*. (1995, 1997) has described the effect of carbonation of greenschist-facies metamafic-rock sills by infiltration of a CO_2-bearing hydrous fluid. This has produced a distinctive zoning pattern in the sills, in which the primary amphibole-epidote assemblage is preserved in the cores, whereas the schistose margins have been altered to calcite, chlorite and quartz. These authors also observed that there is an asymmetry in the width of the zones across the sill, such that one altered margin is much wider than the other. They concluded that this asymmetry was controlled by the orientation of the sill with respect to the direction of fluid flow and the partitioning of flow along and across the sill. The contrast between a narrow altered margin at the base of the sill at Ardilistry Bay (Figure 2.24), and a thicker one at the top, might have been controlled in this manner, and it could be significant that the metapyroxenite layer occurs immediately above the narrower, least altered margin.

10.4 Conclusions

Metapyroxenite rocks are relatively rare in the British Isles. They are found in the Lewisian Gneiss Complex of north-west Scotland, which are generally at a high metamorphic grade (amphibolite- to granulite-facies), and occur as very low-grade rocks, such as in the Shetland and the Ballantrae Ophiolite-complexes. However, it is possible that the metapyroxenite at Ardilistry Bay might be the only greenschist-facies metapyroxenite preserved and exposed in the British Isles.

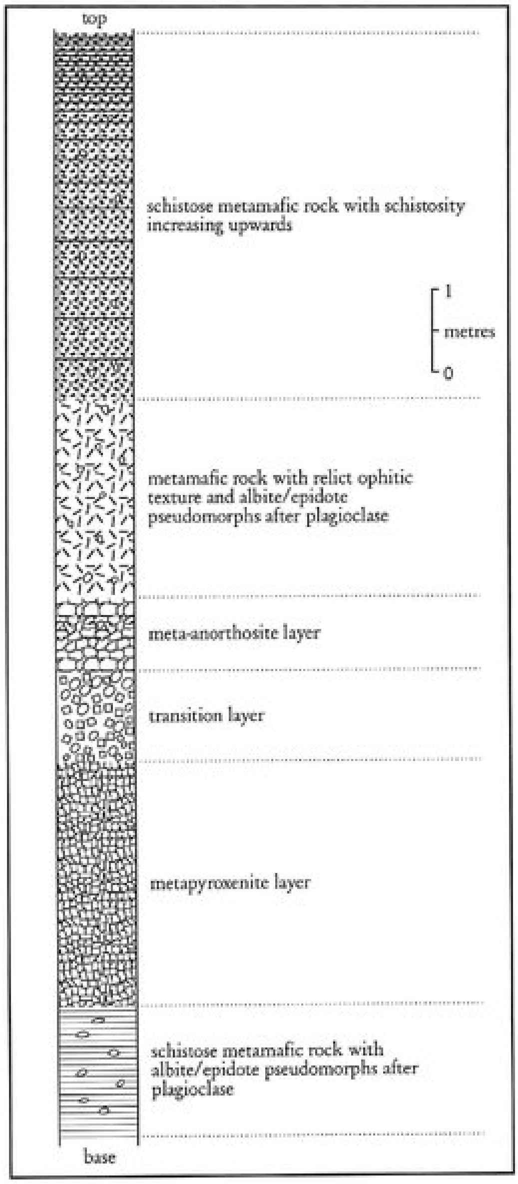
The metapyroxenite layer is up to 3 m thick and consists almost entirely of coarse-grained actinolite, a Mg-rich calcic amphibole that has replaced original clinopyroxene during metamorphism. It occurs in a sill that also has a 1 m-thick layer of meta-anorthosite, representing an original plagioclase-rich layer. The sill, therefore, is an excellent example of a layered basic igneous intrusion that has been metamorphosed to the greenschist facies. Whereas deformation and fluids associated with the metamorphism have altered the margins of the sill, which now has a schistose fabric, the inner part has retained the original igneous textures, particularly in the metapyroxenite and meta-anorthosite layers. The good exposure, and the very distinctive appearance of this rock, enhances the geological attractiveness of an already geologically fascinating small corner of Islay.

References



(Figure 2.22) Map of the area around the Ardilistry Bay GCR site, south-east Islay.

(Figure 2.23) Topographic expression of sills of metamafic rock at Ardilistry Bay, south-east Islay, viewed looking south-east from Locality X on (Figure 2.22). (Photo: P.W.G. Tanner.)



(Figure 2.24) Schematic vertical section through the metapyroxenite-bearing sill at Ardilistry Bay, south-east Islay.