Carsaig Bay

Highlights

The site is notable for:

1. the presence of the thickest development of basal Palaeocene sediments on Mull, which contain debris derived from weathering of Cretaceous and earlier rocks under desert conditions;
2. a complete section through a composite (basic–acid) sill containing cognate and accidental xenoliths. Some of the latter have been partially fused and their high-temperature minerals include mullite.

Introduction

Carsaig Bay is a site of multiple interest, extending between Rubh' a' Chromain and Carsaig House, including the off-shore island of Gamhnch Mhor and the cliff at An Dunan. The interest of the site can be divided into the following categories:

1. Palaeocene sedimentary rocks, which attain their maximum development in the site and comprise sandstones and mudstones with numerous chalk clasts from the underlying Cretaceous strata.
2. The Rubh' a' Chromain composite xenolithic sill: this sill belongs to the Scridain Suite of sills which exhibit felsitic, basaltic and hybrid portions rich in cognate and accidental xenoliths.
3. The Gamhnach Mhor Syenite.

There has been no recent investigations into the geology of this site and the Mull Memoir is again the main source of information. A recent study concerned with magmatic processes which operated during the emplacement of a Scridain Suite sill to the west of the site has been made by Kille *et al.* (1986). This investigation, which has some applications to the Rubh' a' Chromain sill, demonstrated localized turbulent flow of the magma during emplacement and selective assimilation of wall rocks. The geology of the site is depicted in (Figure 5.12).

Description

Palaeocene sediments are well represented in the gully above Aird Ghlas [NM 534 212] and at Feorlin Cottage [NM 535 221], where they attain their maximum thickness of 1–2 m. At Aird Ghlas, Bailey *et al.* (1924) have recorded the following sequence:

6. Basalt lava	
5. Soft, shaly sandstone with flint fragments	0.30 m
4. Greenish sandstone with flints and silicified chalk clasts	0.60 m
3. Purple mudstone	0.30 m
2. Greenish, partly glauconitic sandstone with chalk and flint fragments	1.60 m Gap
1. Cenomanian sedimentary rocks (for details see Lee and Bailey, 1925, pp. 118–20)	

The purple mudstone, which commonly occurs beneath the basal lava flow in Mull and Morvern, is interbedded with other sediments at this locality. Chalk fragments in the sandstones are hard and siliceous; their size and angularity suggests that they were derived locally, the silicification probably took place after the deposition of the sandstone (Bailey *et al.,* 1924). Abundant Cretaceous foraminifera have been identified within the chalk clasts (Jones, *in* Judd, 1878). The sandstone which underlies the mudstone consists of beautifully rounded, presumably wind-worn, quartz grains cemented by a dark, cherty matrix which also surrounds the chalk fragments. The latter are less abundant to the east, distinct horizons rich in chalk clasts being absent at Eas Mheannain [NM 538 221], where the fragments are irregularly scattered

within the underlying thick, red-stained, pebbly sandstone.

The sequence within the stream section at Feorlin Cottage [NM 535 221] differs from that at Aird Ghlas and is as follows:

5. Basalt lavas	
4. Purple mudstone	1.0 m
3. Chalk fragments in a black sandy matrix	0.20 m
2. Massive, white pebbly sandstone with some iron staining and containing a lenticular bed of white flints towards the top	6.0 m
1. Glauconitic sandstone (Cenomanian) passing down into concretionary limestones	

Still farther east in the site, no chalk is encountered within the sandstone, which grades rapidly downwards into a more glauconitic sandstone containing crushed bivalve debris thought to have been derived from the Cenoman-ian; the rock may or may not be of Palaeocene age. Sediments comprising 3–7 m of pale-green to buff-coloured breccia containing clasts of fine-grained vesicular basalt in a black, calcitic matrix, occur in the cliffs between Carraig Mhor [NM 555 211] and An Dunan [NM 563 212], within the lava succession. Plant remains have been located in shaly deposits a little below this horizon.

The first basalt lavas, lying immediately above the sediments, are markedly columnar — a feature characteristic of basaltic flows found elsewhere near the base of the Mull sequence. However, it is not known if these flows belong to the typically columnar Staffa Magma Type flows, examples of which occur at Ardtun. The basal lavas reach their maximum development of around 350 m, with an average flow thickness of 15 m in the Carsaig area (Bailey *et al.,* 1924).

The Rubh' a' Chromain Sill, exposed at the western edge of the site, is related to the Scridain Suite of sills (Bailey *et al.,* 1924). It is a striking and clearly exposed example of a composite intrusion having a sheet-like form and dipping to the north-west. The centre of the sheet contains felsite distinctly separated from basaltic margins which are normally chilled against the country rock (Figure 5.13). The special interest of this composite intrusion lies in the presence of a varied suite of cognate and accidental xenoliths up to a metre in diameter; these are described below.

In detail, the intrusion cuts an earlier, irregular trachytic (bostonite) intrusion with a fine-grained, purplish-grey, aphyric appearance. Like the sill, the bostonite is xenolithic; a xenolith of black fossiliferous limestone has been tentatively assigned to the early Lias age, possibly related to the Broadford Beds (Lee and Bailey, 1925).

The lower contact of the Rubh' a' Chromain Sill abuts the Lias which appears to have been locally fused, resulting in the formation of tridymite. Kille *et al.* (1986) have described widespread fusion of pelites where doleritic Scridain sheets cut Moine metasediments to the west of the site at Traigh Bhan na Sgurra [NM 424 185]. The following section through the composite intrusion at Rubh' a' Chromain is based on the work of the Survey:

Top	
Bostonite, at upper contact	
Chilled tholeiitic basalt	0.08 m
Tholeiite with cognate gabbroic xenoliths	1.20–1.80 m
Quartz dolerite with densely packed aluminous xenoliths	0.60–1.50 m
Porphyritic felsite with scattered xenoliths of sandstone at the margins and sandstone and shale xenoliths more centrally	6–9 m
Banded, possibly hybridized felsite	0.50 m
Quartz dolerite with numerous cognate xenoliths and a few accidental types	0.60–1.50 m
Chilled tholeiitic basalt	0.10 m
Lias sandstones	
Bottom	

The quartz dolerite is poor in olivine with brown, elongated, often curved crystals of augite. The interior felsite has a sharp contact with the quartz dolerite and contains sparse crystals of labradorite in a felsitic groundmass. Some chilled patches of rhyolite or acid pitchstone (Bailey *et al.,* 1924) occur in the centre of the sill; they exhibit skeletal and devitrification textures under the microscope.

The cognate xenoliths are generally dark-coloured, coarsely crystalline dolerites which appear as glomeroporphyritic patches of bytownite, hypersthene and rare greenish augite in a fine-grained variolitic matrix. A few olivine pseudo-morphs are also present. Accidental xenoliths are much more variable and, although not all of the following types occur at Rubh' a' Chromain, they characterize the Scridain Suite as a whole (see Bailey *et al.,* 1924 and Kille *et al.,* 1986 for other localities where similar xenoliths are described within the Scridain sheets).

1.	Micaceous gneiss
	Granulite
	Quartzite
2.	Granite
	Pegmatite
3.	Sandstone
	Shale
	Carbonaceous rock
	(bituminous shale/coal)
4.	Basalt lava

A significant feature of the Rubh' a' Chromain Sill is the distinctive, high-temperature mineralogy of the thermally metamorphosed aluminous xenoliths. They appear to have partially fused and have a reaction rim containing anorthite, pink sillimanite, green hercynite/pleonaste spinel, corun dum and cordierite. Of these, the corundum or sapphires occur isolated as small, blue, tabular crystals. The feldspars often take on a rosy hue owing to the inclusion of needles of rare pink sillimanite. The inclusions are generally completely recrystallized to granular hornfels. Shaly and sandy xenoliths are frequently fused to buchite. A fuller description of these xenoliths is given by Thomas (1922); the sillimanite was later identified as mullite ($3A1_2O_3.2SiO_2$), a common mineral in bricks (Bailey *et al.,* 1924, p. 268).

At the entrance to Carsaig Bay, the low island and surrounding reefs of Gamhnach Mhor are formed from an alkaline syenite. The body is assumed to be a sill although the contacts are not visible; it was tentatively given a Tertiary age by Bailey *et al.* (1924). The rock is yellowish to greyish-brown with a rough, irregular fracture and composed mostly of sodic orthoclase, with subordinate aegirine and pale-green aegirine-augite. Accessory minerals include a strongly blue-green, alkali amphibole, magnetite and apatite. Phenocrysts are absent, as is nepheline in hand specimen. The intrusion is traversed by numerous segregation veins, basic dykes and a tholeiitic sheet bearing cognate xenoliths belonging to the Scridain group of sills.

Interpretation

The Palaeocene sediments at Carsaig Bay are of special significance as it is here that they attain their maximum development. The sandstones, containing wind-worn quartz grains and rounded chalk fragments, were probably deposited in a desert environment, which persisted from late Cretaceous times when major uplift of the Chalk occurred and Palaeocene sedimentation commenced (Bailey *et al.,* 1924). The persistent purple mudstones at the base of the lavas and above the desert sandstones occur throughout Mull and have probably formed by the lateritic decomposition of basaltic ash in a warm and moist climate (Bailey *et al.,* 1924). The ash may have been the product of an initial volcanic explosion on Mull followed by a long repose period prior to the eruption of the first lavas.

The Scridain sheet swarm is an important and conspicuous feature of Tertiary igneous activity on Mull. The numerous sheet-like masses have intruded the lava plateau, Mesozoic sediments and Precambrian basement rocks of the Ross of Mull and Gribun peninsulas. Bailey *et al.* (1924) considered the sheets to belong to a single complex containing a wide range of rock types from basalt through to rhyolite. The sheet exposed within the site is, however, a fairly uncommon example of a Scridain sill by virtue of its composite nature (a few other examples are quoted by Bailey *et al.,* 1924, p.

287). It provides evidence for the coexistence of acid and basic magmas during Tertiary volcanism on Mull, which is in line with evidence from numerous other localities quoted in this volume. The absence of a chilled contact between the tholeiite and the felsite in the sill implies that felsitic magma was injected into the centre of the sill before the tholeiite had cooled; both were probably liquid together, as shown by the presence of banded, possibly hybridized felsite at the contact.

There have been no published, detailed, petrological investigations into the origin of the different magma types in composite sills or in the suite as a whole. Bailey *et al.* (1924) suggested that the wide range of magma types represented by the Scridain Suite were the result of crystal fractionation in a magma reservoir. This reservoir probably existed beneath the lava pile and the evidence provided by the accidental xenoliths suggests that it disrupted Precambrian and Mesozoic country rocks. The xenoliths were regarded by Bailey *et al.* as having been broken off the walls of the magma chamber and accumulated towards the base, hence the more basic parts of the sheets are richer in xenoliths. Alternatively, it is suggested that fusion of the country rock could create an acidic and intermediate melt by mixing. Ample evidence that assimilation of country rock by the basic magma is a real process comes from partly digested xenoliths, fusion of sandstone at sill margins and evidence for fusion of metasedi-ments at Traigh Bhan na Sgurra (Kille *et al.,* 1986). However, no firm conclusion can be reached on this issue until considerable further fieldwork and petrological investigations have been undertaken.

The occurrence and alteration of the cognate xenoliths in this composite sill are very important features of this site since they:

1. provide information about subsurface rocks in this part of Mull; and
2. prove that the magmas of the Scridain sills were hot on emplacement, possibly over 1100°C (cf. Kille *et al.,* 1986).

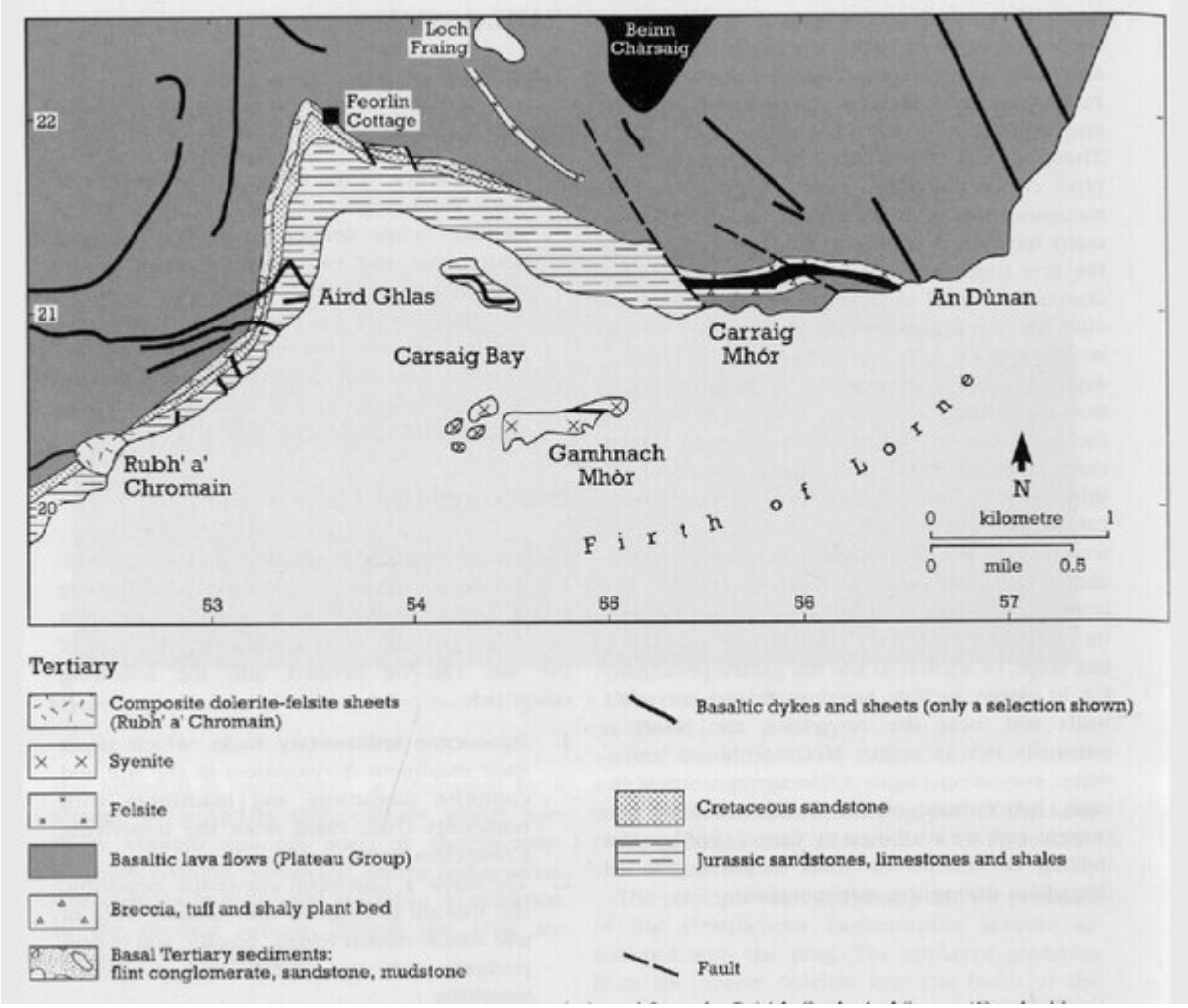
Fusion of sediment at the lower contact indicates that these temperatures were sustained, thus the turbulent flow envisaged during sill emplacement elsewhere probably also applies at Rubh' a'Chromain (cf. Kille *et al.,* 1986).

Bailey *et al.* (1924) suggested that the intrusive Scridain Suite was probably contemporaneous with the emplacement of late basic cone-sheets associated with the central complex. The syenite is therefore of an earlier age; apart from this, little is known about the rock, which is a distinctly unusual type in the BTVP.

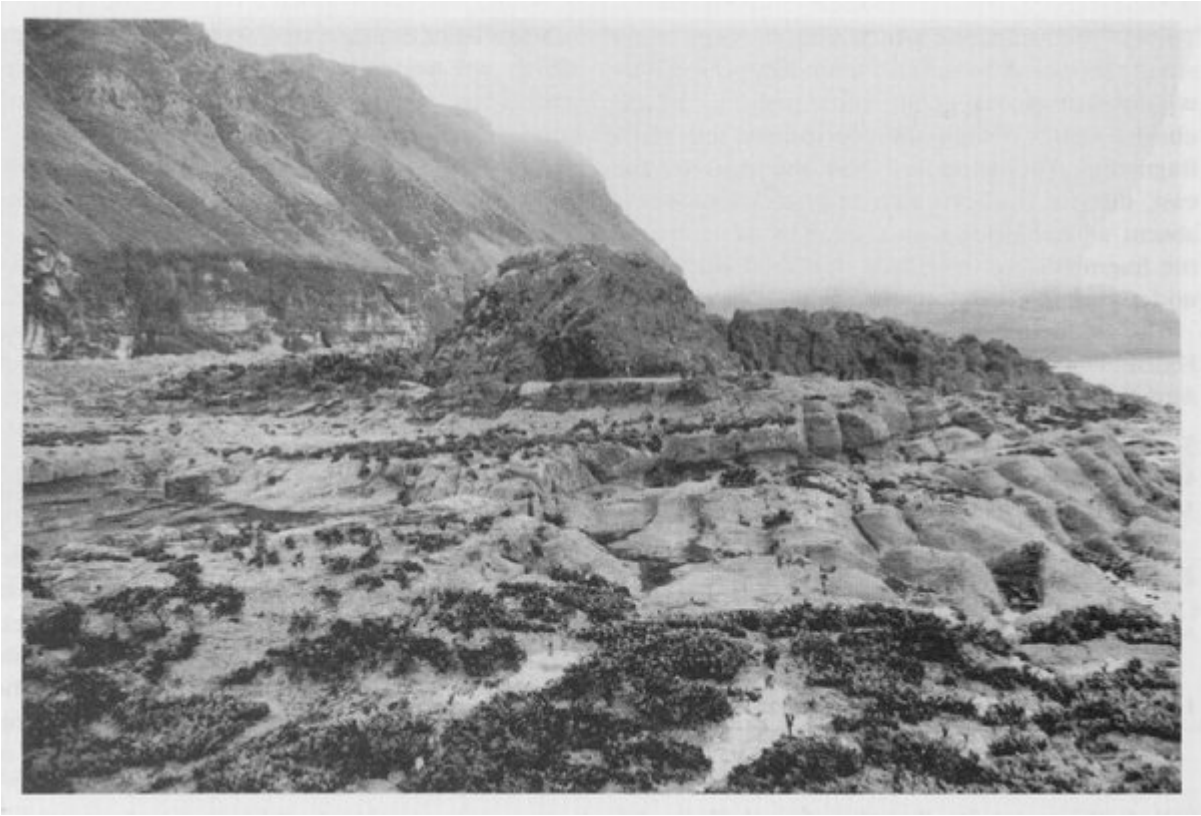
Conclusions

The site is of exceptional value as it contains several unique features of Tertiary igneous activity on Mull. Basal Tertiary sediments are well developed in Carsaig Bay and record a continuation of an arid, desert environment from the late Cretaceous into the Palaeocene. Warm, temperate conditions then prevailed when an initial explosive volcanic event marked the onset of Tertiary volcanism and spread ash over much of the region to form a basal mudstone. The Rubh' a' Chromain sill provides a clear example of a composite intrusion which belongs to the extensive Scridain Suite, emplaced during a single event along with the late basic cone-sheets associated with the central complex (Table 5.1). It provides further evidence from the BTVP for coexisting acid and basic magmas; the acid portion derived either from crystal fractionation or crustal assimilation in a shallow-level magma reservoir. Abundant accidental xenoliths appear to have been derived from Precambrian, Mesozoic and Palaeocene rocks, possibly from the walls to the magma chamber. The Gamhnach Mhor Syenite is an earlier intrusion of probable Cenozoic age and is unusual by reason of its thoroughly peralkaline character.

References



(Figure 5.12) Geological map of the Carsaig Bay site (adapted from the British Geological Survey One Inch' map, Sheet 44, Mull).



(Figure 5.13) The Rubh' a 'Chromain composite sill exposed at the western edge of the Carsaig Bay site, Mull. (Photo: CJ. MacFadyen.)

(youngest)

Dykes were intruded throughout the sequence (Loch Bà–Ben More)

Loch Bà Centre (Centre 3; North-West or Late Caldera)

Loch Bà felsite ring-dyke (Allt Molach–Beinn Chaisgidle, Loch Bà–Ben More)
Hybrid masses of Sron nam Boc and Coille na Sroine (Loch Bà–Ben More)
Beinn a' Ghraig Granophyre (Loch Bà–Ben More)
Knock Granophyre (Loch Bà–Ben More)
Late basic cone-sheets (Loch Bà–Ben More)
Early Beinn a' Ghraig Granophyre and felsite (Loch Bà–Ben More)
Glen Cannel complex and some late basic cone-sheets (Allt Molach–Beinn Chàisgidle, Loch Bà–Ben More)

Beinn Chàisgidle Centre (Centre 2)

Glen More ring-dyke (Loch Sguabain, Cruach Choireadail)
Late basic cone-sheets (Allt Molach–Beinn Chàisgidle), Loch Scridain sheets (intruded towards middle and end of Centre 2 and start of Centre 3)
Ring-dyke intrusions around Beinn Chàisgidle
?Augite diorite masses of An Cruachan and Gaodhail (Loch Bà–Ben More)
Corra-bheinn layered gabbro (Loch Bà–Ben More)
Second suite of early basic cone-sheets
Second suite of early acid cone-sheets
Explosion vents (numerous at margin of the South-East Caldera) (Loch Bà–Ben More)

Glen More Centre (Centre 1; including the Early or South-East Caldera)

Ben Buie layered gabbro
Loch Uisg granophyre-gabbro
First suite of early basic cone-sheets (Loch Bà–Ben More)
Early acid and intermediate cone-sheets (Loch Bà–Ben More)
Acid explosion vents containing porphyritic rhyolite material (Loch Bà–Ben More)
Glas Bheinn and Derrynaculen granophyres (Loch Spelve–Auchnacraig)

Updoming and folding in south-east Mull as a result of rising diapir (Loch Spelve–Auchnacraig).

Lava eruption on to eroded surface of Mesozoic and older rocks. Latest flows overlap in time with formation of the South-East Caldera where pillow lavas are found. (Lavas: Bearraich, Ardtun, Carsaig Bay, Loch Bà–Ben More. Pillow lavas: Loch Sguabain, Cruach Choireadail)

(oldest)

(Table 5.1) The Mull Central Complex: sequence of events (after Skelhorn, 1969, pp. 2–6)