Loch Spelve–Auchnacraig

Highlights

This is a classic locality of international importance for demonstrating concentric folding associated with the emplacement of an igneous central complex. Exposure of Dalradian and Moine rocks in fold cores proves the nature of the Precambrian basement beneath Mull and show that the Great Glen Fault was offset by emplacement of the central complex.

Introduction

The rocks exposed on the western shores of Loch Spelve and on the peninsula lying between its northern arm and the Firth of Lorne lie within a site of multiple interest. Principally, the exposures provide a traverse through clearly defined circumferential folds around the earliest centre (Centre 1) of the Mull central complex, which are best developed in the south and east of the island. In addition, the site contains a unique succession of Triassic strata, which is the thickest sequence in the Hebrides, together with sections through Devonian lavas, Lower and Middle Jurassic (Lias, Inferior Oolite, Great Estuarine) and Cenomanian beds unconformably succeeded by Palaeocene sedimentary rocks. Basement Precambrian rocks are also exposed as inliers. lavas dominate the Tertiary (or other) igneous rocks present in the site but there are also exposures of the early Glas Bheinn Granophyre within the western margin of these, and basaltic dykes, especially in coastal exposures (Figure 5.14).

The folds were first described in the Mull Memoir by Bailey *et al.* (1924), who chose the area covered by this site to be the most favourable for the demonstration of the structures. Subsequent discussions relating to the nature of the folding have been published by Cheeney (1962), Rast *et al.* (1968) and Skelhorn (1969). Most recently, Walker (1975) has related the structures of this area to the early evolution of the central complex.

Description

Bailey *et al.* (1924) have distinguished the following structural elements within the area around Auchnacraig:

1. Marginal tilt (outermost zone). A general centripetal dip of up to 50°towards the caldera of Centre 1 is easily recognizable along the coast between Grass Point [NM 748 308] and Rubha na Faoilinn [NM 729 274] where Mesozoic rocks underlie early Cenozoic sediments and lavas.
2. Duart Bay Syncline. The axis of this fold passes just east of Auchnacraig and traverses the eastern slopes of Garbh Dhoire. The Tertiary lavas, which exceed more than 300 m in thickness, have been affected by this fold; Bailey *et al.* (1924) recorded the highest lava as being Big-Feldspar basalt (Table 5.2), while Cheeney (1962) recognized lavas of the Central Group (Table 5.2) a short distance west of Gortenanrue [NM 728 279]. The syncline is approximately symmetrical with maximum dips of around 45°.
3. Loch Don Anticline. The crest of this anticline extends through Loch a'Ghleannain and Meall Reamhar [NM 726 301]. It is offset by over 100 m by a WNW-trending, sinistral, strike-slip fault which passes through Port Donain [NM 740 290]. Immediately south of the fault the anticline bifurcates. In the north of the site, the core of the structure exposes Dalradian schists and limestones which are succeeded by Devonian lavas similar to lavas of the Lorne Plateau, Mesozoic sediments and Palaeocene lavas. The fold plunges southwards so that Dalradian and Devonian rocks pass below ground to the south of the Port Donain Fault. The Mesozoic rocks of the eastern branch of the fold do not extend beyond Can Ban [NM 722 289] but reach the coast near the ruined chapel [NM 709 284] in the western branch. The anticline is highly compressed, the eastern limb is, in places, vertical or overturned, while the western limb normally dips at between 30° and 60°, but occasional attitudes of up to 80° are recorded. The intensity of the folding has led to the brecciation of the Devonian and Tertiary igneous rocks (Bailey *et al.,* 1924). The former are generally crushed while the latter show only local crushing, a difference attributed to post-Devonian but pre-Tertiary movements along the Great Glen Fault, which is coincident with the southern margin of the Mull complex.

Northwards, the Loch Don Anticline weakens and passes into a faulted monocline and then into a series of *en echelon* folds of the Craignure Anticline (Bailey *et al.,* 1924).

4. Coire Mor Syncline. This syncline is best developed to the north beyond the site boundary where it is expressed by the distribution of Big-Feldspar basalt flows. However, it is clearly demonstrated around Rubha na Cille [NM 706 283] where its eastern limb adjoins the Loch Don Anticline marked by Mesozoic and older strata along the crest. The western limb of the syncline is recognized in the exposures of vertical, crushed Trias and Lias beneath Tertiary lavas at [NM 706 286]. The fold is again very compressed with steep and overturned limbs.
5. Loch Spelve Anticline (innermost zone). The core of this fold contains Moine schists to the south of Balure [NM 675 268] and Mesozoic sediments at Rubha na Faing [NM 707 297] on the north-eastern shore of Loch Spelve. The fold is tight and markedly asymmetrical; its inner margin coincides with the boundary of the South-East, or Early Caldera (Bailey *et al.,* 1924; (Table 5.1)).

Interpretation

The annular fold belt surrounding the Mull central complex is the most clearly defined in the BTVP. The cores of the folds expose Precambrian rocks including both Moine and Dalradian schists, proving:

1. that the area lies across the line of the Great Glen Fault; and
2. that this major pre-Tertiary structure is notably offset south-eastwards by about 5 km away from its normal trend (Walker, 1975).

In addition to revealing the deeper basement beneath this part of Mull, the folds also show that the area is underlain by Devonian lavas similar to those of Lorne and by Triassic and Jurassic rocks.

Formation of the arcuate folds was tentatively regarded by Bailey *et al.* (1924) as one of the earliest events in the Mull central complex. Their origin was ascribed to the intrusion of the early granophyres of Glas Bheinn and Derrynaculen; thus, forcible intrusion of acid magmas was clearly envisaged at this early stage in research on Mull. Cheeney (1962) observed an angular discordance of about 60° between Mesozoic sediments and overlying lava flows near Auch-nacraig, leading him to recognize two periods of folding, the first post-late Cretaceous, but before eruption of the earliest Palaeocene lavas, the second after the main series of lavas had been erupted. Further evidence for an early phase of folding was claimed by Rast *et al.* (1968), who considered that the folding commenced as early as Triassic times; however, this view has received little support in subsequent discussion. A further contribution came from Skelhorn (1969) whose (unpublished) observations suggested that the folding may be related to the first centre (Centre 1 or Glen More Centre; (Table 5.1)). The folding pre-dates all the intrusions associated with this centre, but folding has deformed some of the (regional) NW–SE-trending dykes. There is clearly a consensus that folding occurred at an early stage in the development of the Mull central complex, but further, detailed field investigations are required to determine how many phases of folding occurred, exactly when they took place and whether the folding was an ongoing process possibly preceding and overlapping activity at Centre 1.

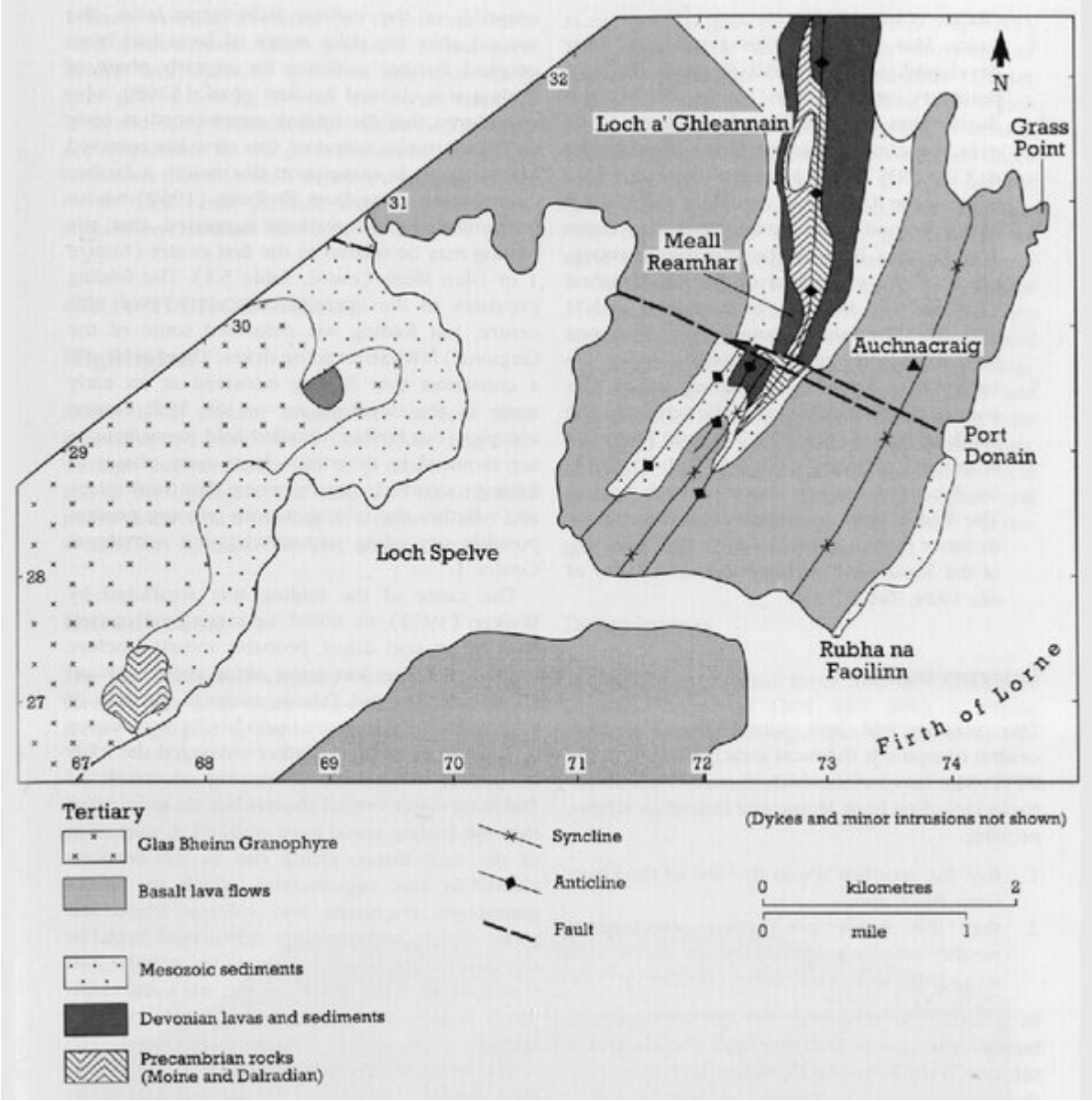
The cause of the folding was attributed by Walker (1975) to initial updoming of central Mull by an acid diapir, probably initiated before eruption of the first lavas since these rest on Moine gneisses and Triassic rocks in the area of folding, whereas they are underlain by Cretaceous or Jurassic elsewhere. Walker envisaged the folds as gravity structures, producing as much as 500 m of upper crustal shortening. He speculated that the folding could have resulted in unroofing of the acid diapir, giving rise to the breccias classed as vent agglomerates, which are full of granophyre fragments, and volcanic fragmental rocks replete with rhyolitic debris now found in the Coire Mhor syncline (part of the annular fold system 4 to 8 km NNW of the site) and 1 km south of the site on the southern side of Loch Spelve.

The tectonic effects of the emplacement of the Mull central complex are the finest developed in the BTVP and are regarded as textbook examples of international importance. They are, however, still poorly understood in detail and would merit a thorough reinvestigation.

Conclusions

Clearly defined concentric folds associated with the early emplacement of Centre 1 on Mull are the finest expression of this type of deformation associated with igneous activity in the British Tertiary Volcanic Province (BTVP). Initial structural disturbances, which probably commenced before lava effusion, updomed the area while later gravity folding around the dome involved lavas and early Centre 1 acid volcanics. The folds are responsible for the preservation of Moine and Dalradian inliers, which define the course of the Great Glen Fault, possible Devonian lavas and successions through Mesozoic strata.

References



(Figure 5.14) Geological map of the Loch Spelve—Auchnacraig site (adapted from the British Geological Survey 'One Inch' map, Sheet 44, Mull).

Mull Memoir (Bailey *et al.*, 1924)	Beckinsale *et al.* (1978)	Morrison (1978) Thompson *et al.* (1982) Morrison *et al.* (1985) Thompson *et al.* (1986)
Central Group (= NPCMT) (Includes pillow lavas in central complex)	Not dealt with in detail	Some samples analysed, all zeolitized or hydrothermally altered.
Plateau Group (majority = PMT) Pale Group of Ben More (= PMT) (with interlayered mugearite and Big-Feldspar Basalt)	Group 1 olivine basalts (mainly sampled in north-west Mull) and Group 3 olivine basalts (mainly sampled around Lochaline, Morven)	Mull Plateau Group (MPG) Note that many are transitional between alkali basalt and tholeiite, and compare closely with Skye Main Lava Series. Some lower crust contamination.
(Staffa Type at base = NPCMT)	Group 2 of south-west Mull	Staffa Magma Type (SMT) Variably enriched in lower and upper crustal contaminants.

(NPCMT = Non-Porphyritic Central Magma Type) later = tholeiitic basalt
(PMT = Plateau Magma Type) later = alkali olivine basalt but many flows are in fact transitional between alkali basalt and tholeiite
Total thickness of Mull lavas estimated about 2000 m (Bailey *et al.*, 1924)

(Table 5.2) Classification and correlation of the Mull lavas

(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)