Excursion 16 Creetown and Cairnsmore of Fleet: igneous intrusion and tectonic deformation

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OS 1:50 000 sheets 83 Newton Stewart 6- Kirkcudbright, 77 Dalmellington to New Galloway

BGS 1:50 000 sheets 4E Wigtown, 8E Loch Donn

Route maps: (Figure 53) and (Figure 54)

Main points of interest Structural relationships of igneous intrusions, from pre-to post-tectonic, at a range of scales; evidence for the early development of thermal (contact) metamorphism relative to igneous intrusion.

Logistics The itinerary utilises the A75, between Gatehouse of Fleet and Newton Stewart, and the A712 Queen's Way, from its intersection with the A75 just east of Newton Stewart to Clatteringshaws Loch en route to New Galloway. Locality 1 is coastal and the critical exposure is obscured at high tide. Localities 2 and 5 are on open fell-side and involve some rough walking, particularly in the latter case where a round trip of about 10 km is involved. Localities 3 and 4 are quarries where protective helmets must be worn; Kirkmabreck Quarry (Locality 4) is worked intermittently and particular care should be taken near the unstable faces. The quarry is owned by Tarmac Ltd and it is essential that permission for access is obtained in advance. Localities 6–8 are in the Kirroughtree Forest, and Locality 9 is in the Glentrool Forest, both owned by the Forestry Commission.

Introduction

The Ordovician and Silurian turbidite sequences of the Southern Uplands are contained in a series of ENE-striking, vertical, fault-bounded slices and show three phases of deformation (see Introduction chapter and (Figure 1), (Figure 2), (Figure 3), (Figure 4)). The major, tract-bounding faults, now spaced 2–5 km apart, originally formed as north-dipping thrust faults in association with D1 folding and cleavage (S1) formation but were then rotated into their present near-vertical position. Thrusting detached the turbidite sequence within the basal Moffat Shales, the thrust front effectively migrating southwards into progressively younger strata. Hence this D1 event, the only phase of deformation to have affected many of these rocks, was diachronous, becoming younger southwards (Figure 4). Locally it was succeeded by minor refolding (D2), forming inclined, south-verging open folds and small recumbent folds, the latter associated with a sporadically well-developed subhorizontal cleavage (S2). A third phase of deformation (D3), marked by steeply plunging sinistral folds, occurs in places, often in association with the tract-bounding faults. This deforms the S2 cleavage at one locality (Excursion 13, Locality 1). One of the strike-parallel faults, the Orlock Bridge Fault, shows evidence of major sinistral, strike-slip reactivation (the Moniaive Shear Zone, Excursion 17) which may have been associated with the D3 event.

The earliest intrusions in the Southern Uplands thrust stack were swarms of lamprophyre and felsite sheets (Barnes et al., 1986; Rock et al., 1986a and b) which, although dominantly emplaced parallel to bedding, are commonly referred to as dykes since they are broadly upright. They are concentrated in a strike-parallel zone in the south-central part of the Southern Uplands, the part in which all three phases of folding also occur. Relationships between dykes and tectonic features show some of the dykes were emplaced during the deformation (Localities 1 and 2 and Excursion 13). Later dykes were emplaced along conjugate NW-and N-trending minor faults. These were largely succeeded by dioritic and granodiorite intrusions of intermediate size (Localities 3 and 4) and the three large, zoned diorite to granitic plutonic bodies of Loch Doon, Cairnsmore of Fleet and Criffell. The latter are known from isotopic dating (Halliday et al., 1980) to be of late Silurian or early Devonian age and are probably largely post-tectonic. However, aspects of the aureole to the Fleet intrusion (Locality 5c) suggest that it formed before or during a late phase of deformation, perhaps associated with movement on the Moniaive Shear Zone (Excursion 17), although the granite itself shows little evidence for deformation (e.g. Localities 5a and 5b).

Metamorphism associated with the dioritic and granitic intrusions has usually produced a relatively simple biotite hornfels aureole, which is seen in the field as a colour change to purple in the host turbidites due to the development of microscopic biotite. Such aureoles are usually explained by the conduction of heat away from an igneous body as it cools after emplacement (Kerrick, 1991). However, the Cairnsmore of Fleet and Kirkmabreck intrusions ((Figure 54), Localities 4 and 5) have much more complex aureoles, indicating that several events intervened between formation of the hornfels and the emplacement of the associated igneous body.

1 Shore at Low Auchenlarie: pre-, syn- and post-D1 lamprophyre dykes

Medium to low tide is needed to see the best exposures, although there is no danger of becoming stranded by the rising tide. An alternative account of the section is given in Excursion 12, Locality 3. Access is through the caravan park adjacent to the A75, 10 km south of Creetown; permission for access should be sought from the reception office at the entrance to the park. The shore is reached using a path at the west side of the public house in the SE corner of the site, where there is ample parking space. On reaching the shore [NX 540 517] follow the high water mark to the SE, passing medium-bedded fine-grained turbidites with well-developed sedimentary structures. These are characteristic of the Hawick Group, Kirkmaiden Formation. Bedding dips moderately NW but is variable due to open, steeply inclined, south-verging D2 folds. An almost bed-parallel S1 cleavage is generally overprinted by a subhorizontal cleavage (S2). The latter is related to a conjugate set of recumbent D2 folds not developed here but seen at Excursion 13, Locality 2.

After about 125 m, a small upright fold pair, plunging gently seawards, can be seen just below high water mark. At first sight a 33 cm 'sandstone bed' is continuous around the fold, although close inspection will confirm that this is actually a bedding-parallel lamprophyre dyke. Although the dyke is altered, it is distinct from the enclosing sandstone, particularly in the inclusion of green chlorite pseudomorphs after mica. In the anticlinal hinge the dyke is fractured, with some mudstone injected upwards; cleavage in the lamprophyre indicates that the dyke was folded with the enclosing sediments and not passively intruded around a pre-existing fold. Looking down on the fold hinge it can be seen that the trace of the cleavage on the upper, bedding-parallel surface of the dyke is not quite parallel to the fold axis, a feature characteristic of D1 folds in this area. This is the only clear example known in the Southern Uplands of a dyke which is deformed by such a fold.

A further 70 m to the south a field boundary reaches the shore. About 30 m south of here a felsite dyke 4 m thick has been intruded along a NW-trending sinistral wrench fault with a displacement of about 3 m. This is an example of the huge number of later dykes which were emplaced into such faults.

Follow the high water mark around the small headland a short distance (30 m) to the south and move seawards across the foreshore a little way (tide permitting) to look back at the low cliff where an overturned D1 anticline is well exposed. Several small recumbent D2 folds are developed in the steep, overturned, southern limb associated with a cleavage dipping gently south. A lamprophyre dyke up to 1 m thick, with conspicuous thin zones of amygdales 20–30 cm from either margin, cuts stepwise up through this structure and, in this case, clearly postdates the formation of the D1 fold.

The section can be followed a further 600 m south to Ringdoo Point, across intensely folded strata with dykes frequently emplaced into the fold hinges. Return by the same route.

2 High Auchenlarie to Ben John: syn-D1 felsite dykes

Ben John is best approached from the farm of High Auchenlarie [NX 538 532]. From the Low Auchenlarie caravan park, turn right on to the A75 and then left after just over 1 km. Follow the minor road for about 1 km and turn right along the track to High Auchenlarie Farm. There is little space to park vehicles on the roadside so permission to park in the farmyard should be sought from the farm. Permission for access should also be gained, although the exposures of interest are situated on land belonging to the adjacent farm of Laggan. On a clear day, the superb view from Ben John [NX 544 548] over Kirkcudbrightshire and Wigtownshire in itself makes the walk worthwhile.

A track immediately west of the farm buildings leads north through two fields before ending at a gate. Pass through the gate and turn immediately east along the wall to the intersection with another wall which can be crossed using a large

boulder. The exposure just over the wall is analogous structurally to that at Locality 1. Well-bedded turbidites dipping NW have been folded by open, steeply inclined D2 folds and a later subhorizontal cleavage has been superimposed in association with minor recumbent folds. A pale-coloured felsite dyke, about 2 m thick, is conspicuous parallel to bedding and passes around the open folds; has it been folded or passively intruded into previously folded strata? Close inspection of the dyke will reveal a cleavage fabric within it at about 90° to its margins. This angle is more or less constant at various positions around the folds, indicating that the dyke was folded after the cleavage was formed. The cleavage in the dyke is the early (S1) fabric, which is nearly parallel to bedding in mudstone but refracts to a high angle in sandstone beds and the dykes. This dyke was therefore intruded before the S1 cleavage was formed but its relationship to D1 folding cannot be established at this locality.

Those who do not wish to go farther can retrace their steps to the farm, but the recommended route continues obliquely up the hill in a NNE direction. After about 350 m the slope begins to flatten out on to a shoulder of the hill from which an area of extensive exposure will be visible; this should be reached a further 400 m in the same direction. There are no clear landmarks here to identify individual exposures but, by moving around, numerous variably cleaved felsite dykes can be seen. The dykes, usually bed-parallel, range from vertical to steeply NW-dipping whereas the cleavage typically dips moderately southwards. If the junction of a dyke with the enclosing sandstone or mudstone is located, the cleavage in the dyke can be seen to be continuous with that in the host rock. Where a dyke is adjacent to sandstone then the dip of the cleavage in both lithologies is similar. If the junction is against mudstone, the cleavage will refract into a steeper dip in the latter. The same effect will be seen where this cleavage passes between interbedded sandstone and mudstone, such refraction at lithological boundaries being a common feature. However, in these exposures, the early cleavage in the mudstone is typically overprinted by the subhorizontal S2 cleavage which is not developed in the sandstone beds or dykes. The cleavages can be distinguished locally in mudstone where the less intense S2 cleavage can be seen to crenulate the S1 fabric; the latter continues, though refracted, into adjacent sandstone. Careful attention should also be paid to the attitude of bedding and its younging direction. Younging is mainly indicated by grading (emphasised here by the rotation and increased development of cleavage in finer-grained sandstone) which will point to the presence of a number of large-scale upright folds. There is no indication that the dykes are folded by these structures and examples can be found where dykes have been emplaced along fold axial planes. However, the cleavage in the dykes is clearly that which relates to the folds, and it seems most likely that the dykes were emplaced soon after the folding but before the imposition of a cleavage.

3 Bagbie Quarry, Carsluith: post-tectonic, zoned diorite intrusion

From High Auchenlarie, return to the A75 and drive NW until Carsluith Castle is passed on the left. A new by-pass continues the A75 from this point, but take the old road which requires a right turn to Carsluith. After crossing the burn at the margin of the village the road swings to the left; 120 m on from the bend, park opposite the row of cottages on the right and follow the short track immediately south of the cottages. This leads into Bagbie Quarry [NX 489 549].

The intrusion that was quarried is wedge shaped, being at its widest here (200 m) and pinching out rapidly to the NE along the trace of the strike-parallel fault into which it is interpreted to have been emplaced. It is characteristic of the smaller dioritic intrusions in the Southern Uplands in that they are zoned from a more basic margin into a granitic core. Here there are simply two phases, a porphyritic dark grey diorite and a white granodiorite. The latter forms the back face of the quarry and the former can be seen in the faces either side, where the nature of the junction between the two lithologies is well displayed. The contact is sharp and steeply dipping, although irregular in detail. In the SE face the coarser, white granodiorite includes two slabs of the diorite, about 2 and 4 m thick, indicating that the latter was emplaced first. The granodiorite in the back of the quarry is well jointed with slickensides on some of the fracture surfaces. A basalt dyke (probably of Tertiary age), 30–40 cm thick, takes an irregular course through the north face of the quarry, cutting both diorite and granodiorite phases of the main intrusion.

From the track in the entrance to the quarry it is possible to walk SE through the wood to the Carsluith Burn which flows along the junction between the diorite and the host turbidites of the Cairnharrow Formation. Although the contact is relatively smooth and subparallel to the vertical bedding in the host sandstone, small steps allow thin dykes of the diorite to penetrate along bedding planes. The sandstone has been altered by contact metamorphism, with biotite extensively

developed in the matrix. This is too fine grained to be observed directly but it gives the sandstone in particular a distinctive purple coloration on a freshly broken surface. Cleavage is obliterated by the recrystallisation and it is apparent that this intrusion is, here at least, post-tectonic.

As the lower part of the burn passes through the garden of a private house it is necessary to return through the wood to the quarry and thence to the road.

4 Kirkmabreck Quarry, Creetown: post-tectonic granodiorite with metasomatic alteration of aureole

The complex contact relationships of a 500 m-thick granodiorite sheet, emplaced into a strike-parallel fault, are well exposed in Kirkmabreck Quarry [NX 480 565] adjacent to the A75, 2.5 km south of Creetown. At this locality the development of the biotite hornfels aureole and emplacement of the granodiorite are seen to have been separated by an interval during which several other veining and intrusive events occurred. This quarry, one of several in the granodiorite, was originally developed for building stone but more recently has been intermittently worked for aggregate. **Permission for access must be sought from the quarry owners** in advance of any visit (Tarmac Roadstone (Scotland) Ltd, 134 Nithsdale Drive, Glasgow) and **particular care should be taken near the steep quarry faces where protective helmets are essential.**

Park at the quarry entrance or in the yard on the opposite side of the road and walk up the track around the north side of the quarry. A little way up the track a view over the whole quarry shows the essential features. The south wall, dipping at about 60° north, is cut along the footwall contact of the granodiorite. The hanging wall contact is visible in the north side of the quarry, above which a suite of subparallel dykes can be seen within the dark grey meta-sandstone host-rock of the Gala Group. The detail of the hornfels, the granodiorite margin and the dykes can be seen in three benches accessed from further up the track.

The hornfels exposed on the benches shows greenish bands of skarn alteration, typically a few mm thick, due to replacement of the biotite in the matrix of the metasandstone by epidote and actinolite. Close to the granodiorite contact, and particularly well displayed in some of the large loose blocks, this alteration encloses veinlets and some larger, irregular pods filled by quartz and bronze-coloured grossular garnet. In this situation the alteration is sometimes zoned symmetrically away from the vein, with an inner pale green zone dominated by diopsidic pyroxene and the epidote-actinolite forming a darker green outer zone. This skarn alteration must have been caused by the passage of calcium-bearing hydrothermal fluids because there is typically little calcium in the unaltered sandstone. The skarn veins are cut, and therefore postdated, by quartz-carbonate veins, sometimes irregular but often in the form of tension gash arrays. The quartz-carbonate veins are best developed in the exposure adjacent to the upper bench. Here they are locally very intensely developed in narrow lenses or screens of hornfels between the anastomosing dykes. The veins never penetrate the dykes which must have been emplaced after the veining, a relationship confirmed by the rare occurrence in the dykes of hornfels xenoliths with quartz-carbonate veining. The dykes, composed of a porphyry of similar geochemical composition to the main granodiorite sheet, have sharp, smooth contacts and are generally less than 1 m thick. They are best exposed on the lower bench where narrow chilled margins and a strong, wall-parallel flow-banding is apparent in some examples. An unusually thick (c.2 m) dyke is present at the margin of the granodiorite. Although broadly parallel to the dykes, the granodiorite margin is irregular in detail with narrow offshoots extending into the porphyry dyke. A narrow (c.5 cm) granodiorite dyke can also be seen at the margin of the next porphyry dyke. There is no sign of chilling of the granodiorite and the contact with the porphyry may be quite diffuse across a 2 cm-thick biotite rich zone. The main granodiorite sheet seems to postdate the porphyry dykes, a relationship supported by the tendency for the contact to obliquely cut across the undulating dykes up through the quarry sections.

Old quarries higher up the hill, along the strike of the granodiorite sheet, are reached on foot by continuing to the top of the track past Kirkmabreck Quarry and then proceeding up the hill to where large piles of granodiorite blocks are visible. Alternatively, vehicles can be taken (with permission) up the narrow access road off the A75 just south from Kirkmabreck Quarry and parked inside the gate to the upper quarry area. The two largest quarries here are both flooded but the hanging wall contact of the granodiorite with the hornfels, again including porphyry dykes, is visible in the north side of

both. The dykes and the granodiorite contact here have a similar orientation to those in the lower quarry. Angular blocks of porphyry can be seen as xenoliths in the granodiorite below the hangingwall contact, confirming the age relationship between the two. Aplite dykes occur locally within the granodiorite, marking the final intrusive phase.

5 The south-western contact of the Cairnsmore of Fleet granite pluton

The Cairnsmore of Fleet granite, one of three major plutons which outcrop in South-west Scotland, has been dated at about 395 Ma by the Rb-Sr method (Halliday et al., 1980), a date confirmed by a new zircon U-Pb age (J Evans written comm., 1994). The outcrop of the granite is elliptical. The northern and southern margins are largely parallel to bedding in the host rocks, apparently being controlled by the location of mudstone units of the Moffat Shale Group and/or associated strike-parallel faults. The western side of the granite is almost perpendicular to the regional strike. Three localities at the SW side of Cairnsmore of Fleet serve to demonstrate contradictory relationships between the development of the strong tectonic fabric in the host rocks (probably related to the Moniaive Shear Zone and discussed further in Excursion 17), the contact metamorphism, and the emplacement of the granite.

At McClave's Pantry (Locality 5a) and Graddoch Burn (Locality 5b) the granite contact and thin granite veins in the adjacent hornfels cut across the tectonic fabric and are not themselves deformed, although one granite dyke is locally cleaved. Cordierite is widely developed in the aureole and locally, as at Culcronchie Burn (Locality 5c), it is seen to predate at least part of the development of the tectonic fabric. However, the fabric and the cordierite are overprinted by the biotite hornfelsing. Evidence for local metasomatism of the Cairnsmore of Fleet hornfels, comparable with that exposed at Kirkmabreck (Locality 4), is also seen and again this postdates formation of the biotite hornfels but is cut by the granite. Together, these aspects suggest a similar situation to that at Kirkmabreck (locality 4), with evidence for the intervention of two events (cleavage development and skarn alteration) between the initial phases of contact metamorphism and the emplacement of the intrusion.

5a McClave's Pantry

The craggy exposures at McClave's Pantry [NX 490 660] provide the best place to study the south-western granite contact. Access involves a significant walk; use the forestry track which climbs the hill behind Bardrochwood House, leaving the road along the east side of Bargaly Glen at [NX 461 650]. The track climbs to the Cairnsmore Burn [478 654] from which strike directly up the hill between the burn and the forestry fence. From the point where the fence turns towards the north, McClave's Pantry lies about 350 m uphill to the NE.

In the approach up the side of the Cairnsmore Burn there are numerous exposures of Gala Group greywacke which display both a well-developed foliation and a linear fabric. In places both of these are cut by quartz veins, and at one locality [4856 6569] ramifying quartz veins have produced a breccia zone with disorientated blocks of lineated greywacke.

The granite contact is well exposed amongst a jumble of large granite boulders. Veinlets and apophyses of the granite occur over a zone of about 2–3 m in the hornfels adjacent to the main granite mass. They markedly cross-cut the bedding and the bedding-parallel foliation, here with a strongly developed linear component; neither the veins nor the main granite are deformed.

5b Graddoch Burn

The next two localities are best reached from Cairnsmore Farm [NX 471 640] where a parking and picnic area has been provided just north of the farm path for walkers to Cairnsmore of Fleet. A visit to both localities involves a total walk of about 10 km, partly on tracks but generally over exposed countryside, and a total climb of about 500 m.

From the parking area, follow the track south past the farm, turning east at the cottage after 400 m. After a further 300 m the track crosses the Graddoch Burn, where exposures of medium-bedded Gala Group greywacke dipping moderately northwards are visible beneath the bridge, then passes along the edge of a field. A conspicuous exposure in the field

shows massive greywacke with a purple colouration on freshly broken surfaces due to the development of biotite in the matrix. The rock contains a foliation, distinguished by mm-scale, flattened biotite clots possibly representing pseudomorphs after cordierite, dipping moderately northwards. Oblate, foliation-parallel lenses of greenish alteration mark replacement of the biotite by skarn minerals similar to those seen at Locality 4. Continue along the track which, once out of the field and on to open moorland, becomes more distinct and closely follows the burn. Exposures of metagreywacke in the burn hereabouts also include closely spaced, discontinuous zones of skarn alteration, typically 5–10 cm thick. Bedding may also be distinguished in these exposures, lying parallel to the ubiquitous north-dipping foliation.

The burn forks 700 m east of the field and the track continues along the southern branch towards Locality 5c. To examine the contact between the hornfels and granite at Locality 5b, leave the track and follow the northern branch of the burn for just over 1 km until the wall bounding the forestry plantation to the north crosses the burn. Medium- to thick-bedded greywacke interbedded with black rnudstone is intermittently exposed for 25 m either side of this point. An irregular granite dyke is exposed 35 m west of here in the south side of the stream. The dyke cuts narrow skarn zones in the hornfels and contains angular xenoliths of the foliated metagreywacke, but is itself locally foliated parallel to the steeply dipping fabric apparent in the metagreywacke immediately to the west. The margin of the main granite is exposed about 120 m east of where the wall crosses the burn [NX 496 646]. The granite, extensively exposed upstream, is free of xenoliths and no chilling is noticeable at the contact. Small irregular veinlets of granite and quartz aplite extend from the granite over a zone about 5 m wide, markedly cross-cutting the bedding and skarn zones in the metagreywacke. The foliation in the host rock near the contact is masked by the hornfelsing and the granite and aplite are undeformed.

5c Culcronchie Burn

To return to the vehicles, retrace the route taken from Cairnsmore. To proceed to Culcronchie Burn, walk for 1.5 km SE across the moorland strewn with granite boulders. After about 1 km you should meet the track from Cairnsmore. From this point a cliff can be seen on the southern flank of Cairnsmore of Fleet to the NE. This feature is formed by a narrow screen of metagreywacke within the granite, parallel to the southern contact but 500 m in from it. From the track, descend into the valley to where the wall, apparent on the far side, crosses the burn [NX 510 638]. In addition to the foliated metagreywacke, a dark cherry lithology is exposed hereabouts and is interpreted as a contact metamorphosed mud-stone of the Moffat Shale Group. The local existence of extensive quartz veining, in a network of brittle fractures, has encouraged a mine trial which cuts through the bend in the burn. Lenticular cordierite pseudo-morphs, up to 5 mm long, occur widely in the hornfels here but are particularly well developed, up to 2 cm long, in metagreywacke exposed in a small knoll a few metres west of the stream. The intense fabric in the hornfels wraps around the pseudomorphs, which are flattened and also define a gently plunging lineation, indicating that they predate at least part of the deformation which formed the foliation. Return to Cairnsmore Farm by walking westwards up the hill to regain the track that leads back to the car park.

6 The northern contact of the Cairnsmore of Fleet granite pluton

The northern contact between the granite and the metamorphosed sedimentary host rocks is generally poorly exposed. It is near-parallel to the regional strike of bedding and cleavage fabric in the enclosing strata, and occurs just south of the linear outcrop of Moffat Shale along the Orlock Bridge Fault (Figure 54). Two localities showing the parallel junction between the granite and hornfels are easily reached from the A712 (Queen's Way) between Newton Stewart and Clatteringshaws Loch.

6a Bar

Exposures of the granite contact in the forest at Bar [NX 483 705] are best accessed from the Glen of the Bar picnic site on the A712 [NX 483 711], 1.3 km SW of the campsite at Talnotry. A narrow footpath leads south through the forest from the car park and should be followed for 400 m until it joins a forest road (it is worth marking the road to enable the foot path to be found on return). Turn east along the forest road for about 250 m to the top of an up-hill section then walk NNE

into the forest for about 70 m, towards a large exposure which will gradually become visible through the trees. Here the granite forms a low cliff, the junction with the hornfels occurring near the top; the hornfels is also exposed in a higher cliff.

The junction is sharp, generally parallel to the strong banding and foliation in the hornfels but stepping across it locally, and without xenoliths in the granite. Immediately above the granite contact in the west part of the exposure, bedding is apparent in the hornfels dipping about 10° more steeply than the foliation — a typical relationship between bedding and S1 cleavage. Thin quartz veins, developed parallel and oblique to the fabric, are a characteristic feature of the hornfels in the northern part of the aureole. The banded horn fels can be examined further in the higher cliff. Retrace the route to the car park at Glen of the Bar.

6b Craigdews Hill

This craggy hill, in the wild goat park at Talnotry, provides a spectacular exposure of the granite/hornfels contact at the northern edge of the Cairnsmore of Fleet pluton. From the Glen of the Bar picnic site drive 3 km east and park in the lay-by [NX 502 721] provided for viewing the wild goats which live on Craigdews Hill [NX 497 723]. The crags in the hillside are mostly composed of pinkish grey granite but the contact with the darker grey hornfels above, slanting gently to the west, is visible in crags near the top of the hill. The junction actually dips NW, near-parallel to the pervasive bedding-parallel cleavage in the host strata. As at Bar (Locality Ca), the junction is sharp and no xenoliths are present in the granite.

Note that other localities in this vicinity are described in Excursion 17.

7 Clatteringshaws Dam Quarry: outer facies of the Cairnsmore of Fleet granite pluton

The Cairnsmore of Fleet pluton comprises an inner medium-grained granite facies and an outer coarse-grained facies. The outer phase can be examined at the quarry [NX 547 754] near Clatteringshaws Dam. The quarry lies just off and slightly above the A712 immediately SE of the dam. It can be accessed by a rough track which leaves the road about 100 m south of the north end of the dam. Parking is simplest at the entrance to the Raiders Road (forestry track) about 200 m farther south on the main road [NX 547 752].

The quarry is in coarse-grained grey granite characterised by large (3–4 cm) tabular feldspar crystals. These are commonly aligned and, along with preferred orientation of the micas, impart a marked N- to NNW-dipping foliation to the granite. In thin-section the foliation may be marked by zones of granulation, implying a tectonic rather than a magmatic origin. The disposition of the foliation across the mass as a whole, however, suggests that it may relate to the forceful intrusion and ballooning of the mass rather than later post-intrusive deformation.

At various points in the quarry the granite is cut by aplite and pegmatite veins ranging up to 15–20 cm across. Many of these appear to cut and postdate the foliation, supporting the above views. However, two-thirds of the way along the long wall of the quarry (from left to right facing the quarry wall) the foliation in the granite can been seen to be continuous with a conspicuous cleavage apparent in a flat-lying aplite dyke. This fabric, dipping moderately north, is parallel to the foliation in the hornfels a short distance to the north. Foliated aplite dykes are also apparent in the road cutting to the north of the quarry, although **any investigation of these roadside exposures should be made with extreme caution** due to the lack of visibility for vehicles entering the cutting. These features suggest a tectonic element to the development of the foliation in the granite.

8 River Dee, Clatteringshaws: Loch Doon pluton, granodiorite/greywacke contact

The marginal facies and contact relationship of the Loch Doon pluton can be examined a little farther NW. Return SW along the A712 for about 500 m and then turn north (right) on to a minor road which leaves the A712 about 400 m west of the bridge over the River Dee below Clatteringshaws Dam. Continue on this minor road along the west side of Clatteringshaws Loch for about 8 km and park at the car park near Craigencallie [NX 504 780]. Continue on foot through the gate and along the forestry road for about 1.5 km and, at a T-junction, turn right on to the road leading north across a

bridge over the River Dee. The contact of the granodiorite with the local greywackes is exposed on the north side of a second T-junction, just beyond the bridge [NX 496 795].

The contact may be examined over a 60 m section exposed in small crags at the side of the forestry road. At the east end of the section, dark purple hornfelsed greywackes of the Shinnel Formation are largely devoid of veining. About 5 m to the west of a small stream, small (1–2 mm) acid veinlets appear, broadly parallel to the NE-trending strike. Westwards these increase in abundance, the foliation in the greywackes becomes less regular and the rock develops a brecciated appearance. Calcareous concretions are broken and cross-cut by the vein-lets. About 10–15 m east of the contact, granitic veins become relatively abundant and are markedly cross-cutting in relation to the greywacke bedding. The veins are generally 1–2 cm in thickness although locally they coalesce to form patches up to 50 by 70 cm. Immediately adjacent to the contact the greywacke is recrystallised with the loss of primary bedding features, giving the rock a massive appearance. The marginal facies of the pluton is here a quartz diorite. It is massive and unfoliated and here, at least, free of xenoliths. Note that the granitic veins in the greywacke are more acid than the main granodiorite mass, and that this does not itself vein the country rock. This implies that the material in the veins was generated as a contact effect.

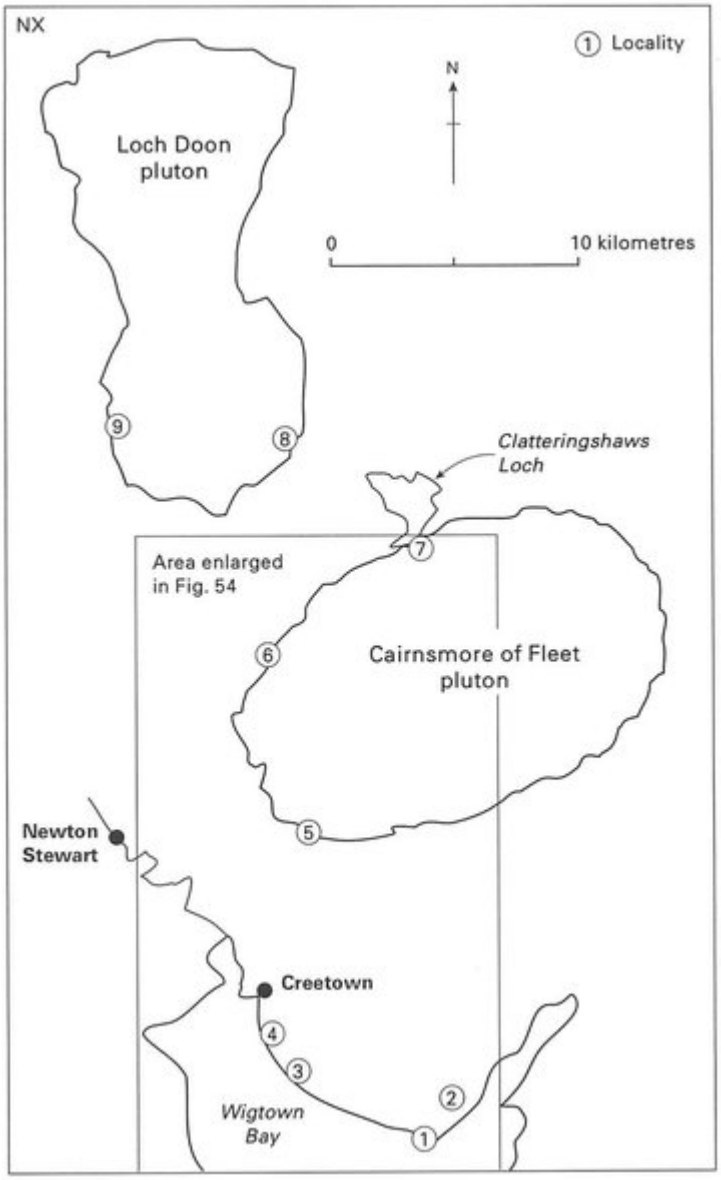
In the quarry behind these roadside exposures, further excellent sections through the purple hornfelsed greywackes may be examined. On the east side, massive sandstone beds alternate with thin (50 cm) siltstone beds, with little acid or quartz veining present. To the west side of the quarry, dark siltstones become more abundant and contain lines of calcareous concretions. These siltstones contain many more quartz veinlets and lenses than do those to the east, a contrast which may have more to do with the overall host lithology than with proximity to the igneous contact.

9 Buchan, Glen Trool: Loch Doon pluton, granodiorite/greywacke contact

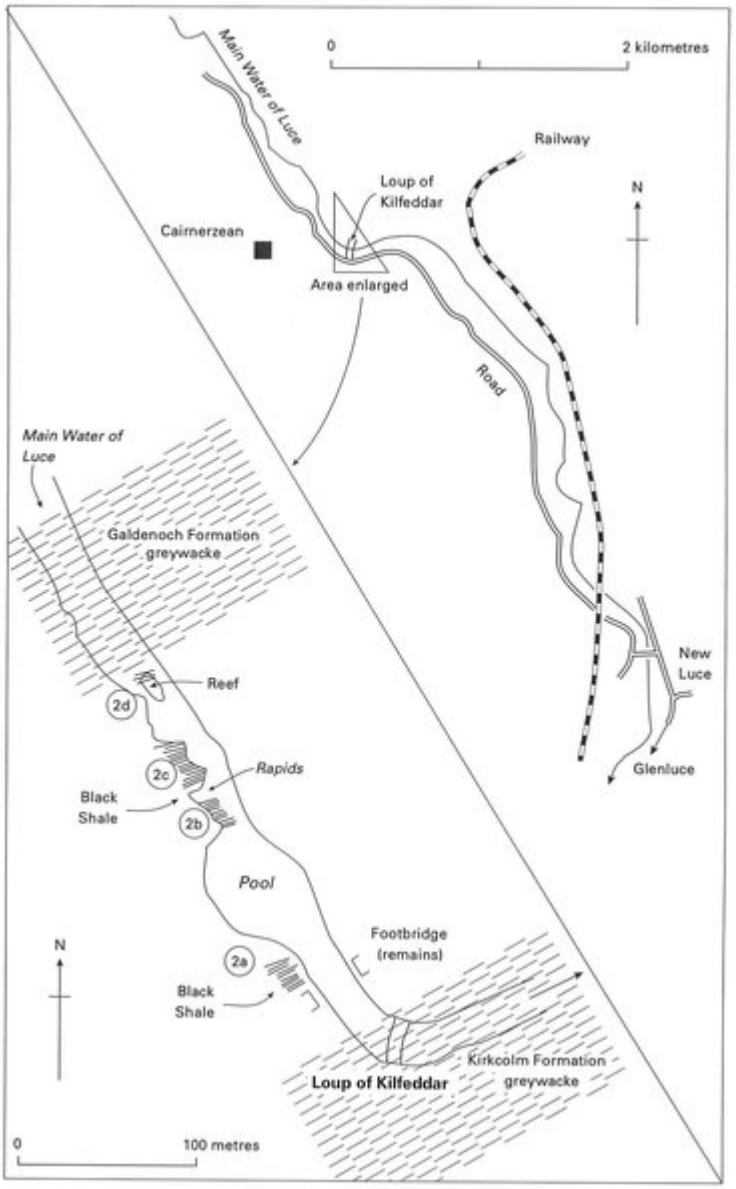
From Craigencallie, return to the A712, continue west to Newton Stewart and take the A714 towards Girvan. At Bargrennan, about 12 km north of Newton Stewart, turn east on to the minor road leading to Glen Trool. Drive to the end of the Glen Trool road and park at the car park [NX 416 803]. Proceed east on foot along the track past Buchan House and, just beyond the house, strike up the hillside on the well-marked path to Loch Valley. After 500 m the path goes through a gate in a stone wall and some 70 m beyond this, the granodiorite contact is exposed on a series of crags rising steeply to the north [NX 426 808]. The contact runs up the crags with an approximate north–south trend, parallel to the local bedding strike of the greywacke country rocks.

The granodiorite contains abundant xenoliths of greywacke, with the long axes generally orientated parallel to the contact. Most xenoliths are only 10–20 cm long, although large elongate relicts up to 1 m long can be seen in places; some xenoliths are cut by late acid veining. Locally the granodiorite exhibits a weak foliation which is also orientated parallel to the contact. At the contact, the country rock (here greywacke turbidites of the Portpatrick Formation) shows the local development of feldspar porphyroblasts along some bedding planes, giving the rock a coarse gneissose appearance. Calcareous concretions are relatively unaffected by the feldspathisation, and the calcareous pods lying within the feldspathised greywackes give the meta-greywacke a superficial resemblance to the igneous rock with its sedimentary xenoliths. New feldspar is only observed within a zone between 50 and 90 cm wide adjacent to the contact. Beyond this the greywackes contain some minor acid veinlets but these, in turn, disappear within a few metres of the contact. It is notable that no veins of granodiorite extend from the main mass. These relationships were formerly cited as evidence for a 'front' of granitistation, although the intrusive nature of the granodiorite is no longer in dispute. Despite the similarity in appearance between the feldspathised greywacke and the foliated and xenolith-rich igneous rock, close examination shows that the contact between them is sharply defined.

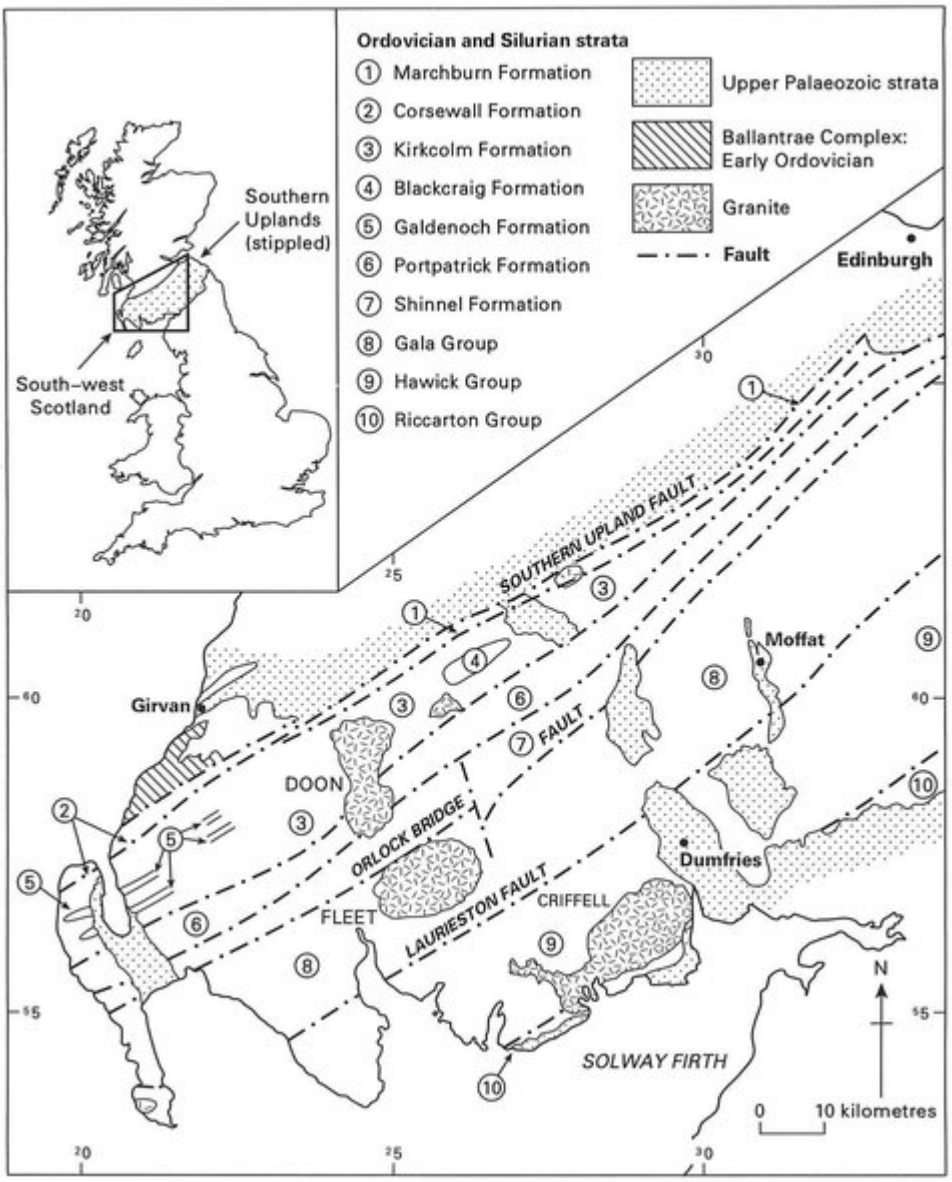
References



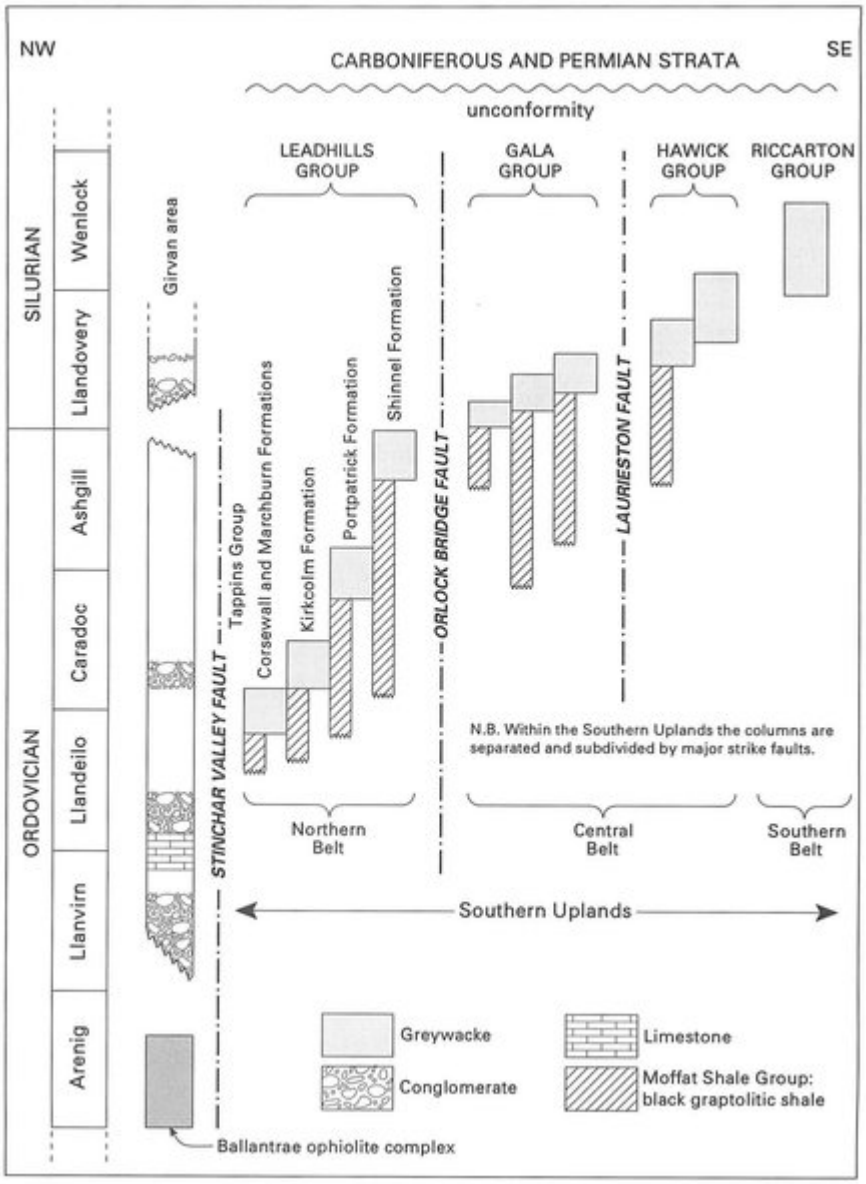
(Figure 53) Locality map for the Creetown, Cairnsmore of Fleer, Clatteringshaws and Glentrool excursion.



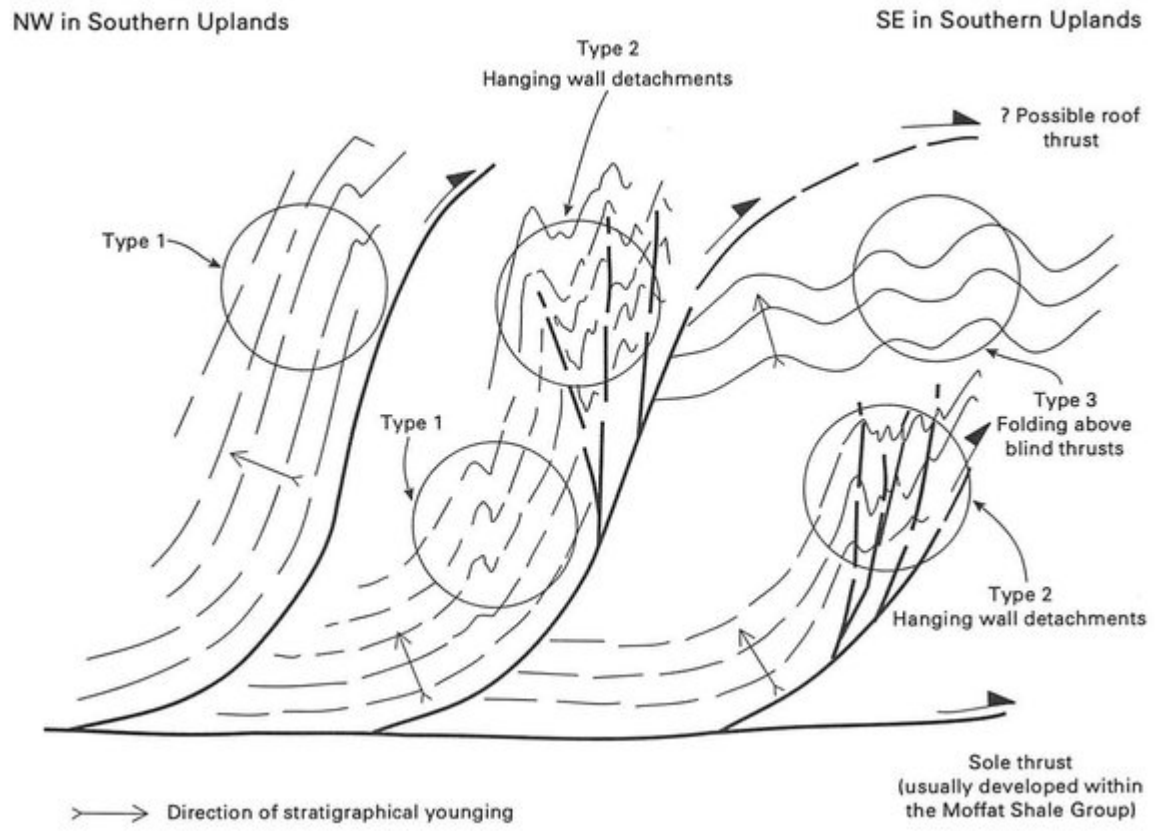
(Figure 54) Locality map and outline geology for Creetown and Cairnsmore of Fleet.



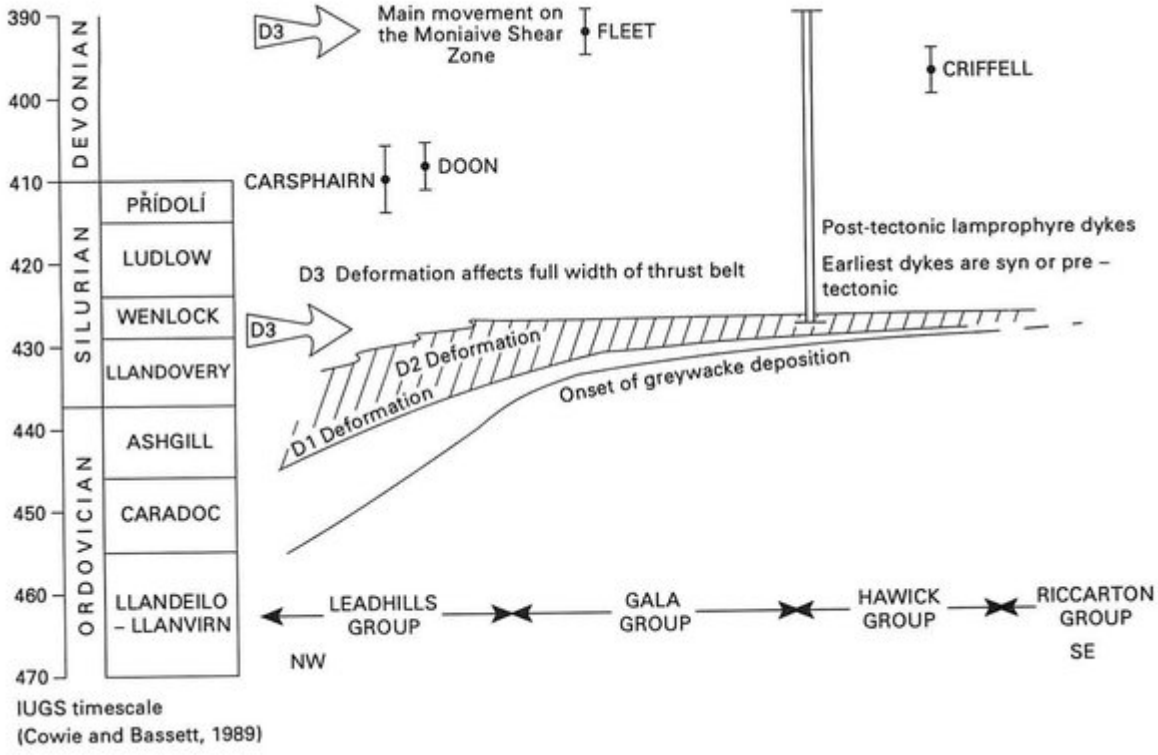
(Figure 1) Principal features of Lower Palaeozoic geology in south-west Scotland.



(Figure 2) Schematic representation of stratigraphical relationships in south-west Scotland.



(Figure 3) Variable fold style developed within an idealised thrust sequence: examples are seen in the Southern Uplands.



(Figure 4) Summary of information used to establish controls on the timing of Caledonian deformation in the Southern Uplands (cf. Barnes et al., 1989, fig. 1) Ages of post-tectonic plurons (in million years): Carsphairn: 410 ± 4, Rb-Sr, Thirlwall (1988). Loch Doon: 408 ± 2, Rb-Sr, Halliday et al. (1980). Fleer: 392 ± 2, Rb-Sr, Halliday et al. (1980). Criffell: 397 ± 2, Rb-Sr, Halliday et al. (1980). Dyke ages (range): Rb-Sr and K-Ar, Rock e. al. (1986b).