# Na Buirgh (Borve), South Harris

[NG 009 937]–[NG 038 964]

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## Introduction

The Na Buirgh (Borve) GCR site covers a 4 km-long coastal section in South Harris stretching from Sgeir Liath to Rubha Romaighidh. It provides an across-strike traverse from the South Harris Igneous Complex, north-east through Palaeoproterozoic metasedimentary rocks of the Langavat Belt, to the migmatitic Archaean gneisses and Laxfordian granites of the Uig Hills–Harris Granite Vein-Complex. Recent work has shown that these three elements have distinct and disparate geological histories although their boundaries have been the subject of debate.

The metamorphosed diorite and tonalite found at the south-west end of the section belong to the South Harris Igneous Complex (SHIC) (see 'Introduction', Roineabhal GCR site report, this chapter). The diorite is volumetrically the largest member of the complex. Here, it is locally gabbroic and is cross-cut by thin orthoclase feldspar-bearing basaltic dykes termed 'shoshonites' (potassic variety of basaltic trachy-andesite). At Bàgh Steinigidh (Bay Steinigie) [NG 019 939] the diorite is in contact with a metasedimentary succession 60–70 m thick, composed of thinly banded amphibolite and subsidiary metalimestone, calc-silicate rock and gneissose pelite (Figure 2.9). Immediately north-east of these rocks, lies a thin strip of tonalite, which together with the metasedimentary rocks, forms a *c.* 4 km-long and 100–300 m-wide septum, included within the diorite body. The foliation and shear zones in the diorite increase in intensity towards its north-eastern boundary. The deformation is accompanied by amphibolite-facies retrogression of the earlier granulite-facies mineralogy.

The Langavat Belt metasedimentary rocks and intercalated gneisses to the north-east form a *c.* 1.35 km-wide outcrop between Borvemore and Borve Lodge (Taigh Buirgh). They consist of generally thinly banded quartzofeldspathic gneisses with abundant amphibolite pods and bands. The metasedimentary belts range from quartzitic to semipelitic with abundant biotite, but metalimestone is present locally. Zoned ultramafic pods and strongly foliated, thinly banded amphibolite units are present. Deformation is high and the majority of elements dip steeply to the south-west. The south-western contact zone between the belt and the foliated diorite lies concealed beneath the sands of Traigh Mhòr, but the north-eastern contact zone is exposed in places.

The Langavat Belt rocks pass rapidly northeast into Archaean, migmatitic, banded felsic gneisses with subsidiary pods and thin bands of amphibolite. Sheets of granite and pods and veins of granitic pegmatite are common. These late-Laxfordian intrusive elements become very abundant within 100–200 m of the contact. Farther to the NNE along the coastal section, granitic sheets and veins continue to dominate, and thick unfoliated granite sheets are present in parts, for example on Rubha Romaighidh.

Some younger dykes are also present in the section. Thin ENE-trending camptonite dykes of Late Carboniferous to Permian age are found just east of Sgeir Liath, and NNW-trending basalt and dolerite dykes of the Palaeogene Skye swarm are present in several places (Fettes *et al.,* 1992).

The Langavat Belt rocks were recognized and defined by Jehu and Craig (1927), but were mapped in more detail and divided further by Dearnley (1959, 1963), Myers (1968) and Palmer (1971). Fettes *et al.* (1992) considered the various interpretations put forward by previous authors, and adopted a broad tripartite lithological division of the metasedimentary and metavolcanic rocks of the belt. Dearnley (1959) and Horsley (1978) both mapped the diorite in considerable detail, and Graham (1970) described its structure. Fettes *et al.* (1992) summarized the mineral chemistry of the diorite and also noted the textural, mineralogical and geochemical changes that occur with increased retrogression and shearing. The Laxfordian-age Uig Hills–Harris Granite Vein-Complex that borders the Langavat Belt to the north-east was mapped and described in detail by Myers (1968, 1971).

Geochronological studies have shown that sediment deposition in the Leverburgh and Langavat metasedimentary belts, emplacement of the SHIC, and granulite-facies metamorphism all occurred within a limited time-frame between *c.* 1890 Ma and 1870 Ma, during the Palaeoproterozoic Era (Cliff *et al.,* 1983; Friend and Kinny, 2001; Whitehouse and Bridgwater, 2001). These conclusions support the island-arc subduction model of Baba (1998, 1999b) (see Roineabhal GCR site report, this chapter). Further geochronological work showed that the Langavat Belt was strongly reworked by Laxfordian deformation and metamorphic episodes (Cliff *et al.,* 1998) and that later episodes of uplift occurred, possibly culminating in shear-zone movements along the north-eastern margin of the Langavat Belt in Grenvillian time (Cliff and Rex, 1989). Fettes *et al.* (1992), Friend and Kinny (2001) and Mason and Brewer (2005) all proposed different interpretations for the north-east part of the Langavat Belt and its boundary with the Archaean gneisses.

## Description

The picturesque Na Buirgh (Borve) coastal section consists mainly of low-relief bedrock sections, separated by wide sandy bays and backed by dunes. The rock was scoured during the Late Devensian and earlier glaciations by ice moving south-east and shell sand commonly blows onshore resulting in clean, etched exposures. In the northern part of the section steeper cliffs up to 10 m high occur around Gèodha Martainn [NG 036 961]. Access is relatively easy from the nearby A859 Tarbert–Leverburgh road. The geological description below traverses from south-west to northeast.

### Sgeir Liath and Bagh Steinigidb

These localities provide excellent exposures of the metamorphosed diorite and tonalite of the South Harris Igneous Complex. From Sgeir Liath [NG 0095 9390] eastwards dark-grey and white mottled diorite is seen. It is composed of plagioclase (andesine), pale-green clinopyroxene, dark-green hornblende, biotite, and accessory magnetite and apatite. Minor quartz is also present. Orthopyroxene is common in the less-deformed parts of the diorite, which retain their granulite-facies mineralogy. Where clinopyroxene and hornblende are more abundant, the diorite has been described as 'gabbroic' (Horsley, 1978). Garnets are common locally, both in patches and in specific zones, for example adjacent to the banded amphibolites and metasedimentary rocks at Bagh Steinigidh. Pegmatitic veins and patches are also seen. A weak foliation is discernable in the diorite, and small shear-zones are also present (see below). Dark-grey dykes up to 50 cm wide cut the diorite, the pegmatitic veins, and the early foliation at several places. The dykes trend approximately north–south and dip steeply to the east. Horsley (1978) and Palmer (1971) showed that in thin section they consist of clinopyroxene laths in a granular microcline feldspar-biotite-plagioclase (albite) matrix with accessory apatite, opaque minerals, titanite and quartz. Their igneous mineralogy and geochemistry are typical of potash-rich basaltic trachyandesites, known as shoshonites. Thin pseudotachylite veins and breccia zones are also present in the diorite.

Towards the rocky embayment of Bagh Steinigidh, the diorite is more strongly foliated and the fabric swings to strike north-west and dip subvertically (Figure 2.10). Locally (at [NG 0182 9387]) the diorite is broken and xenolithic. At the Bagh itself, partly garnetiferous, thinly banded and foliated dark-green amphibolites are interbanded with white to cream and pale-green metalimestones, calc-silicate rocks, and fawn and purplish-grey psammites and semipelites. Four separate meta-limestone bands can be distinguished with the largest reaching 2.2 m wide. Locally, veins of grey tonalite cut discordantly across the amphibolites and metasedimentary rocks. The rocks are tightly folded with fold axes varying in plunge from gently to the south-east to sub-vertical. Fold axial planes dip very steeply to the north-east. Refolded fold patterns are seen locally. On the north-east side of Bagh Steinigidh, tonalite is dominant. It is a pale-grey, coarse-grained rock composed of plagioclase feldspar, hornblende, biotite and quartz with rare microcline feldspar (Fettes *et al.,* 1992). It is foliated and altered with abundant scapolite, epidote, sericite and calcite. Ovoid xenoliths of amphibolite are common east of the Bagh and shear zones are common. Sheared and altered diorite occurs to the east (Figure 2.9) with the main foliation dipping some 75° to the north-east.

### Trisigh Mhòr-Sta Bay–Allt Borgh Beag (Borvebeg Burn)

The diorite-Langavat Belt boundary is not exposed on the coast section, but its position can be interpolated from inland outcrops just north of Loch Iochtabhat (Eachkavat). A thick amphibolite sheet within the metasedimentary rocks also lies beneath the sands (Figure 2.9). On the north-east side of Traigh Mhor are quartzofeldspathic gneisses, interbanded and inter-laminated with abundant fine- to medium-grained amphibolite. The amphibolite units are locally up to several metres thick and commonly show internal hornblende-, biotite- and feldspar-rich layering. Some of the amphibolite layers and lenses are folded into tight to isoclinal minor folds with thick hinge zones and attenuated and boudinaged limbs. The dominant banding and foliation in these gneisses dips at 65°–70° to the south-west. The mafic rocks are more subordinate towards Rubha Sgeir nan Sgarbh. At [NG 0253 9469] a 25 m-wide pod of dark-green to black serpentinized ultramafic rock occurs in the gneisses. It has weathered to a prominent buff colour with a pitted surface. Its marginal zones show alteration to tremolite-actinolite and talc schist. Some 50 m of felsic and mafic striped gneisses, locally rich in biotite, separate this ultramafic pod from the larger, *c.* 80 m-wide, body that forms the headland of Rubha Sgeir nan Sgarbh. The marginal alteration zones that are rich in actinolite and talc are correspondingly wider in this main intrusion. It is the most north-westerly of a series of ultramafic pods that occur at intervals down the central part of the Langavat Belt (Fettes *et al.,* 1992). Except for Scara Ruadh, which shows banding, they are dunites or peridotites with olivine-tremolite-serpentine centres and altered shells containing anthophyllite, chlorite, actinolite and talc.

The gneisses to the north-east of the main ultramafic pod are dominantly felsic and quartzose banded gneisses with subsidiary thin bands and small pods of amphibolite. Actinolite-epidote-rich bands and lenses are also present locally. The banding is locally highly attenuated, and veins and pods of quartz and quartz-feldspar pegmatite are present. The banding/foliation dips consistently at 65°–70° to the south-west. The promontory immediately south-west of Sta Bay [NG 0292 9494] is composed of some 35 m of finely banded amphibolite with diopside lenses up to 30 cm across containing abundant pyrite and epidote. This amphibolite sheet can be traced south-eastwards along the length of the Langavat Belt to Finsbay. A thin metalime-stone band containing the assemblage forsterite (mainly serpentinized)-calcite-dolomite occurs adjacent to the amphibolite on the south-west side of Sta Bay. The bay itself has formed by preferential erosion of a large Palaeogene dolerite dyke. On the north-east side of Sta Bay some 20 m of thinly banded to laminated, semipelitic to psammitic gneisses with minor amphibolite bands occur. A single metalimestone band is also present. The typical violet-tinged biotite-rich felsic gneisses consist of quartz, plagioclase feldspar (oligoclase) and biotite (foxy brown), with subsidiary potash feldspar and locally abundant pyrite. Epidote and garnet are also present in parts (Dearnley, 1963). Relict clinopyroxene has been recorded in some of the laminated amphibolites (Fettes *et al.,* 1992).

North-east from Sta Bay numerous laminated amphibolite units up to 25 m thick are inter-banded with finely banded quartzofeldspathic gneisses. Epidote-, biotite- and pyrite-rich bands are present in the sequence. The bulk of the rocks farther to the north-east as far as the Allt Borgh Beag are finely banded quartzofeldspathic and amphibolitic gneisses with a dominant banding and foliation that dips at 50°–70° to the south-west. Quartz and quartz-feldspar pegmatite veins are abundant locally, but are strongly deformed or attenuated. The boundary of the Langavat Belt is placed at the Allt Borgh Beag, where the proportion of amphibolite falls significantly, and to the north-east the gneisses are dominantly felsic. Small amphibolite pods and bands do occur to the north-east but the fine-scale banding and interlamination of quartzofeldspathic gneisses and amphibolite is absent. This change, although difficult to pinpoint exactly (see discussion below), also corresponds to the incoming of thicker less-deformed pegmatitic granite and granite veins of Laxfordian age.

### Allt Borgh Beag-Rubba Romaigbidh

The gneisses in the northernmost section of the GCR site range from thin- to medium-banded pale-grey felsic gneisses with subsidiary pods and thin bands of amphibolite, to more-nebulous granitoid gneisses with only a weakly developed biotite fabric. The gneisses are strongly recrystallized and partly migmatitic and contain abundant pale-grey to pink, medium-grained biotite granite sheets and veins, in part pegmatitic (Myers, 1971). These granites are weakly to moderately foliated in the southern part of this section but their late-Laxfordian origin is shown by their locally discordant and unfoliated nature. The proportion of granite increases rapidly to the north-east from the Allt Borgh Beag to constitute up to 50% of the bedrock. On Rubha Romaighidh, the felsic gneisses occur as xenoliths in a particularly thick massive, unfoliated granite sheet. Pegmatitic bodies up to 10 m wide are present marginal to the larger gneiss xenoliths. The regional banding and foliation in the gneisses dips to the south-west at between 50° and 70°.

### Structure and metamorphism

The foliation in the diorite on Sgeir Liath is weak, strikes north-east, and dips some 60° to the north-west. It becomes more intense and finer grained where it curves into the small shear-zones, which trend *c.* 140°–150° and *c.* north-south, and show both sinistral and dextral movement geometries. The trend of the foliation changes eastwards and it becomes steep and NW-trending as Bàgh Steinigidh is approached. There is also a marked increase in the fabric intensity, matched by the incoming of amphibolite-facies assemblages. At Bagh Steinigidh, tight folding of the metasedimentary rocks and tonalite veins on several scales is seen. Minor folds in the calcareous rocks have axes that plunge at 85° to 305° and appear to refold earlier structures. A larger-scale synformal structure has axes that plunge at 26° to 138°. The related axial-plane fabric dips very steeply to the north-east and corresponds to the main foliation and general banding. To the north-east of Bàgh Steinigidh dextral shear-zones are abundant and the sub-vertical NW-trending foliation is dominant.

The overall structure of the Langavat Belt appears to be simple. It is dominated by an attenuated, steeply SW-dipping, lithological banding and sub-parallel foliation. Tight minor folding is present but no large-scale structures can be recognized convincingly. Between Traigh Mhòr and Rubha Sgeir nan Sgarbh, tight to isoclinal minor folding of the amphibolite bands and compositional banding is common. A locally prominent quartz lineation plunges at 16° to 305°, but fold axes plunge at 60° to the WSW. Fold axial planes dip steeply to the southwest and Z-profile (northwards verging) folds are most abundant, as noted by Myers (1968). Farther to the north-east, towards Sta Bay, minor folding is best developed immediately southwest of the banded amphibolite. Here tight to isoclinal minor folds of the compositional banding have axes that plunge at 55°–65° to the south-west and WSW. The remaining part of the Langavat Belt shows only sporadic folding but here too axes plunge at 50° to the south-west. However, these are later, open to tight folds that fold the main foliation.

In the migmatitic, dominantly felsic gneisses north-east of the Langavat Belt, minor folding is not abundant but both tight to isoclinal early folds and related lineations plunge gently to moderately to the WNW and north-west.

Although granulite-facies assemblages are preserved in the diorite, amphibolite-facies assemblages are dominant in the Langavat Belt rocks and are ubiquitous in the migmatitic gneisses north-east of the Langavat Belt. The diorite assemblage is plagioclase feldspar (andesine)-hornblende-clinopyroxene-magnetite-quartz. Garnet is locally abundant and pink-grey orthopyroxene is present in the most westerly part of the exposed section. Mineral compositions reflect the granulite- and upper-amphibolite-facies metamorphism rather than the original igneous mineralogy (Dearnley, 1963; Horsley, 1978). Thus, the clinopyroxene lies in the calcic augite field, and the orthopyroxene is hypersthene with low Fe/Mg ratios.

At Bàgh Steinigidh the calcareous rocks contain forsterite, diopside and humite group minerals. This mineralogy is typical of upper amphibolite-facies conditions, although alteration products are abundant, such as serpentine (from forsterite) and actinolitic hornblende (from diopside). In the adjacent tonalite and diorite the typical assemblage is hornblende-biotite-plagioclase-quartz, with large poikiloblastic hornblendes common. Farther east the retrogression is more penetrative and the assemblage hornblende-biotite-epidote-plagioclase feldspar (oligoclase)-quartz-titanite is typically developed (Dearnley, 1963).

In the Langavat Belt the rocks are strongly recrystallized and the dominant mineral assemblages lie within the amphibolite facies. The typical assemblage in the quartzofeldspathic gneisses is quartz-plagioclase feldspar (oligoclase)-biotite-potash feldspar (orthoclase)-magnetite with accessory pyrite. However, remnants of higher-grade assemblages are preserved in parts, for example near Sta Bay relict clinopyroxene has been recorded in foliated amphibolite (Fettes *et al.,* 1992). Myers (1968) recorded grunerite/cummingtonite and anthophyllite from the mafic and ultramafic rocks and staurolite, garnet and sillimanite from the pelitic rocks. The presence of forsterite in the calc-silicate rocks, albeit strongly serpentinized, also suggests that the metasedimentary and meta-volcanic rocks experienced upper-amphibolite-or even granulite-facies conditions prior to their extensive deformation, recrystallization and metamorphism under lower-amphibolite conditions during Laxfordian and possibly Grenvillian reworking.

## Interpretation

Jehu and Craig (1927) recognized the rocks of the Langavat Belt as possible metasedimentary and metavolcanic rocks on account of their finely interbanded felsic and mafic nature, and the presence of pelitic and quartzitic lithologies, metalimestones and calc-silicate rocks. Subsequent workers have generally agreed with this basic interpretation, but the detailed disposition, number and extent of metasedimentary and metavolcanic units, and structural pattern, have all been interpreted somewhat differently (see Fettes *et al.,* 1992; Mason and Brewer, 2005 for summaries). The Langavat Belt lithologies contrast with those of the Leverburgh Belt, where granulite-facies mineralogies are still present, the rocks are less thoroughly reworked, and their sedimentary protoliths are more readily recognized. The mineralogy and composition of the finely interbanded amphibolite and quartzofeldspathic gneisses that dominate the northeastern part of the Langavat Belt are compatible with being derived from basic volcanic or volcaniclastic rocks, at least in part, but they may also represent highly deformed Archaean orthogneisses with abundant mafic intrusions as preferred by Mason and Brewer (2005). Individual metasedimentary and possible metavolcanic units can apparently be traced along the length of the exposed belt. Dearnley (1963) postulated that the beds in the central part of the Langavat Belt were disposed in a near-isoclinal antiformal fold and that minor fold vergence changed across the belt. Myers (1968), Palmer (1971), Fettes *et al.* (1992) and Mason *et al.* (2004b) all rejected this interpretation as they failed to find any duplication of lithological units and could not confirm any systematic variation in minor fold vergence.

High strain, the presence of shear zones and mylonitic rocks, and lack of observed contact relationships all mask the relationships between the Langavat Belt and the adjacent intrusions of the SHIC to the south-west. However, Fettes *et al.* (1992) noted a divergence of regional strike between the diorite boundary and individual metasedimentary units, such that mapped quartzitic units became progressively cut out to the south-east. Hence, they interpreted the diorite as being intrusive into the metasedimentary rocks, an interpretation rejected by Mason *et* al. (2004b) (see below). The relationship between the major amphibolite bodies and metasedimentary rock units within the belt is also unclear. The main south-western sheet, some 125–150 m thick, is concealed beneath Traigh Mhor on the coast section. Inland, it is a consistently foliated amphibolite with flattened feldspar aggregates and lacks quartzofeldspathic gneiss interbeds. It is interpreted as a highly deformed metagabbro sheet, linked to the SHIC, as regionally it appears to cut across the Langavat Belt stratigraphy (Fettes *et al.,* 1992). However, the thinner laminated amphibolite unit on the south-west side of Sta Bay appears to bound the Sta Bay metasedimentary succession and may not relate to the SHIC. It may represent an earlier basic intrusion or mafic lavas.

The north-eastern boundary of the Langavat Belt has been defined as a transition from interbanded quartzofeldspathic gneiss and amphibolite north-eastwards over *c.* 100 m into coarser-grained, recrystallized and migmatitic, grey, biotitic felsic gneisses and more-leucocratic granitoid gneisses (Dearnley, 1963; Fettes *et al.,* 1992). This coincides with the incoming of Laxfordian medium- to coarse-grained granite sheets, pods and dykes and pegmatitic granite pods and veins, part of the Uig Hills–Harris Granite Vein-Complex. When both the Langavat Belt rocks and the adjacent felsic gneisses in the vein-complex were assumed to have Archaean protoliths, it was relatively easy to envisage that the extensive Scourian and Laxfordian deformation would have erased any trace of the sediment–gneiss unconformity, or conversely any intrusive relationship. However, Friend and Kinny (2001) postulated that, although the felsic gneisses do have Archaean granodioritic protoliths, the metasedimentary rocks are Palaeoproterozoic in age. The resultant boundary should represent a major crustal suture, as well as an early-Laxfordian and possible Grenvillian deformation front. This is not in accord with its transitional appearance in the field. As a result Friend and Kinny (2001) have suggested that the boundary be placed at Rubha Sgeir nan Sgarbh, coincident with the ultramafic pods. They interpreted the rocks north-east from here to [NG 031 950] as mylonites derived from felsic gneisses and granite sheets, and the rocks to the south-west as being non-mylonitic with granite sheets absent. However, the purported mylonites include the calcareous and semipelitic rocks of Sta Bay, and the amphibolite-rich gneisses to the north-east, both of which are placed within the Langavat Belt by all other authors. Dearnley (1963), Myers (1968) and Fettes *et al.* (1992) also failed to recognize any significant differences in the gneisses to the north-east and south-west of Rubha Sgeir nan Sgarbh.

Mason *et al.* (2004b) and Mason and Brewer (2005) suggested an alternative interpretation. Firstly, they postulated that the metasedimentary component of the Langavat Belt had been overestimated by earlier workers and suggested that the bulk of the rocks, some 70%, were derived from Archaean tonalitic gneisses and subsidiary mafic intrusive bodies. They explained the interrelationships of metasedimentary rocks and the orthogneisses by early structural imbrication, the pattern being obscured by the subsequent high Laxfordian strain and shear-related deformation. They suggested that the more finely banded units adjacent to the diorite were composed of blastomylonitic rocks, locally highly quartz-rich, and that two ages of mylonites and ultramylonites could be recognized (cf. Friend and Kinny, 2001). The earlier-formed (Laxfordian) amphibolite-facies mylonites (type-1 tectonites) were intruded by late-Laxfordian pegmatitic granite pods and veins, which show only slight deformation, whereas the later-formed greenschist-facies mylonites (type-2 tectonites) contain strongly deformed pegmatitic bodies. Zircons from a representative pegmatitic granite pod from near Finsbay were dated by U-Pb TIMS methods at 1657 ± 2 Ma (Mason *et al.*, 2004b). Hence, Mason *et* at (2004b) suggested that the Langavat rocks are not part of the Roineabhal Terrane of Kinny and Friend (2001) and that the Bàgh Steinigidh septum belongs to the Leverburgh Belt, not the Langavat Belt. They postulated that the main suture lay adjacent to the diorite where the gneisses are very highly sheared. Recent SIMS zircon age dates obtained by Kelly *et al.* (2008) show that the felsic gneisses from the north-east boundary of the Langavat Belt formed from tonalitic protoliths between *c.* 2850 Ma and 2830 Ma. High-grade metamorphism followed rapidly at *c.* 2830 Ma with evidence for a later Archaean event at *c.* 2730 Ma. Kelly *et al.* (2008) also confirmed the age of emplacement of the late-Laxfordian granite sheets at between 1704 Ma and *c.* 1670 Ma, noting that their intrusion overlapped shearing. The age of the metasedimentary units thus remains open to speculation.

As noted in the Roineabhal GCR site report, the geological history of South Harris has been significantly revised in recent years in the light of radiometric dating results. Friend and Kinny (2001) and Whitehouse and Bridgwater (2001) presented U-Pb zircon geochronological evidence that the SHIC and the host Langavat and Leverburgh metasedimentary and metavolcanic belts are Palaeoproterozoic in age and were formed between *c.* 1890 Ma and 1870 Ma. These conclusions support the island-arc subduction model of Baba (1998, 1999b), based on studies of lithologies and metamorphic assemblages in the Roghadal–Leverburgh area. The preferred model suggests that the sedimentary and volcanic rocks were deposited in a trench environment adjacent to an island arc, and then subducted to crustal depths of *c.* 27 km where they were intruded by the SHIC. Further subduction to 35–45 km depth resulted in deformation and granulite-facies metamorphism, followed by rapid uplift. Injection of the shoshonite dykes probably occurred during this later subduction phase. The Palaeoproterozoic terrain was then reworked by later Laxfordian deformation and metamorphic episodes. These later reworking events were more penetrative in the Langavat Belt than in the SHIC and the Leverburgh Belt.

The timing of uplift can be constrained by studies of various mineral isotopic systems that have different theoretical closure temperatures. Cliff *et al.* (1998) obtained $^{40}Ar$-$^{39}Ar$ ages from hornblendes in mafic rocks across South and North Harris. These gave consistent values between 1780 Ma and 1630 Ma implying that uplift had occurred following the main Laxfordian event at around 1800 Ma. Cliff and Rex (1989) obtained 20 Rb-Sr biotite ages from South and North Harris concentrating on the SHIC and the Langavat Belt. The Rb-Sr biotite age pattern is more sensitive to times of uplift than the hornblende $^{40}Ar$-$^{39}Ar$ isotopic systems and shows a distinct step across the Langavat Belt. Ages to the south-west, in the granulite- facies SHIC and Leverburgh Belt, range from *c.* 1630 Ma to 1340 Ma, whereas those to the north-east of the belt range from *c.* 1300 Ma to 950 Ma. Ages from North Harris and Lewis are generally in the range 1115 Ma to 1020 Ma. The youngest ages were obtained from the northeastern margin of the Langavat Belt, suggesting that Grenvillian-age shearing may have occurred along this boundary.

## Conclusions

The Na Buirgh (Borve) GCR site is of international importance, as it provides a coastal section across the complex Langavat Belt, a much debated and significant part of the Lewisian Gneiss Complex in South Harris. The 1.4 km-wide belt is composed of Archaean gneisses, and metasedimentary and meta-volcanic rocks of possible Palaeoproterozoic age. It is sandwiched between the diorite of the Palaeoproterozoic South Harris Igneous Complex (SHIC) to the south-west and Archaean migmatitic, dominantly felsic gneisses, and late-Laxfordian granites to the north-east.

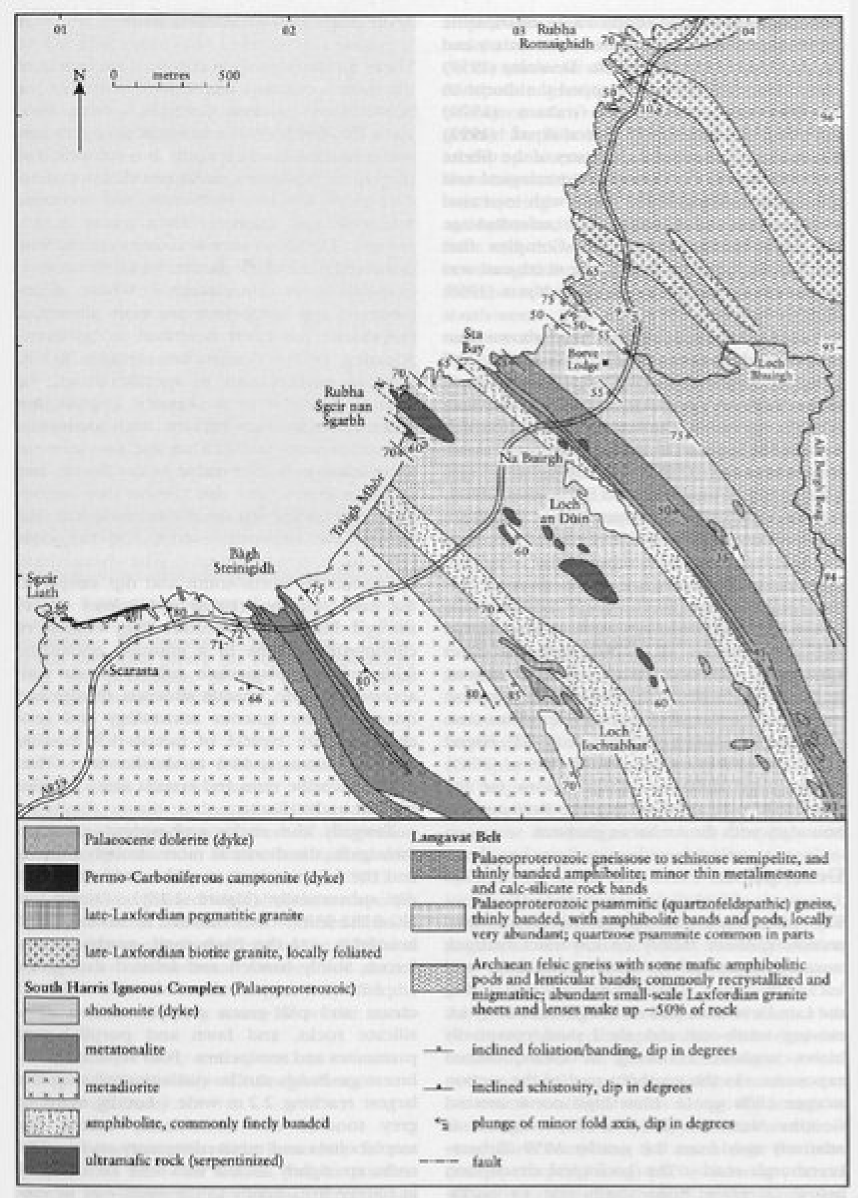
The Langavat Belt consists of thinly banded and laminated felsic and subsidiary amphibolitic gneisses with thin semipelitic, metalimestone and calc-silicate rock-units. Amphibolites that are finely interbanded with the felsic gneisses are interpreted as being derived from basic volcanic rocks, possibly volcaniclastic. In contrast, the more-prominent and coherent amphibolite units are interpreted as highly deformed metagabbro or metadolerite sheets belonging to the SHIC. Serpentinized ultramafic pods appear to represent original Palaeoproterozoic intrusions, now boudinaged, sheared and fragmented by Laxfordian deformation and shearing.

The rocks of the Langavat Belt now retain little evidence of their earliest deformation and higher-grade metamorphic history at deeper crustal levels (see Roineabhal GCR site report, this chapter). Both early- and late-Laxfordian tectonometamorphic events have reworked the units extensively under amphibolite-facies conditions, giving rise to the fine-scale compositional banding and generally parallel foliation or schistosity. The belt has been a locus for shearing and differential uplift movements from *c.* 1870 Ma to *c.* 1000 Ma and hence it has provided vital radiometric dates that help to elucidate the later history of the Lewisian Gneiss Complex in the Outer Hebrides.

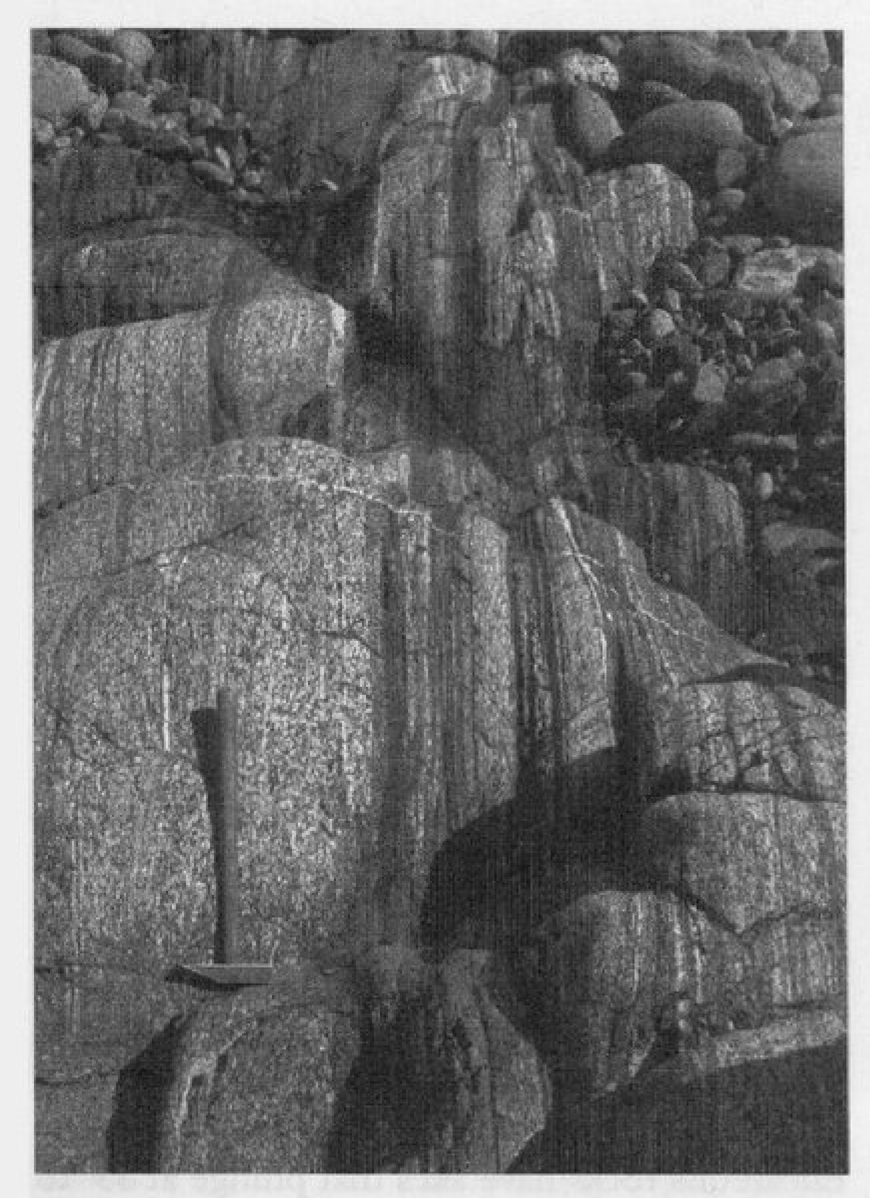
The diorite of the SHIC is less affected by the Laxfordian events and retains relict granulite-facies metamorphic assemblages except in its marginal zone where it becomes progressively more sheared, foliated and recrystallized to amphibolite-facies assemblages as the contact with the Langavat Belt is approached. Within the marginal part of the diorite at Bagh Steinigidh, a 30–100 m-wide septum consists of interbanded semipelitic and calcareous gneisses with prominent metalimestones, calc-silicate rocks and laminated amphibolites, all intruded by a sheet of pale-grey tonalite, some 125 m wide. The tonalite is the youngest member of the SHIC, except for minor late-stage dykes of shoshonite (potassic basaltic trachyandesite). Different authors attribute the Bàgh Steinigidh metasedimentary rocks to either the Leverburgh or Langavat belts.

To the north-east of the Langavat Belt are dominantly grey, biotitic felsic gneisses of undoubted Archaean age. These gneisses are coarsely recrystallized, partly migmatitic and contain weakly banded granitoid rocks that may represent later Scourian (Archaean) granite sheets. The contact is transitional over *c.* 100 m, and has been interpreted very differently by the various workers. Various sheets and pods of grey to pink, weakly foliated, Laxfordian granite have intruded the Archaean gneisses. These granites, some of which are pegmatitic, form part of the Uig Hills–Harris Granite Vein-Complex.

**References**




*(Figure 2.9) Simplified geological map of Na Buirgh (Borve), South Harris.*



(Figure 2.10) Foliated metadiorite and included amphibolitic and felsic gneiss enclaves at Bagh Steinigidh. The hammer is 42 cm long. (Photo: British Geological Survey, No. P008366, reproduced with the permission of the Director, British Geological Survey, © NERC.)