Transect through the Canisp Shear Zone, Achmelvich, North-west Highlands - an excursion

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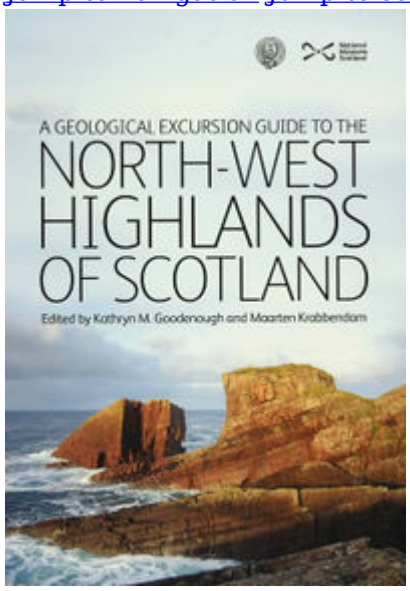
Jump to navigation Jump to search



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Excursion 2 from: Goodenough, Kathryn M. and Krabbendam, Maartin (Editors) A geological excursion guide to the North-west Highlands of Scotland. Edinburgh : Edinburgh Geological Society in association with NMS Enterprises Limited, 2011.

Purpose	To examine the Canisp Shear Zone, which preserves a complex history of deformation and reactivation, from Archaean to Cenozoic time. To study rocks of the Lewisian Gneiss Complex deformed at progressively shallower depths, starting in deep Badcallian basement structures, followed by exposures of Inverian, Laxfordian and later deformation events.
Aspects covered	Badcallian, Inverian and Laxfordian deformation events of the North-west Highlands; Granulite-to greenschist-facies metamorphism; Transpressional shear zone structures and fabrics; Reactivation and strain localisation processes; Non-Andersonian fracturing and 3D strain.
Maps	OS: 1:50,000 Landranger sheet 15 Loch Assynt; 1:25,000 Explorer sheet 442 Assynt and Lochinver. BGS: 1:50,000 sheet S107E, Point of Stoer.
Terrain	4km walk along rough coastal footpaths and over moderate terrain; sturdy footwear and waterproofs are advised. Some scrambling may be required and extreme care should be taken on low cliff sections, especially during windy weather. It is not advised to access the coast during storms, especially if there is a substantial ocean swell, as there is a risk of being caught by large breaking waves.
Time	This is a full day excursion.

Access	There are no access constraints for this excursion, although care should be taken on coastal sections. Please note that as the area includes an SSSI, the use of hammers is prohibited.

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Contents

Locality 2.1 Surface expression of Lewisian basement fabrics – viewpoint looking inland towards Canisp. [NC 0753 2554]

Travelling west from Loch Assynt (or east from Lochinver) on the A837, turn north on the B869 (following signs for Stoer and Drumbeg). After about 3km a viewpoint is reached at the top of a hill. From here there is a wonderful panoramic view of Sutherland's hills and the Assynt Culmination. A number of distinct valleys may be seen running inland towards the hills of Canisp and Suilven, which can also be easily picked out on maps, aerial photos and satellite images. Some of these valleys are fault controlled, including a number that follow the surface expression of the major Canisp Shear Zone (CSZ). Looking around at the gneissic rocks in the area you should be able to pick out a steeply dipping foliation trending ESE–WNW. This is the characteristic fabric of the CSZ (Fig. 20). The CSZ was formed during the Inverian (pre-Scourie Dyke) and reactivated in the Laxfordian (post-Scourie Dyke). This excursion provides a transect across it.

Locality 2.2 Badcallian gneiss on Achmelvich beach. [NC 0565 2503]

Drive for another 1.5km NW along the B869 until you reach a turning on your left side (near Alltan na Bradhan, [NC 0589 2600]). Park in the old quarry/lay-by. From here follow the track for about 100m and you should see a footpath on your left that will take you south to Achmelvich. After a short (20-minute) walk south along the inland footpath you come to a car-park and campsite (NOTE: you can drive here directly from a turning on the B869, but the road is very narrow and is not suitable for large vehicles such as buses). From the car-park, make your way over the dunes to the beach (Fig. 21). Here you can look at the water-washed exposures on the north (and south) side of the beach and examine the general lithology, metamor-phic state and structure of the felsic gneiss (Fig. 22). There is good evidence for high temperature metamorphism with partial melting, with

widespread preservation of schlieren textures that wrap lens-shaped inclusions of coarse-grained mafic to ultramafic material up to one metre across. Here we see dominantly shallowly dipping Badcallian deformation fabrics and cm-scale intrafolial folds, although small, steeply-dipping dextral Laxfor-dian shear zones and faults may be found trending ~NW–SE. This locality lies within the central part of the Lochinver Monocline (Fig. 23).

Locality 2.3 Little-deformed Scourie Dyke and localised Laxfordian dextral shear. [NC 0570 2512]

Walk north round the coast to a 20m-wide WNW–ESE Scourie Dyke, which cuts the north limb of the Lochinver Monocline. Here the discordant, intru-sive relationships between the gneisses and the medium to coarse-grained doleritic dyke can be studied. Xenoliths of felsic gneiss and little-deformed igneous textures are well preserved in the centre of the dyke, and the margins clearly cross-cut the gneissic banding (Fig. 24). Laxfordian features here are typical of much of the Assynt Terrane Lewisian outside the Canisp Shear Zone. The effects of later Lax-fordian shearing are localised in mm-to cm-wide shear zones along dyke margins, with retrogression of both felsic gneisses and dyke to form greenschist-facies biotite-muscovite schists and hornblende-biotite schists respectively. Small foliation-parallel quartz veins are associated directly with this retrogression. Associated mineral stretching lineations are sub-horizontal with numerous examples of dextral shear criteria preserved.

Locality 2.4 Inverian deformation on north beach. [NC 0591 2525]

Walk north to the middle of the next sandy beach. Note how the foliation steepens into the Inverian part of the Canisp Shear Zone, and marking the northern flank of the Lochinver Monocline. Features to be studied include the general lithology, metamorphic state and structure of felsic gneisses associated with Inverian deformation. Characteristic structures include a steeply dipping foliation, moderately to steeply SE-plunging lineation and isoclinal folds.

Locality 2.5 Faulted margin of the Laxfordian Canisp Shear Zone. [NC 0575 2551]

Walk farther north up onto the low crags and round into a marked cleft in the coastline which marks the faulted south margin of the Laxfordian Canisp Shear Zone. The foliation in the gneisses steepens further to sub-vertical between Localities 2.4 and 2.5 and, across the faulted margin, becomes much more attenuated, with a shallowly SE-plunging mineral lineation developing. Later foliation-parallel and cross-cutting faults, together with numerous foliation-parallel quartz veins up to 30cm thick, are also much more common. Look WNW out along the coast for a good view of the NW–SE-trending CSZ fabrics and associated faults, many of which produce distinctive ‘clefts’ in the landscape, including one crossed on the headland at Locality 2.7.

Locality 2.6 Ductile and brittle Laxfordian shear fabrics indicating multiple deformation events. [NC 0575 2556]

The intense ductile fabric (Fig. 25) largely obliterates the pre-existing gneissose texture, with the widespread development of biotite and musco-vite suggesting upper greenschist-to lower amphibolite-facies metamorphic conditions during Laxfordian reworking. Despite the very well-

developed shallowly ESE-plunging mineral stretching lineation (Fig. 26), there are very few unambiguous asymmetric ductile shear sense criteria preserved at this locality, although a dextral sense of shear is inferred (see below). Schistose dark green lenses of amphibolite may represent highly attenuated and retrogressed Scourie Dykes sheared into parallelism with the CSZ folia-tion. At this locality, the foliation is ubiquitously reactivated by 'Late Laxfordian' foliation-parallel sinistral faults and associated Riedel shear systems indicating sinistral senses of shear. These are widely developed, often with spacings of a few cm or less, and they are commonly associated with mainly sinistral-verging brittle-ductile folds. All these structures are cross-cut at high angles by characteristically iron-stained, 'ladder-like' systems of faults, fractures and brecciation thought to be related to Stoer Group rifting (Fig. 27). The geometry of these fractures reflects a non-Andersonian fracture pattern which may be associated with 3D strain, possibly during oblique extension (transtension).

Locality 2.7 Unfaulted margin of the Laxfordian Canisp Shear Zone. [NC 0533 2574]

Follow footpaths along the coast round to a prominent peninsula cut by a distinct cleft (Fig. 21). If tide and sea conditions permit, you can climb across this cleft (extreme care should be taken here, and you should not attempt to cross if alone!) to look at exposures of the unfaulted margin of the Laxfordian Canisp Shear Zone. The outer part of the headland com-prises relatively little-deformed felsic gneisses, while the inner part is mainly schistose mylonite with shallowly plunging mineral stretching lineations derived from felsic gneiss with numerous concordant quartz veins. The original ductile boundary of the Laxfordian CSZ is preserved here and shows clear evidence for a dextral sense of shear based on the asymmetric bending-in of the fabric in the few centimetres adjacent to the shear zone margin.

In the schistose section of mylonites, the foliation is very strongly reacti-vated by 'Late Laxfordian' foliation-parallel faults and associated Riedel shear systems indicating sinistral senses of shear. Once again, these are closely spaced and they are commonly associated with mainly sinistral-verging brittle-ductile folds.

Looking back along the coast to the south-east we can see a good cross-sectional view across the CSZ. It is possible to pick out the changes in dip indicating the presence of the Lochinver Monocline, changes in the base-ment fabric appearance and strain intensity due to the development of the CSZ (from south to north: Badcallian, Inverian and Laxfordian respec-tively) and the presence of a number of large foliation-parallel faults.

Locality 2.8 Refolded folds, sheath folds and reworked Scourie Dykes. [NC 0508 2611]

Using rough footpaths, follow the coast round to the prominent peninsula at Port Alltan na Bradhan (Fig. 21). Care should be taken in this section as cliff sections are very exposed in windy conditions and relatively steep in places, and surfaces may be slippy. If weather conditions are windy, it is possible to cut inland to access the next set of exposures or return to the parking spot.

The best exposures lie on the south side and western end of the penin-sula (Fig. 28). Spectacular 3D exposures of strongly reworked, locally folded yet commonly discordant, Scourie Dykes can be seen; these now occur as foliated amphibolites with little or no igneous mineralogy or textures preserved. Nests of complex Laxfordian folds occur on centimetre to metre-scales and locally refold early intrafolial isoclines (possible Badcallian or Inverian structures?). Mineral lineations and minor

Laxfordian folds plunge predominantly SE at low angles but are locally highly variable, with complex curvilinear geometries and eye-structures that suggest the presence of highly curvilinear fold structures. In detail, these structures that fold the local mineral lineations appear to show curvature arcs about different directions in different localities. There is little evidence to suggest that the folds are regional polyphase structures and a preferred explanation is that they are flow perturbation folds formed during CSZ shearing. The com-plexity seems atypical of the shear zone as a whole and may reflect flow partitioning localised here due to the presence of a very large basic pod which is visible in the cliff south-east of the main peninsula (Fig. 21). This probably represents a large Scourie Dyke as it is strongly wrapped by the shear zone foliation.

Cross the stream to the north of the peninsula and follow the footpath inland back to the parking spot (NOTE: the footpath crosses back over the stream after about 200m and cuts up the hillside leading to a gravel track.)

References

> At all times follow: The Scottish Access Codeand Code of conduct for geological field work

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- 2. Northern Highlands

Navigation menu

Personal tools

- Not logged in
- Talk
- Contributions
- Log in
- Request account

Namespaces

- Page
- Discussion

□

Variants

Views

- Read
- Edit
- View history

- PDF Export

□

More

Search

Search Go

Navigation

- Main page
- Recent changes
- Random page
- Help about MediaWiki

Tools

- What links here
- Related changes
- Special pages
- Permanent link
- Page information
- Cite this page
- Browse properties

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