
11 Camas Nathais

[NM 874 370]–[NM 875 382]

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Published in: The Dalradian rocks of the central Grampian Highlands of Scotland. PGA 124 (1–2) 2013

<https://doi.org/10.1016/j.pgeola.2012.07.009>. Also on [NORA](#)

11.1 Introduction

This GCR site lies 7 km north of Oban in the Benderloch area and is located on the raised beach platform around the head and south-east side of a narrow inlet of the sea, Camas Nathais. Well-scoured rock exposures display an excellent example of a ductile fault, the Benderloch Slide (Litherland, 1980). The slide contact, which is the main feature of interest at this locality, is well exposed for a strike distance of over 100 m and both the plane of movement, and the structures in the rocks on either side of it, can be examined in three dimensions. Such contacts are rarely seen in the Highlands, and this example is exceptional for its clarity, and for the quality of the rock exposure.

For many years the geology of this area was the focus for a fundamental geological debate between the followers of E.B. Bailey (1922, 1953), who interpreted the abrupt east–west changes in rock type seen on a regional scale in terms of nappe tectonics, and those who supported G. Voll (1964), who invoked extreme local facies changes. Bailey considered that radically different stratigraphical successions had been brought together by syntectonic faults called slides, the slide at Camas Nathais being correleated with a major tectonostratigraphical dislocation in the south-west and Central Grampian Highlands, later named the 'Iltay Boundary Slide' (Stephenson et al., 2013a). On the other hand, Voll concluded that the lithological differences seen across the area are of sedimentary origin, and that the rocks constitute a single, unbroken succession. The situation was resolved by Litherland (1980, 1982) who, by means of detailed field mapping, demonstrated that the so-called 'Banded Leven Schists' of Bailey (1922) could be subdivided into the 'true' Leven Schists of the lower Appin Group to the west, and rocks belonging to the lower part of the Argyll Group to the east. However, he confirmed that these two parts of the Dalradian succession had been brought together by a major tectonic break, which he named the Benderloch Slide.

At the head of Camas Nathais, the Benderloch Slide appears to place part of the Ballachulish Limestone (Appin Group) against the base of the Argyll Group, so excising a significant part of the Appin sequence. The plane of movement is marked both by a strong lithological contrast between black graphitic slaty pelites on one side and orange-yellow metadolostone and pale grey quartzite on the other, and by a zone many metres thick of sheared rocks that display a pronounced stretching lineation. The tectonic break is inferred to have developed early in the tectonic history of the area, with both the fault plane and the adjacent rocks having been subjected to several phases of later movement. The Benderloch Slide is no longer regarded as part of an intraregional 'Boundary Slide', but it can be correlated with the Ballachulish Slide found farther north (Rast and Litherland, 1970). The GCR site reports for *St John's Church* and for *Tom Meadhoin and Doire Ban* also discuss the possibility that the slide might be of synsedimentary origin and was only re-activated during later 'tectonic' events.

11.2 Description

The geological setting of this site is shown on (Figure 3.24), with the Benderloch Slide being strikingly exposed at [NM 87626 37938], near the head of the bay (Figure 3.25). The structural break was first recognized by Bailey, who stated that '...on the western side of Garbh Ard the margin of the quartzite, where exposed upon the foreshore, is separated from the Appin Limestone by a few feet of black slates and limestone but, unfortunately, there are signs of considerable movement having taken place near the junction line' (in Kynaston and Hill, 1908, p.36). Bailey later re-assigned the rocks described above as 'Appin Limestone', to the Ballachulish Limestone.

The slide plane dips at 42–46° to the north-west and lies within a sequence of rocks that all dip steeply (50–75°) in a north-westerly direction. The junction between a 0.5–1.0 m-thick band of boudinaged, discontinuous orange-weathering metadolostone below, and a black pelite-metalimestone unit above, marks the actual dislocation (Figure 3.26). When the slide plane is viewed at beach level from the north-west, flat surfaces of intensely lineated quartzite are seen in erosional windows carved out of this metadolostone sheet.

On the Fionn Ard peninsula, north-west of Camas Nathais, there is a wide outcrop of dark, finely banded semipelitic and pelitic rocks belonging to the Leven Schists. At the head of the bay, units of grey-green phyllitic semipelite and cream-coloured, finely laminated metadolostone structurally underlie these rocks, but the contact is not exposed (Figure 3.24). The metadolostone weathers orange-brown and forms thick units, one of which was formerly quarried at the site, but also occurs interbedded on a metre-scale with semipelite. The lowermost 10 m or so of rock above the slide consists of dark grey to black phyllitic rocks, which contain a band of black metalimestone less than a metre thick (L on (Figure 3.25)). The metadolostone-‘phyllite’ sequence, and the dark ‘phyllite’ and metalimestone, have been correlated, respectively, with the lower and upper parts of the Ballachulish Limestone Formation (Bailey, 1922; Litherland, 1980), but Litherland (1982) subsequently correlated the dark phyllitic unit with the much younger Lismore Limestone.

The rocks below and south-east of the slide plane consist largely of quartzite and were subdivided into the Baravullin Quartzite, Castle Dolomitic Flags, and Tralee Bay Quartzite by Litherland (1980). The Baravullin Quartzite is pale grey to white in colour and occurs in the footwall immediately below the slide. It has been intensely brecciated, but evidence of crudely defined bedding planes can still be detected, defining units up to 40 cm thick separated by thin phyllitic layers or films. The quartzite is underlain structurally by the Castle Dolomitic Flags, which form the spine of the Garbh Ard peninsula and consist of a banded alternation of buff-coloured quartzite ribs with dolomitic semipelite and greenish phyllitic rock.

A stretching lineation is strongly developed in rocks adjacent to the slide contact (inset to (Figure 3.26)), and dominates the fabric for a distance of some 10 m into the hanging-wall semipelites and pelites. It has a consistent orientation and plunges at an average of 34° to 352°. The orange-weathering metadolostone that lies immediately below the slide plane has been boudinaged, with boudin necks aligned normal to the stretching lineation. This lineation is deformed by a crenulation cleavage that affects rocks on both sides of the slide. Evidence for later movement on the fault plane is given by a veneer of silicified fault breccia, up to 15 cm thick, found in contact with the metadolostone (Litherland, 1982). It contains fragments of randomly orientated, crenulated slaty rocks similar to those found adjacent to the slide.

In the immediate footwall to the slide, beneath the metadolostone bed, there is a 1 m-thick zone of highly fractured quartzite, with numerous quartz veins, underlain by a considerable thickness of pervasively fractured rock. Throughout this fractured zone the quartzite consists of interlocking fragments 1 to 2 cm across, separated by deeply weathered seams and fissures, which are of possible pressure-solution origin. In some beds the fragments are equidimensional, but in general they are crudely aligned at a moderate angle to bedding. In three dimensions they have extremely flattened and elongated pancake shapes, and have a veneer of white mica on their surfaces. Where minor folds are developed in these rocks, the fragments are aligned roughly parallel to the axial planes of the folds and to the penetrative cleavage in the more-micaceous bands, so that they appear to define a rough cleavage. This relationship is seen to within 2 m of the slide plane.

Deeper into the footwall, bedding in the Baravullin Quartzite and Castle Dolomitic Flags is cut by a less-steep penetrative main cleavage dipping to the south-west, which is in turn cut and reworked by a crenulation cleavage that dips at 20–35° to the north-west, and is associated with minor folds up to a few tens of metres in wavelength.

In the hanging wall, metre-scale upright folds are associated with a penetrative axial planar cleavage in the more-micaceous bands, which dips steeply to the north-west. In places there is clear evidence that a generation of minor folds, with an axial-planar penetrative cleavage, pre-dates the main cleavage. These early folds are clearly seen in the laminated metacarbonate rocks, which develop thin axial-planar quartz veins. As in the footwall rocks, the main cleavage is cut by a spaced crenulation cleavage, which dips at a low angle (30–40°) in the same direction and is accompanied by minor folds plunging to the south-west. Calcareous bands in the phyllitic rocks preserve the main cleavage but are commonly reduced to a series of sigmoidally shaped lenses by the development of a cross-cutting, later, spaced

pressure-solution cleavage having the same geometry as the crenulation cleavage in the phyllitic rocks.

11.3 Interpretation

The pelites, semipelites, psammites and dolomitic rocks in the hanging wall to the slide at Camas Nathais (units C to F, (Figure 3.25)) have been correlated with the lower part of the Ballachulish Limestone by previous workers, and the dark phyllitic pelite and black metalimestone beneath them (unit D, (Figure 3.25)) with either the upper part of the Ballachulish Limestone (Bailey, 1922; Litherland, 1980), or with the Lismore Limestone (Litherland, 1982).

South-east of the Benderloch Slide, the Barravullin Quartzite, Castle Dolomitic Flags and Tralee Bay Quartzite can be correlated with elements of the Islay Subgroup on Islay and Jura. Farther to the north-east, the Tralee Bay Quartzite is overlain by the Selma Black Slates and the Selma Breccia (Figure 3.24), rocks equated respectively with the Jura Slate (see the *Kilnaughton Bay* GCR site report) and Scarba Conglomerate (see the *Lussa Bay* GCR site report). Crucial to this assignment of rocks south-east of the slide to the Argyll Group is the correlation of the Baravullin Boulder Bed with the Port Askaig Tillite (see the *Garvellach Isles* GCR site report). The Baravullin Boulder Bed is not exposed at Camas Nathais but, according to Litherland (1980), it crops out inland 3 km to the north-east of the GCR site, and on the south-east side of the projected line of the slide (Figure 3.24). A thin sliver of the Islay Limestone (locally called the Baravullin Dolomite) was also reported from this locality. These stratigraphical correlations suggest that (1) the Benderloch Slide lies at, or close to, the base of the Argyll Group, and (2) following Litherland (1980), most of the Ballachulish Subgroup, and all of the Blair Atholl Subgroup, are cut out at the line of the slide.

Evidence from the area around Loch Creran, well to the north of Camas Nathais, shows that the main movement on the Benderloch Slide occurred before the first deformation. The latter affected both the footwall and hangingwall, and was responsible for the formation of the early penetrative cleavage. In the Loch Creran area the S1 slaty cleavage cuts across the plane of the slide (Voll, 1964) and the slide is locally folded by map-scale F1 folds (Litherland, 1982).

The Dalradian sediments preserved in this area were laid down in an unstable environment at the margin of a large basin and the slide could represent mass movement of part of the bedded sequence down the submarine slope, into the developing basin. Evidence for basin-margin instability and slumping of material at a slightly later time is clearly preserved in the form of the Selma Breccia described in the *Port Selma* GCR site report. The evidence that brecciation of the quartzite in the footwall to the slide at Camas Nathais occurred before an early phase of deformation is compatible with these conclusions, although the relationship of the earliest penetrative cleavage to the slide cannot be demonstrated directly. However, the stretching lineations associated with the slide movement are deformed by the low-angle, NW-dipping crenulation cleavage that affects both the footwall and hangingwall rocks at this site, so placing a minimum age on the main slide movement. Some rejuvenation of the faulting then occurred after the crenulation event, as is witnessed by disorientated fragments of already crenulated phyllitic pelite and semipelite in the late fault breccia.

New fieldwork carried out to date suggests that the rocks on both sides of the Benderloch Slide have been affected by the same sequence of structural events. Correlation of the early penetrative cleavage and the crenulation cleavage between footwall and hanging wall, and with the D1–D4 deformation phases documented in the wider area by Litherland (1982) is premature. It needs confirmation by a more-complete study of the geometry of the structures, and of the tectonic fabrics in thin section. The stratigraphical correlation of the hanging wall sequence with the known Dalradian succession in the area, the nature of the fault rocks, and the shear sense on the slide plane, also remain to be determined.

11.4 Conclusions

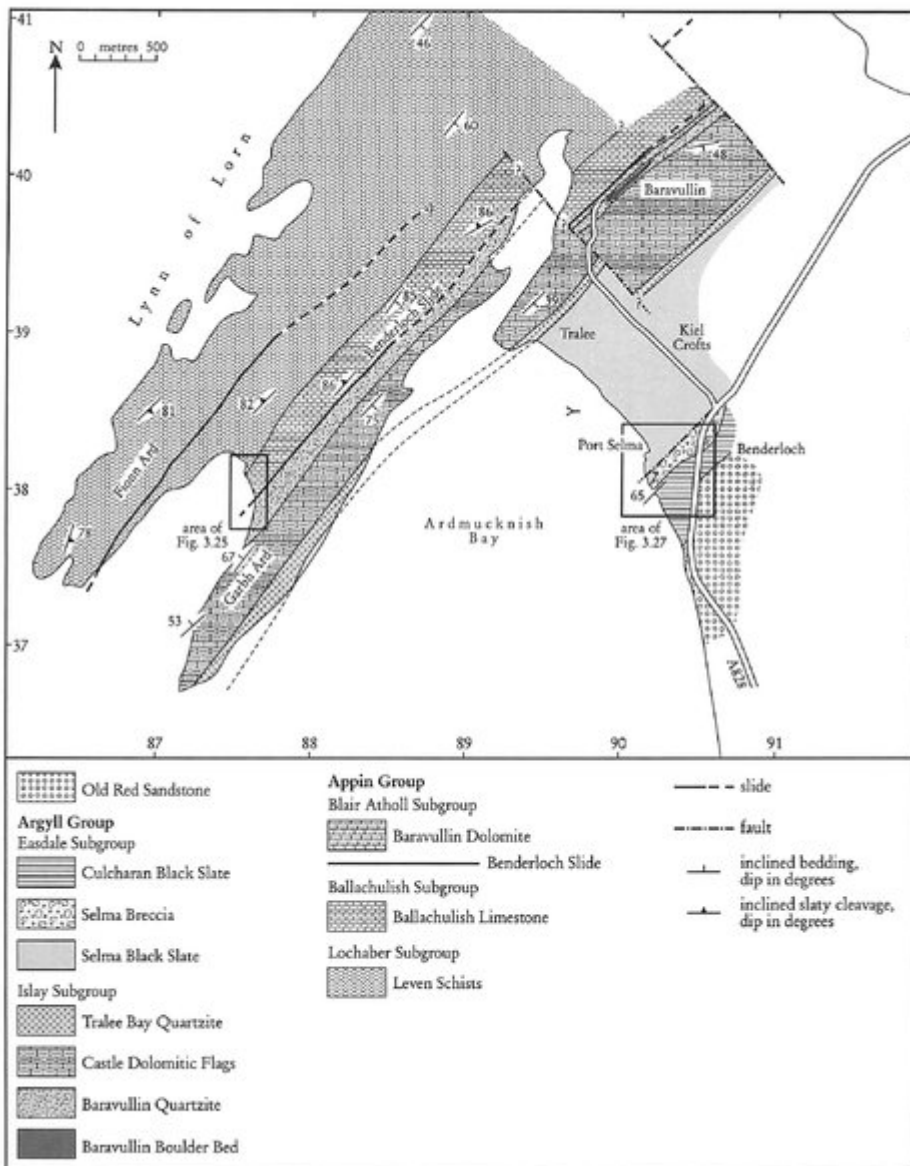
At Camas Nathais a large fault, termed the Benderloch Slide, has juxtaposed two different parts of the Dalradian sequence. As the rocks within such fault-zones are generally physically weaker than the country rocks, they are easily removed by erosion when they become exposed at the Earth's surface. In this way, crucial evidence is destroyed that could have been used to determine the nature and amount of movement that had taken place on the fault, and the relative timing of the event. Hence, it is only in exceptional cases, such as are seen at this GCR site, that the zone of

crushed and distorted rocks that forms at the contact between the two fault blocks is preserved. This site is also of historical importance as there has been a dispute over the nature and significance of the junction between the two groups of rocks at this locality, since E.B. Bailey first identified it in 1908.

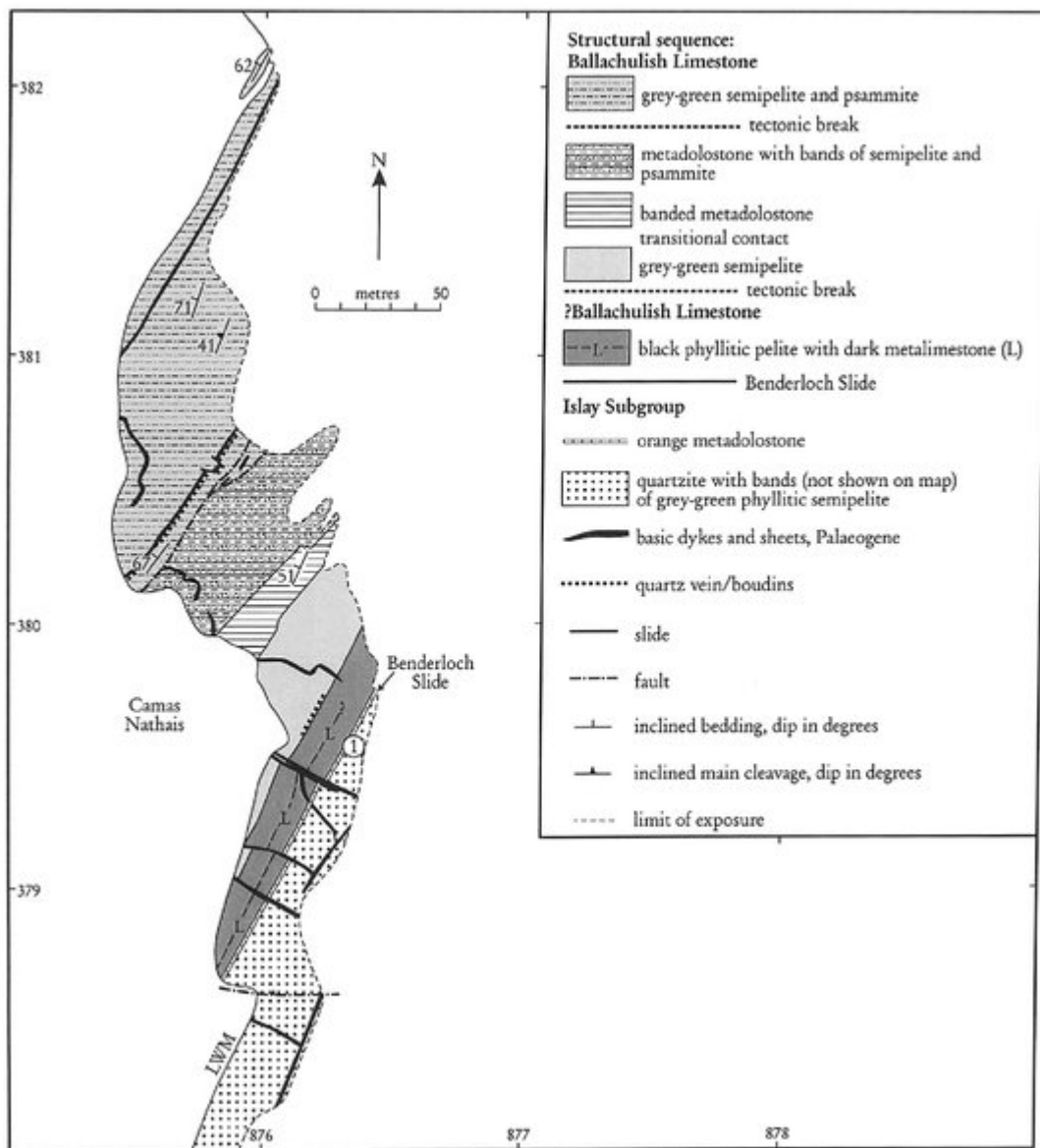
It is important to know whether the fault movement occurred early in the history of deformation, when the fault would be subjected to later folding and overprinted by the main cleavage, or later, when it would cut and displace the fold structures themselves. Field evidence from outwith the GCR site, as summarised above, indicates that the first movement on the fault took place before the main deformation had begun, probably at about the time that the sediments were being laid down. This plane of weakness could have provided a focus for later, repeated movement, as found at Camas Nathais, and its origin is in stark contrast to that of the Selma Breccia, described in the *Port Selma* GCR site report.

This site has considerable potential for further research. The fault rocks are well preserved, despite later folding and metamorphism, and by studying the structural fabrics under the microscope it should be possible to determine the relative direction of movement of the two blocks. Many outstanding questions still remain to be resolved before we have a clear idea of the geometry, timing, and causes, of the displacements on this major slide.

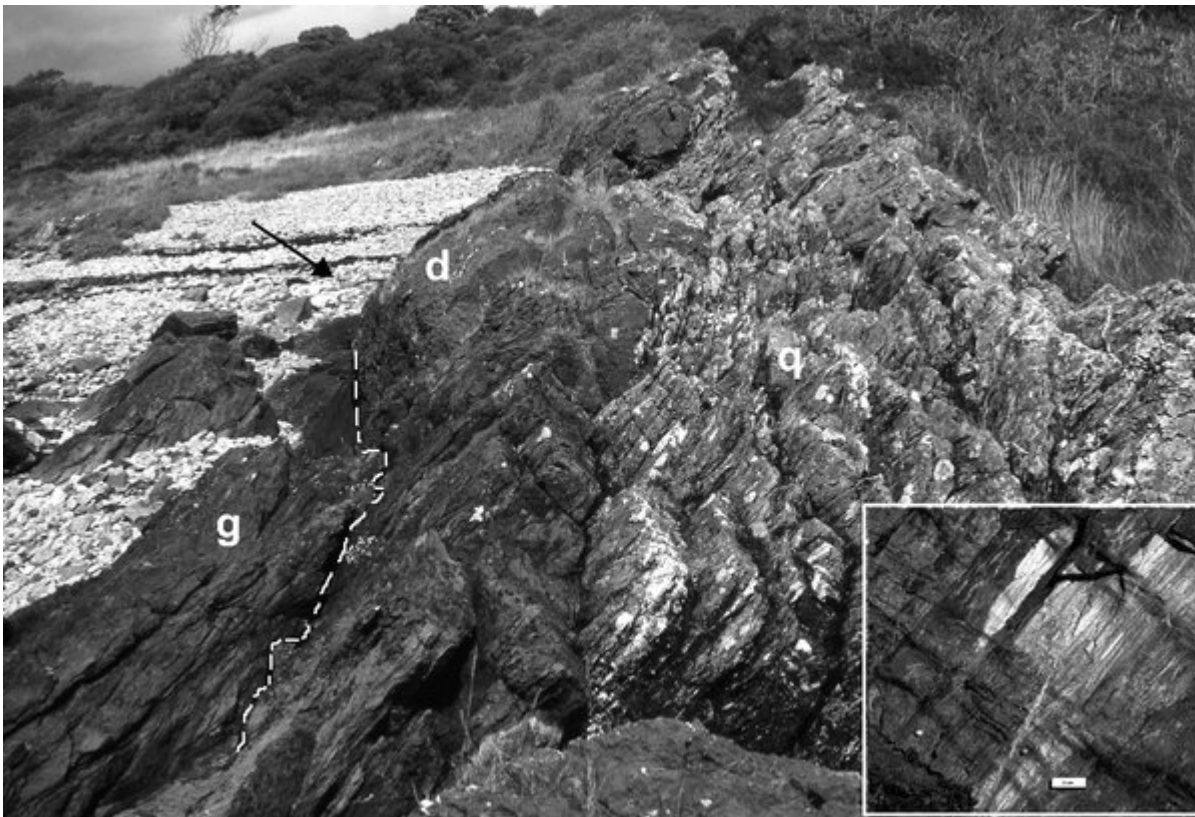
References



(Figure 3.24) Map of the Lochnell Peninsula and adjoining area, north of Oban, modified from BGS 1:50 000 Sheet 45E (Connel). It shows the regional setting of both the Camas Nathais and Port Selma, Ardmucknish GCR sites (labelled inset boxes), and the line of the Benderloch Slide.



(Figure 3.25) Detailed map of an area at the head of Camas Nathais (see inset on (Figure 3.24)), based upon a survey by P.W.G. Tanner using GPS for location. The irregularly shaped Palaeogene dykes and sheets provide a guide to location on this featureless rock platform. The map shows the relationship of the rock sequence and structure in the hanging wall of the Benderloch Slide (S), to those in the footwall.



(Figure 3.26) The Benderloch Slide at Camas Nathais, as seen looking north from locality 1, (Figure 3.25). The slide-plane dips steeply to the north-west and separates graphitic pelite (g) above, from a strongly boudinaged and disrupted unit of orange-weathering dolostone (d) below. To the right of and beneath the dolostone is the intensely fractured Baravullin Quartzite (q). Inset: Lineations in the graphitic pelite just above the slide, as seen looking in the direction of the arrow in the main photo. Two sets of steeply plunging lineations lie in the plane of the phyllitic cleavage. The lineation plunging steeply to the left (north) is the stretching lineation associated with the slide movement, and it is crossed by later crenulation lineations and kink bands plunging to the right (south). (Photos: P.W.G. Tanner.)