24 Ben Oss

[NN 291 265]–[NN 296 271]

J.E. Treagus

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24.1 Introduction

The Ben Oss GCR site has been selected to exemplify the fracture history of the Tyndrum Fault, one of the major system of NE-trending, dominantly left-lateral faults that dissect the Grampian Terrane between the Great Glen and the Highland Boundary faults ((Figure 3.1) and Stephenson et al., 2013a, fig. 1). The principal period of fault movement was in the late Silurian and is closely associated with Caledonian intrusions, such as the adjacent Garabal Hill–Glen Fyne granitic pluton and microgranite and appinitic microdiorite dykes in the Tyndrum area. Late-Carboniferous quartz-dolerite dykes, with a regional east to east-north-east trend, cut across the fault-zone.

Previous studies have established the strike-slip component of movement on this system of faults, although the importance of dip-slip components has also been recognized (Anderson, 1951; Johnstone and Wright, 1957; Pitcher, 1967). Treagus (1991) constructed geological profiles on either side of some of the principal fault planes within the Grampian Terrane to demonstrate that the components of movement on the individual faults were both left-lateral strike-slip (up to 8 km) as well as dip-slip (up to 2 km). The Tyndrum Fault, in particular, was shown to have a significant dip-slip component of 2 km, down to the east, as well as a left-lateral strike-slip component, which is greatest (4 km) in the central portion of the fault, the area of this GCR site. Treagus *et al.* (1999) have made a detailed study of the fault and its associated mineralization.

24.2 Description

This GCR site, which lies some 4 km south-west of the village of Tyndrum, occupies a gully of the Allt Coire Chruinn, which drains the northern slopes of Ben Oss (Figure 3.57). On these slopes, one major fault and many minor fractures associated with the Tyndrum Fault are particularly well exposed. The fault, termed here the Ben Oss Fault, can be traced from [NN 295 269] into good exposures in the 300 m-long gully in the Allt Coire Chruinn at [NN 291 265] to the south-west. It is a major splay of and is very close to the line of the Tyndrum Fault, which in the area of the site is occupied by a microdiorite dyke.

At the north-east end of the gully, a quartz reef is exposed for 100 m in the hanging wall of the fault, which here trends 040° and dips at 72° to the south-east. To the south-west the reef becomes a breccia, composed of clasts of vein-quartz, 1–15 cm in length, in a cataclastic matrix of indurated fine-grained quartz and micas, evidence of extensional opening of the fault. In the wall formed by the margin of the breccia, many fault-parallel fractures are seen. These are marked by horizontal grooves, confirming strike-slip movement, and by a series of steeply N-pitching pinnate fractures, whose geometry indicates left-lateral movement. Many steep SE-dipping fractures are seen in the footwall of the fault (the north-west side of the gully), comprising both a fault-parallel set and another set orientated some 10–25° anticlockwise to the fault. The former are interpreted as Y shears, the latter as R shears, both with movement senses sympathetic to that of the main fault (see Sibson, 1977). In the schists in the footwall, 2–3 m to the west of the fault plane, small-scale, steeply plunging, drag-folding of bedding also indicates left-lateral movement.

There is also evidence of left-lateral movement in the area immediately to the north-west of the fault gully. Here, major fractures can be seen on the aerial photographs, branching at some 20° anticlockwise from the fault at regular 50 m intervals for several hundred metres to the north of the gully (Figure 3.58). The fractures contain both illite-quartz and pyritic gouges with textures indicating left-lateral movement. One major fracture at [NN 2925 2677], occupied by the stream, contains a 3 m-thick quartz-vein breccia, kink folds and bedding offsets in the schists that show clear left-lateral displacements ((Figure 3.57), locality marked X and to its south-west). Slickensides and grooves (localities marked S on (Figure 3.57)) plunge at an average of 2° towards 221° on the fault-parallel fractures, and at 7° towards 197° on the anticlockwise set, confirming the dominant strike-slip movement sense. The anticlockwise set of fractures is not seen to the south-east of the fault.

However, there is also evidence of right-lateral movement on the fault. Measurements of bedding to the west of and adjacent to the fault, at about [NN 292 267], show a 100 m-wide fold plunging at 43° towards 188°, the sense of deflection indicating right-lateral shear. Moreover, the swing in strike of the regional bedding, where followed for 1 km to the west of the fault, shows a similar pattern that also indicates a right-lateral deflection. Small right-lateral displacements and kinks have also been observed on some anticlockwise fractures (e.g. the two localities indicated on (Figure 3.57)), suggesting re-activation, and a 30 cm-wide Caledonian dyke at [NN 291 265] shows both left-lateral and right-lateral metre-scale displacements. The north-western margin of the dyke that occupies the Tyndrum Fault shows effects of further brecciation, shearing and hydrothermal alteration (e.g. at [NN 295 270]), which could represent this right-lateral movement. A thick late-Carboniferous dyke shows a slight dextral deflection where it crosses the fault at [NN 296 271].

24.3 Interpretation

Regional considerations suggest that the earliest movement on the Tyndrum Fault may have been a tensional opening as a normal fault (see Treagus *et al.*, 1999); this is supported by the 70° dip of the Ben Oss Fault and associated fractures, as well as by the hydrothermal breccias. Two fracture sets are evident in the GCR site, a fault-parallel set and another some 10–25° anticlockwise to the fault (Figure 3.58); these are interpreted as Y shears and R shears, respectively, with sympathetic left-lateral shear in response to movement on the major fracture, in the traditional manner of fault analysis (Sibson, 1977). Many fault-related features on minor fractures (pinnate structures, kink-folds, bedding displacements and gouge textures) support the left-lateral displacements. Thus the Ben Oss Fault can be confidently interpreted as a major fault with left-lateral displacement.

The principal evidence for the magnitude of the left-lateral displacement comes from the offset of the Ben Lawers Schist/Ben Lui Schist junction. On the west side of the Ben Oss Fault, this junction trends 040° and dips steeply to the south-east; it is apparently displaced by some 3 km on the east side of the fault to near Cononish (Figure 3.57), inset. However, Treagus (1991, figure 3) showed that the latter occurrence of the junction represents the limb of a major F2 fold (a component of the regional Ben Lui Fold) that is structurally lower than the junction on the western side of the fault; the two fold limbs have been brought together by movements which had components of displacement of 1.8 km dip-slip (down to the east) and about 4 km left-lateral strike-slip.

Evidence for significant right-lateral movement in the fault-zone can also be established from the displacement of the Ben Lawers Schist/Ben Lui Schist junction in the Ben Oss area. There is a narrow sliver of Ben Lawers Schist directly east of the Ben Oss Fault, in which the junction is shifted some 300 m to the south-west (Figure 3.57). This sliver is separated from the Ben Lui Schist farther east by a 14 m-wide, steeply SE-dipping, Caledonian dyke of porphyritic microdiorite. This dyke must be intruded along the major displacement plane of the Tyndrum Fault-zone, immediately east of the Ben Oss Fault. The interpretation of the movement history of the zone is shown in the inset to (Figure 3.57). The early major movement displaced the Ben Lawers Schist/Ben Lui Schist junction as described above (with components of displacement up to 8 km in a left-lateral sense and 1.8 km of dip-slip) from its position at Cononish to that in the fault-bounded sliver. The main fault plane was then intruded and sealed by the microdiorite dyke, which is evidence of further extensional opening. A later right-lateral movement occurred on the Ben Oss Fault, which brought the Ben Lawers Schist/Ben Lui Schist junction back to its present position west of the faults. The Ben Oss Fault is therefore interpreted as a major splay of the Tyndrum Fault, having an unknown amount of left-lateral shear, but with a subsequent right-lateral movement of at least 300 m

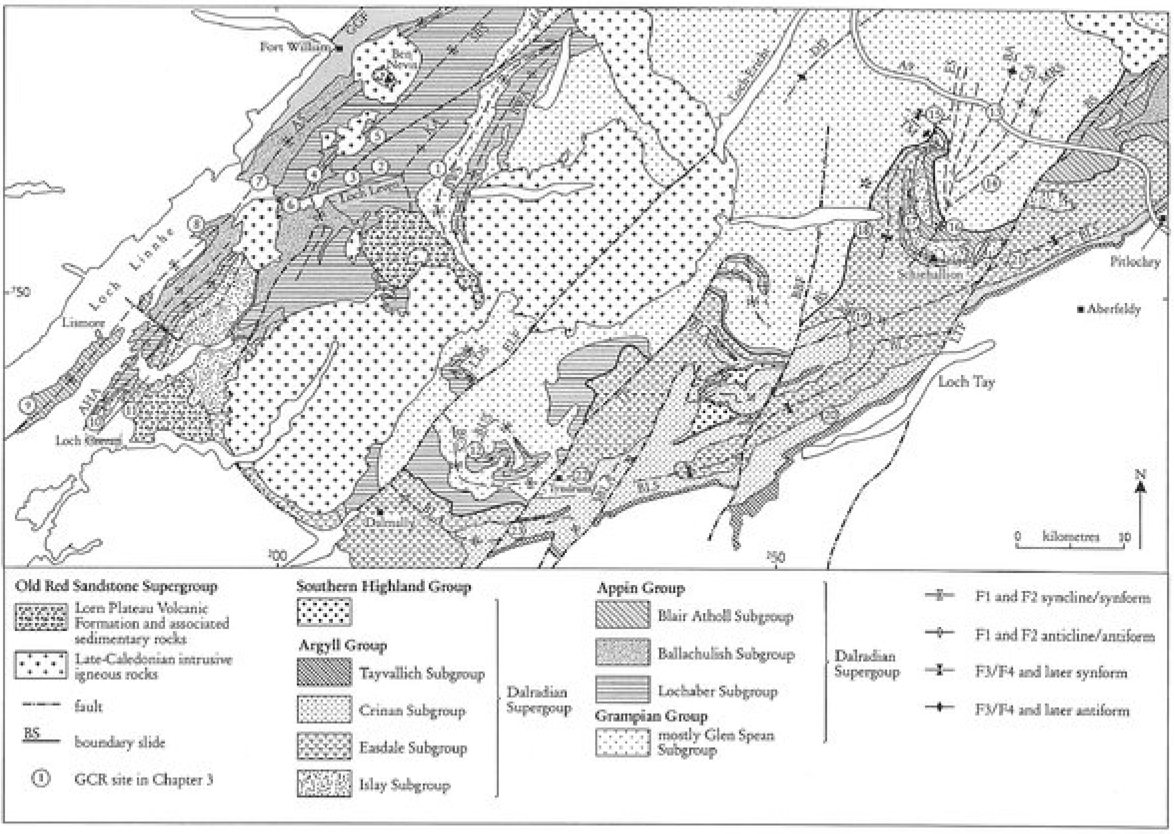
There is no evidence of the early precious-metal-type mineralization, seen elsewhere in the Tyndrum area, apart from minor pyrite mineralization on the faults and minor fractures. However, the later right-lateral movements are equated with those at other localities in the Tyndrum area, where they are associated with the base-metal mineralization (Treagus *et* *al*., 1999).

24.4 Conclusions

The Ben Oss GCR site provides exceptional exposures of a major fault, the Ben Oss Fault, together with associated minor and major fractures. Many of the features associated with major faults are well displayed, such as fault breccias, fault-gouge clays, slickensides and quartz veins. The fault is a component of the Tyndrum Fault, also exposed at this site, which is one of the major dislocations that traverse the Grampian Terrane from north-east to south-west.

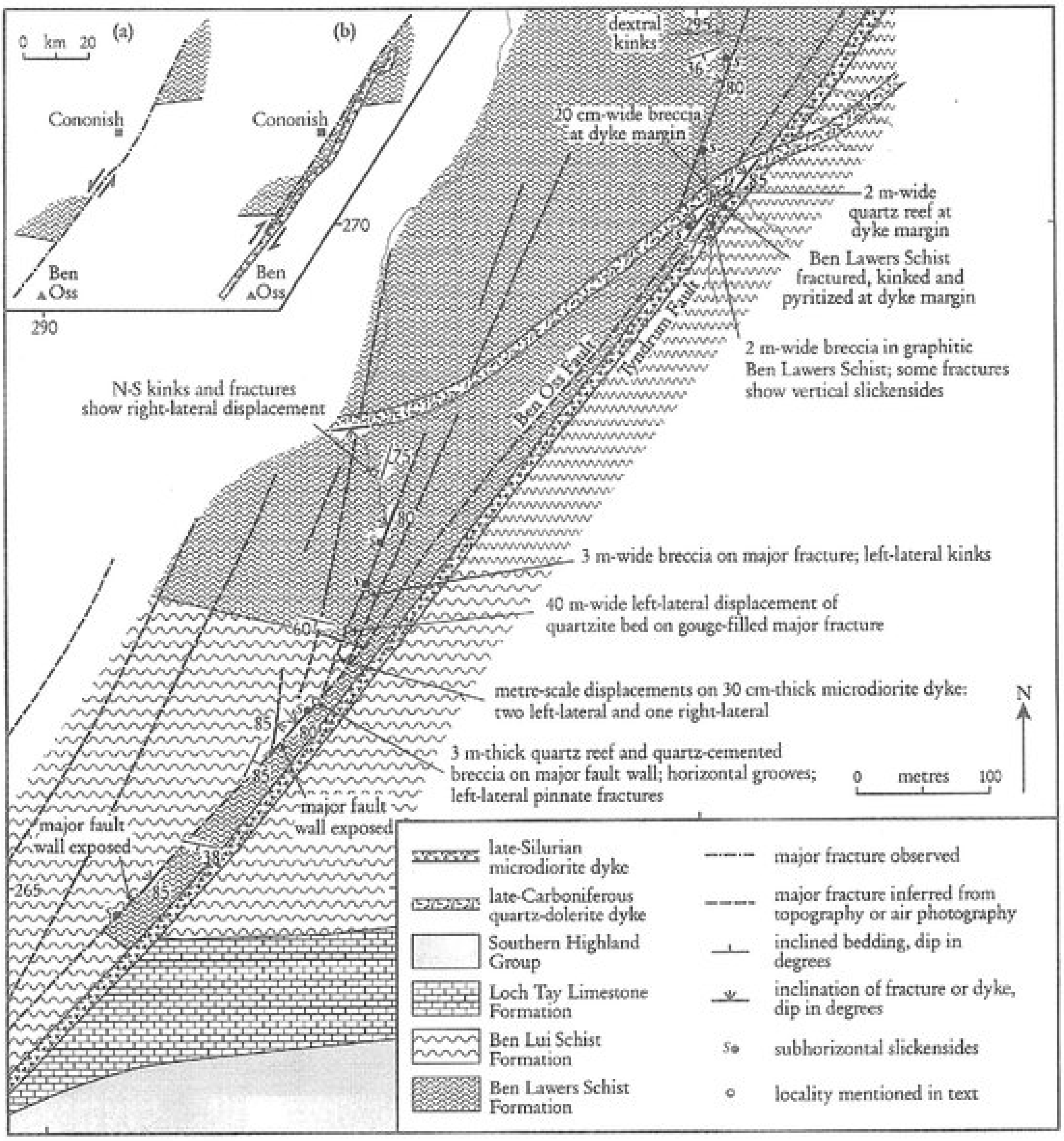
Evidence from the exposed fault planes, together with that seen on aerial photographs, allows the movement sense on the major structure to be predicted. Both faults have a complex history, which principally involved a left-lateral sense of movement, such that the north-west side of the faults moved sideways to the south-west; the Ben Oss Fault probably only moved a few hundred metres but the Tyndrum Fault moved a minimum of 4 km and possibly as much as 8 km. The evidence also suggests that the history of the faults, involved sideways movement in the opposite (right-lateral) sense, as well as vertical movements. Regionally these movements can be linked to the history of mineralization in the area.

References

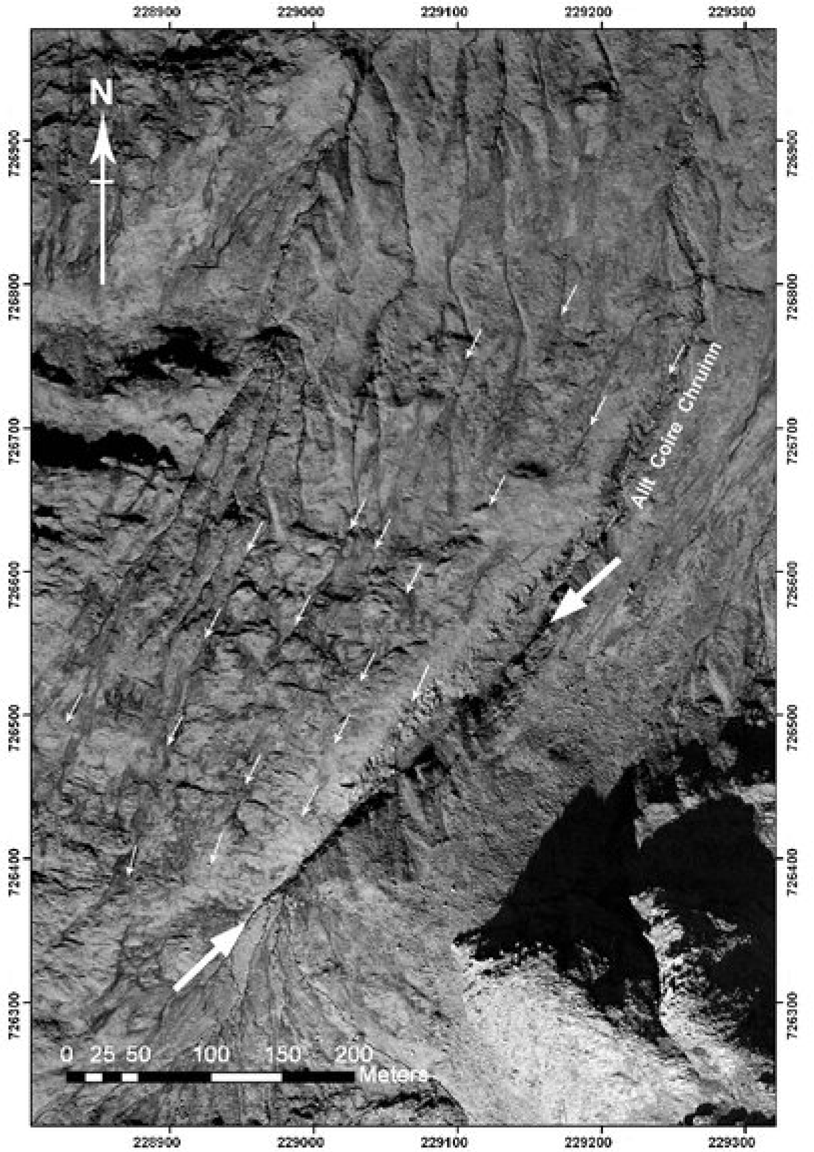


*(Figure 3.1) Map of the Central Grampian Highlands, showing Dalradian subgroups, major structures including the Boundary Slide and locations of GCR sites. Only areas described in Chapter 3 are ornamented. * On the limbs of the late Errochty Synform, to the north of Schiehallion, highly attenuated condensed sequences of the Lochaber and Ballachulish subgroups, too thin to be shown at this scale, are present in the Boundary Slide-zone. GCR sites: 1, River Leven Section, 2 Nathrach, 3 Rubha Cladaich, 4 Tom Meadhoin and Doire Ban, 5 Stob Ban, 6 St John's Church, Loch Leven, 7 Onich Dry River Gorge and Onich Shore Section, 8 Ardsheal Peninsula, 9 South Coast, Lismore Island, 10 Camas Nathais, 11 Port Selma, Ardmucknish, 12 River Orchy, 13 A9 Road Cuttings and River Garry Gorge, 14 Creag nan Caisean–Meall Reamhar, 15 Meall Dail Chealach, 16 Strath Fionan, 17 Tempar Burn, 18 Allt Druidhe, 19 Slatich, 20 Ben Lawers, 21 Craig an Chanaich to Frenich Burn, 22 Auchtertyre, 23 Ben Oss. Faults: BBF Bridge of Balgie Fault, ELF Ericht–Laidon Fault, GGF Great Glen Fault, LTF Loch Tay Fault, TF Tyndrum Fault. F1 and F2 folds: AS Appin/Cuil Bay Syncline, AHA Airds Hill Anticline, BCS Beinn Chuirn Synform, BDS Beinn Donn Syncline, BLA Ben Lui Antiform, BSA Beinn Sgluich Anticline, BUS Beinn Udlaidh Syncline, BWA Blackwater Antiform/Treig Syncline, BWS Blackwater Synform, CA Clunes*

Antiform, IA Inverlair Antiform, KA Kinlochleven Antiform, LDS Loch Dochard Syncline, MRS Meall Reamhar Synform, RA Ruskich Antiform, SBS Stob Ban Synform. F3, F4 and later folds: BA Bohespic Antiform, BLS Ben Lawers Synform, DD Drumochter Dome, ES Errochty Synform, TM Trinafour Monoform.



(Figure 3.57) Map of the Ben Oss Fault-zone with the Tyndrum Fault immediately to its south-east, occupied by a microdiorite dyke. The outcrop of the Ben Lawers Schist (ornamented) is shown between the two faults and its margin with the Ben Lui Schist is shown to the north-west of the Ben Oss Fault. The inset shows, (a) the left-lateral movement on the Tyndrum Fault and (b) the subsequent locking by the dyke and right-lateral movement transferred to the Ben Oss Fault.



(Figure 3.58) Vertical aerial photograph of the northern flank of Ben Oss, showing the Ben Oss Fault (stream gully in centre with large arrows at each end) and fractures orientated at 20° anticlockwise to the fault on its north-west side (indicated by small arrows). See text for explanation. (Aerial Photograph © Getmapping.)