
Warnscale Bottom, Buttermere

[NY 201 135]; [NY 199 135]

F. Moseley

Highlights

The site provides a rare opportunity to examine evidence for the nature of the intra-Ordovician unconformity between the Skiddaw Group and the Borrowdale Volcanic Group. Tight folding and cleavage in the former, contrast dramatically with the uniformly dipping Borrowdale lavas above. The faulted and depositional junctions between the two groups gives evidence of their true stratigraphical and structural relationship, which has been the subject of much contention in the past.

Introduction

Ever since geologists began to make detailed maps of the Lake District, there has been controversy about the junction between the slates of the Skiddaw Group and the Borrowdale Volcanic Group, whether it was conformable, unconformable, or faulted (see Moseley, 1972 for review).

Some exposures of the junction (such as in the present site) are clearly faults, but interest has focused, in recent years, on whether the junction was originally a major orogenic unconformity. Simpson (1967) proposed that two phases of deformation preceded the volcanics, the latter being affected by only gentle folding and a single cleavage. Soper (1970) challenged this interpretation showing that, where the junction is exposed, a single cleavage in the slates passes into the overlying tuffs, and that slate fragments in the tuff show a common cleavage. In spite of various arguments for and against the hypotheses (see 'Introduction', Chapter 1) Soper's (1970) view has prevailed, albeit with much modification.

Several workers have noted that significant north-trending folds, with no associated cleavage in the Skiddaw Group, do pre-date the volcanics (for example, Roberts, 1971, 1977a; Jeans, 1972; Wadge, 1972; Webb, 1972). It now seems to be agreed that these folds (F_0 elsewhere in this volume), which may be tight and have amplitudes up to 500 m, are the product of submarine slumping. These folds are of variable trend. However, since the top of the Skiddaw Group ranges in age, from Upper Llanvirn in the east to Arenig in the west, where it is overlain by the Borrowdale Volcanic Group (Soper and Moseley, 1978), a regional unconformity certainly exists. Several authors and, more recently, Webb and Cooper (1988) have related the unconformity to the incipient Lake District Anticline (Downie and Soper, 1972), and Branney and Soper (1988) have associated the unconformity with both slumping and volcanotectonic uplift.

Description

Two localities are described, the first in Warnscale Beck, the second in Black Beck to the west. The first [NY 201 135] (Moseley, 1975; Wadge, 1978a) provides a continuous section across the junction of the Skiddaw and Borrowdale Groups (Figure 3.12). Starting downstream, the Skiddaw Group is banded with pale, silty layers in dark pelite, and the cleavage is moderately strong, being visibly axial planar to small folds, but also often subparallel or parallel to the silty laminae. Along the stream bottom, the bedding in the slates is clearly seen but not the cleavage. On the stream banks, weathering has clearly picked out the cleavage, but the silty laminae can be seen to be tightly folded as far as the junction, where these folds are abruptly truncated by a sharp plane inclined 60°SE, which must be regarded as a fault. Continuing upstream, a massive, flow-jointed but unfolded andesite dips steadily to the south-east.

Black Beck [NY 199 135] shows a 20 m exposure across the Skiddaw–Borrowdale Groups junction, and although the contact is not so clear, the bedding in the slate is discordant to the junction, which does not appear to be faulted (Bull, unpublished; Wadge, 1978a). Wadge reported 2.8 m of conglomerate at the base of the volcanics, and Bull noticed that there were slate blocks near the base, and that the cleavage in them was parallel to that in the underlying Skiddaw Group

(60/120°). Bedded tuffs, some distance above this locality, show the development of a strong cleavage with essentially the same attitude as that in the Skiddaw Group below.

Interpretation

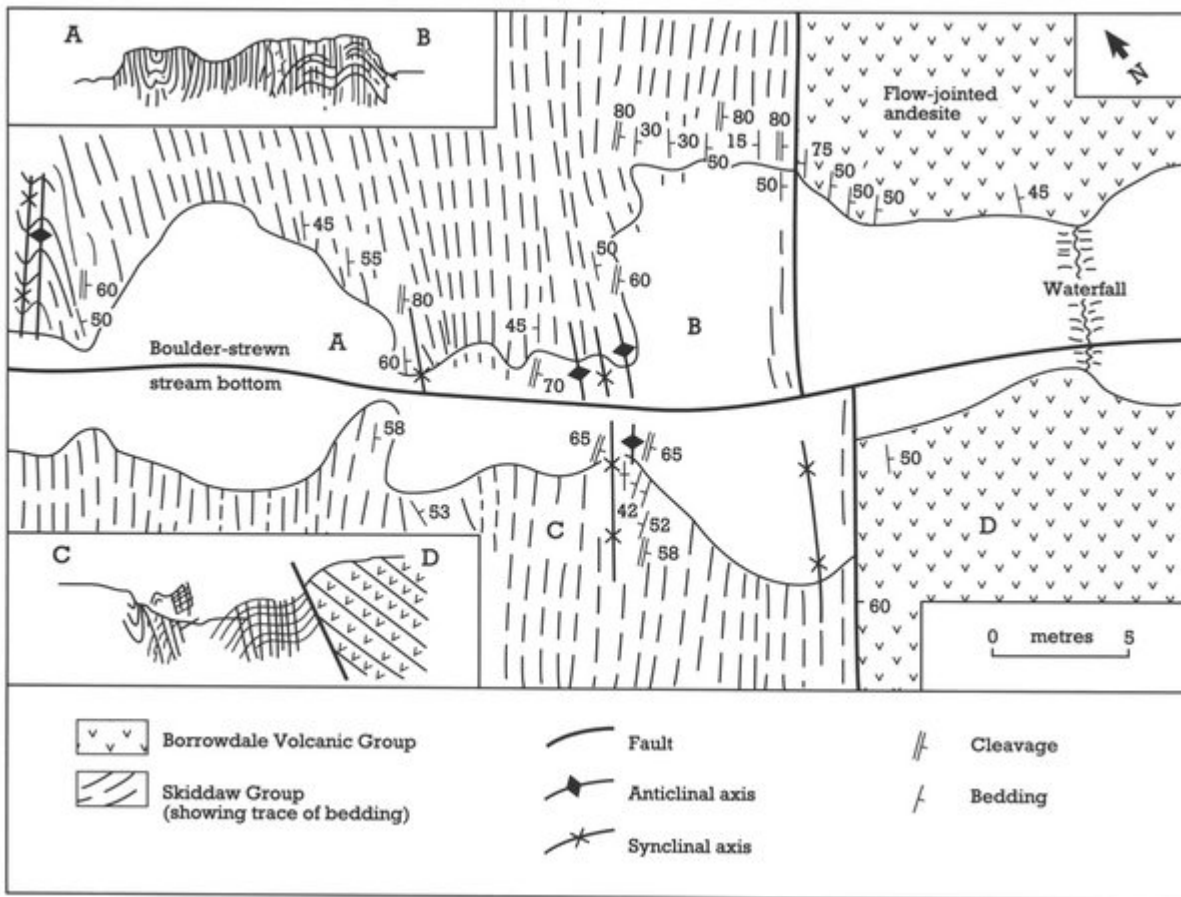
The arguments that have centred on the nature of the Skiddaw Group–Borrowdale Volcanic Group junction can be easily appreciated at these two localities. Below the junction are strongly cleaved, tightly folded sediments; above are uniformly dipping massive volcanics, with only locally a crude cleavage. These observations, in themselves, might only indicate the contrasting behaviour of incompetent and competent lithologies, although the persistence of minor folds in the Skiddaw Group close to the junction and the presence of a conglomerate and of mudstone clasts in the volcanic sequence do suggest an unconformity. The presence of a single cleavage common to both slate and tuff clearly shows that any unconformity pre-dates substantial shortening in the rocks.

The significance of the folding in the Skiddaw Group is problematical. Unlike some folds observed near this junction, they have a Caledonoid northeasterly trend, with axial-planar cleavage. In the light of the recent work of Webb and Cooper (1988), however, it is considered that the folds are slump structures with an original north-easterly trend, which have been tightened, together with the formation of cleavage, during the late-Caledonian deformation. This origin would explain the persistence of the folds close to the un-conformity and at the same time emphasize the importance of slumping in its evolution (Webb and Cooper, 1988).

Conclusions

These exposures provide evidence for the nature of the unconformity between two of the major stratigraphical units in the Lake District; that relationship has been the subject of intense debate in the past. There have been arguments over whether the junction was an unconformity and whether this unconformity was evidence of major earth movements, and how far it was affected by faulting. It was once thought that folds in the Skiddaw Group rocks were evidence of early-Caledonian deformation that pre-dated the eruption of the Borrowdale volcanics. However, by comparison with folds at other sites (discussed above), it is now clear that such folds were formed soon after deposition of these Skiddaw sediments on the sea-bed. The relationships seen suggest that the unconformity, while real, is not of orogenic proportions as was once proposed, and it has been locally modified by faulting.

References



(Figure 3.12) Detailed map and sections of the Skiddaw Group–Borrowdale Volcanic Group junction exposed in Warnscale Bottom. Anticlines, synclines, dip of bedding and cleavage are shown (after Moseley, 1975).