Swindale Beck

[NY 688 275]–[NY 689 278]

Introduction

Swindale Beck is the most important stratigraphical section in the Cross Fell Inlier. It contains the most complete representation of the Dufton Shale Formation, showing parts of the Longvillian to Actonian and the upper Pusgillian. It is also the type locality for several Pusgillian trilobites and for the Swindale Limestone Formation, which is a candidate for defining the base of the Rawtheyan Stage. The southern end of the section contains the only exposures of the uppermost Ordovician Ashgill Formation in the Cross Fell Inlier.

When Harkness and Nicholson (1877) proposed the term 'Dufton Shales', Swindale Beck was the only section they described in detail; their concept was close to modern usage. Dean (1959a, p. 191) suggested that Swindale Beck should be considered the type locality for the formation, even though he excluded the so-called basal '*corona* Beds' (the '*corona* facies' of Burgess and Holliday, 1979, p. 9) from his concept of the Dufton Shales. Nicholson and Marr (1891) used Swindale Beck as the type locality for their '*Corona* Series' although Harkness and Nicholson (1877) first applied the term *Discina corona* Bed' to strata in Pus Gill. Dean (1959a) summarized much of this early terminology, and it is clear that the Swindale Beck section has considerable historical significance.

Virtually all of the stages and substages known to be represented in the Dufton Shale Formation are present in Swindale Beck; only the Onnian Substage of the Streffordian Stage and the lower Cautleyan Stage are unrepresented. The extensive outcrop of Pusgillian strata in Swindale Beck is the source of the type material of several trilobite species (Dean, 1961a, 1962).

The Dufton Shale Formation is overlain unconformably by the Swindale Limestone of Dean (1959a) (=*Staurocephalus* Limestone of earlier authors), for which this is the type locality (Kneller *et al.,* 1994, p. 240). Elsewhere in the Cross Fell Inlier, the Swindale Limestone includes much mudstone, and accordingly Burgess and Wadge (1974) and Burgess and Holliday (1979) included the Swindale Limestone as a lower member of their 'Swindale Shales', which also included shales of latest Ordovician (Hirnantian) age that are seen only in Swindale Beck. Bassett *et al.* (1992, p. 121) argued that these upper shales are the direct equivalents of the Ashgill Formation of the Lake District (see the Ashgill Quarry site report) and that that term can be applied in Cross Fell. Kneller *et al.* (1994, p. 240) included the Swindale Limestone as a member of the Swindale Shale Formation in their appended list of retained lithostratigraphical names; however, in their text (1994, p. 229, fig. 5) they gave formation status to the Swindale Limestone and included it as such on their regional correlation diagram, along with the Ashgill Formation. The latter approach is also adopted here.

A schematic geological map of Swindale Beck was published by Dean (1959a, fig. 2). More detailed maps by Burgess and Wadge (1974, fig. 6) and Burgess and Holliday (1979, fig. 9) not only extend farther south than Dean's map but also differ in recognizing older parts of the Dufton Shales at the northern end of the section and identifying a stratigraphical rather than a faulted contact between the Marshbrookian and Actonian parts of that formation. Dean (1959a) and Burgess and Holliday (1979) included extensive, well-localized faunal lists from the section.

Description

Upper Ordovician rocks are exposed in a sequence of west–east fault-bounded strips crossing Swindale Beck, with the dip of the beds varying from 20–75° and the direction of dip varying from south-east (the dominant direction) to south-west (Figure 11.13). At the northern end of the site, tuffaceous sandy siltstones of the *corona* facies of Longvillian age (see the Harthwaite Sike site report) are faulted against rhyolites of the Borrowdale Volcanic Group. To the south, the *corona* facies is faulted against the best exposed and most fossiliferous Woolstonian (=Upper Longvillian of earlier authors) shales in the Cross Fell Inlier. These in turn are faulted against Marshbrookian mudstones with bands of impure nodular limestone, which pass up into blue-grey Actonian mudstones. The latter are the only rocks accepted to be of that

age in the Cross Fell Inlier (Dean, 1959a), although the palaeontological evidence for this age was considered tenuous by Burgess. and Holliday (1979). As noted by Dean (195?a), some of the beds in Swindale Beck considered by Bancroft (in Lamont, 1948) to be Actonian belong in the Marshbrookian and others in the Pusgillian. There is a second faulted strip of Marshbrookian beds between the Actonian and Pusgillian parts of the section. The extensive outcrops of Pusgillian beds comprise blue-grey mudrocks and impure limestones, and in their upper parts sandy shales of the Billy's Beck Member with upper Pusgillian faunas are developed. The Pusgillian beds and the unconformably overlying Swindale Limestone are, repeated by a strike fault.

The lithological change to the grey, nodular Swindale Limestone is abrupt, and only the faunal evidence indicates the extent of the unconformity. Burgess and Holliday (1979, p. 18) gave a composite section through the 18.7 m of the formation in Swindale Beck that includes 4.9 m of pale-grey mudstone with limestone nodules 1.8 m above the base. At the southern end of the section, the Swindale Limestone is faulted against silty mudstones of the Ashgill Formation, including slightly calcareous beds at the base.

Interpretation

The diverse, shelly faunas characterize, with varying degrees of certainty, the chronostratigraphical units represented by the Dufton Shale Formation and aid its correlation with sequences elsewhere. The Pusgillian rocks in particular yielded the type material of six trilobite species established by Dean (1959b, 1961a, 1962), including the type species of *Duftonia, D. lacunosa.* This species, together with two of the others, *Tretaspis convergens* Dean (now *T. hadelandica convergens*) and *Gravicalymene jugifera* Dean, and one subsequently synonymized with *Brongniartella sedgwicki* (Salter), have proved to be of great value for correlation of part of the succession in the Cautley and Dent districts.

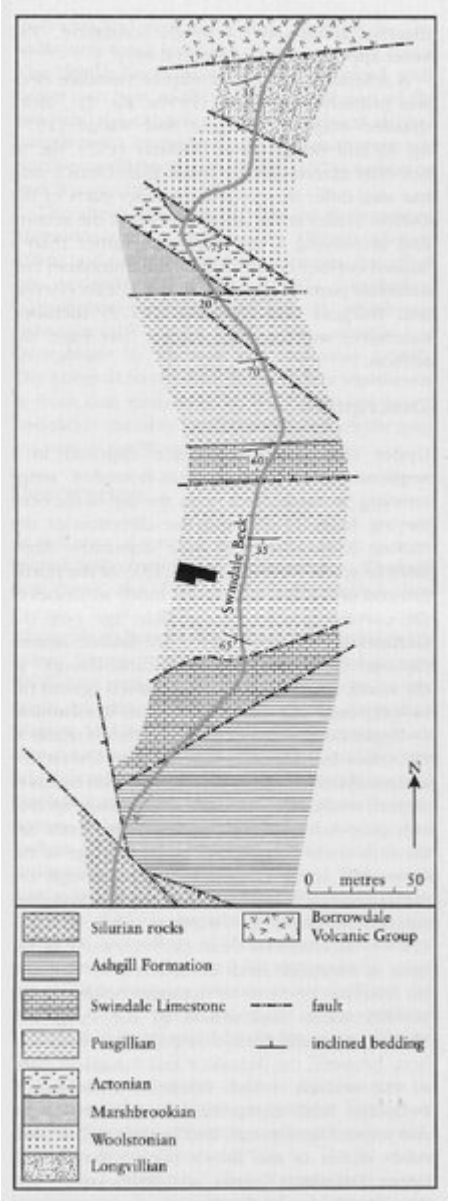
The Swindale Limestone overlies Pusgillian beds of the Dufton Shale Formation in Swindale Beck, whereas in Billy's Beck, 3 km to the southeast, it rests on lower Cautleyan strata, indicating a northward increase in depth of erosion beneath the unconformity (Burgess and Holliday, 1979, p. 18, fig. 12). The Swindale Limestone yields an abundant shelly fauna from decalcified limestones and from the associated mudstones. The age of the Swindale Limestone has been the subject of some debate. A mid-Rawtheyan age was suggested by Ingham (1966, 1977) and Ingham and McNamara (1978), but subsequently Price (1981) described *Tretaspis* cf. *radialis* Lamont from Swindale Beck and Billy's Beck and a new species, *T. caritus,* from Swindale Beck. These indicate a late Cautleyan to earliest Rawtheyan age, slightly older than had previously been thought. Fortey *et al.* (1995, p. 26) suggested that the base of the Rawtheyan Stage may eventually be defined within the Swindale Limestone, here or in Billy's Beck.

The slightly calcareous basal parts of the Ashgill Formation contain a fairly diverse *Hirnantia* brachiopod fauna and the trilobites *Mucronaspis mucronata* (Brongniart) and *M. olini* (Temple)? (Temple, 1952; Burgess and Holliday, 1979). These beds have yielded the conodonts *Amorphognathus ordovicicus* and *Hamarodus europaeus* (Orchard, 1980; Bergström and Orchard, 1985), and cystoids collected by Paul (1973–1997) may also be from here. Bassett *et al.* (1992, p. 121) noted the similarity of these beds to the basal part of the Ashgill Shale Formation elsewhere in northern England. The overlying shales contain a less diverse *Hirnantia* fauna.

Conclusions

Swindale Beck is nationally significant, being the best single site for understanding the later Ordovician history of northern England. It is the most complete representation of the Caradoc and Ashgill series in northern England, and its fossil faunas are critical for correlation with sequences elsewhere. It is the type locality for the Swindale Limestone, and the stratotype base of the Rawtheyan Stage may eventually be defined within the Swindale Limestone in Swindale Beck.

References



(Figure 11.13) Geological map showing the Dufton Shale Formation, Swindale Limestone and Ashgill Formation in Swindale Beck, Knock, based on Burgess and Wadge (1974, fig. 6).