Ashes Hollow–Devil's Mouth

[SO 435 930];[SO 440 942]

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Introduction

Ashes Hollow and Devil's Mouth, both of which fall within the existing Long Mynd SSSI, have been selected as GCR sites as they jointly provide a complete section through the sedimentary rocks representative of the lower part of the Longmyndian Stretton Group. The sections (Figure 5.9) record the transition from the marine environments that dominated the early period of Longmyndian sedimentation in the Stretton Shale and Burway formations, to the alluvial sequences that first appear in the overlying Synalds Formation. This progression is of great importance not only to late Precambrian sedimentology, but to studies of the environments that supported and preserved the fossil assemblage that is seen at this locality (Chapter 8).

The sequence of rocks approximating to the Burway Formation was first recognized by Blake (1890) as a 'Banded Series' within the Eastern Longmyndian. The boundaries of this subdivision have remained largely unchanged to the present day (Cobbold, 1900; Greig *et al.,* 1968; Pauley, 1986, 1990a,b), although the term 'Burway Group', first introduced by Lapworth and Watts (1910), has been superseded by its designation as a formation within the Stretton Group (Pauley, 1990b). The Burway Formation, which mainly consists of greenish grey sandstones and siltstones with subordinate mudstones has been variously considered as a deep-water marine 'geosynclinal' facies (Taylor, 1958) or a shallow water (possibly marine) clastic sequence (Greig *et al.,* 1968; Baker, 1973; Toghill, 1990). However, Pauley (1986, 1990b) has recently demonstrated a range of depositional environments within the formation, ranging from relatively deep-water marine mudstones and turbidites to shallow marine and fluvially-dominated deltaic sequences. It overlies the marine mudstones of the Stretton Shale Formation, the boundary being taken at the base of the Buxton Rock, a thin fine-grained tuff. However, the lithological transition does not always coincide with this tuff horizon, and it is common for the thinly laminated siltstone–mudstone facies of the Stretton Shale Formation to persist into the lower part of the Burway Formation. The top of the formation is taken at the top of the Cardingmill Grit, above which there is a generally sharp transition into the purplish red-brown mudstones of the Synalds Formation.

Description

The steep valley sides of Ashes Hollow provide a virtually complete section through the Burway Formation, largely undisturbed by faulting except in the upper part, and estimated here to be about 640 m thick. The beds generally dip steeply westwards at angles between 60° and 90° and also young to the west, as determined by sedimentary structures. The highest beds of the underlying Stretton Shale Formation, consisting of weathered, dark greenish grey, laminated mudstones, crop out by the footbridge next to the abandoned Ashes cottage ((Figure 5.9), Locality 1).

About 70 m north-west of Ashes cottage, a small quarry [SJ 4392 9267] (Locality 2) exposes the local equivalent of the Buxton Rock, the lowermost member of the Burway Formation. It comprises 4–5 m of a pale greenish grey, highly silicified, fine-grained tuff in beds 20–50 mm thick, but locally up to 0.1 m, with subordinate thin shaly mudstone partings. Thin sections show the tuff to be generally composed of a groundmass of clay minerals, chlorite, quartz and feldspar in which there are a few aggregates of albite feldspar or radially arranged chlorite, both possibly of authigenic origin, together with some small scattered feldspar pyroclasts; geochemical analyses indicate a rhyolitic composition (Greig *et al.,* 1968). The quarry face displays a small thrust duplex that has disrupted the tuff; but its gradational top is exposed in adjacent crags and characterized by alternations of thin (10–20 mm), porcellaneous tuff beds, shaly mudstones and siltstones.

The beds immediately overlying the Buxton Rock are dark greenish grey wispy-laminated mudstones and siltstones, about 15 m thick, similar to lithologies present in the underlying Stretton Shale Formation. Thin siltstone beds, up to 10 mm thick, occur at intervals, although there is little evidence of primary sedimentary structure other than lamination. These strata are overlain by a 150 m-thick sequence of rhythmically interbedded sandstones, siltstones and mudstones with subordinate, thinner packets of siltstone and mudstone (Locality 3). The lithologies are arranged in fining-upwards units, with a 10–20 mm-thick sandstone or coarse siltstone at the base; the latter, in some beds, is marked by poorly preserved sole structures. The sandstones are commonly parallel laminated, and current ripple marks are visible at the top of one or two beds, or as casts on the base of the succeeding bed. The overlying laminated siltstone component grades upwards into wispy laminated mudstones, comparable to those at the base of the formation and in the top of the underlying Stretton Shale Formation; the top of each unit is usually sharply overlain by the succeeding graded bed.

The sandstone beds rapidly increase in thickness and frequency about 250 m north-west of Ashes cottage (Locality 4), in the middle part of the Burway Formation. The succession here generally comprises bundles of thin- to thick-bedded, fine-grained lithic arenites, interbedded with subordinate thin beds of laminated siltstones and mudstones, well displayed in crags [SJ 4365 9288]–[SJ 4352 9294] along the sides of Ashes Hollow (Figure 5.10). As in the underlying succession, the lithologies are also arranged in fining-upward units. In some of these, the mudstone capping is represented by a thin parting, or is absent where sandstone beds are amalgamated. The sandstones, 20–30 mm thick, commonly show parallel bedding or lamination and some thicker beds are normally graded, but a substantial number appear structureless. The bases of many beds are characterized by a number of poorly preserved flute or groove casts and indeterminate sole markings, which are possibly load structures. At intervals within the sequence there are beds of massive to poorly bedded, fine-to medium-grained sandstones, commonly 3 m or more thick, with cuspate loaded bases ('dish structures') and, in a few places, irregular bed-forms resembling slumps.

About 550 m north-west of Ashes cottage, the sandstones give way rapidly upwards into a sequence of greenish grey colour-banded and sand-laminated siltstones and mudstones with beds of planar laminated and ripple cross-laminated sandstones up to 50 mm thick (Locality 5). A variety of delicate sedimentary structures is present in these rocks, including microfaults, small scours and graded bedding; comparable structures have been recorded from the area immediately to the north-east (Salter, 1857; Greig *et al.,* 1968). At intervals within the sequence there are fine- to medium-grained sandstones, locally parallel- and cross-laminated, occurring in amalgamated beds up to 3 m thick with thin mudstone partings. Four such beds have been previously worked from a small quarry on the north side of Ashes Hollow (Locality 6; see also (Figure 8.9)a). Here, unusual ring- or pit-like markings of possible organic origin are seen on bedding planes, and are described in Chapter 8 (Cope, this volume).

Beds of fine- to medium-grained, parallel- and cross-laminated sandstone, containing appreciable amounts of mica, appear towards the top of the succession. Up to 0.3 m thick, such beds are particularly noticeable in the crags of Devil's Mouth, north-east of Ashes Hollow (Locality 5a), interbedded with disrupted and possibly slumped siltstones containing small sandstone clasts. They are overlain by the Cardingmill Grit, the highest member of the Burway Formation, which is well exposed although much faulted in Ashes Hollow and at Devil's Mouth (Locality 7, 7a). The grit is a massive to fairly well-bedded, coarse-grained, lithic arenite about 30 m thick; it is commonly micaceous and pebbly in places, and contains a few thin siltstone beds, locally red-brown in colour. Bedding is commonly irregular, with a tendency to pinch and swell, and there is evidence of large-scale bedding cutouts and cross-bedding in the crags at Devil's Mouth.

The strata overlying the Cardingmill Grit are assigned to the Synalds Formation. These comprise a succession of alternating purplish red-brown siltstones and mudstones with subordinate, thinly bedded, purplish grey sandstones (Locality 8), comparable to those seen at The Pike GCR site. Although the predominant colour of the formation is red-brown, there are a few thin layers of greenish grey strata, and at Ashes Hollow a considerable thickness (up to 120 m) of greenish grey beds overlies the lowermost 60 m of red-brown strata (Locality 9). Features resembling rain imprints and pit-and-mound structures are visible on some surfaces, and a range of comparable subaerial or shallow-water sedimentary structures have also been recorded from the formation (Greig *et al.,* 1968). Similar structures in the underlying Burway Formation have now been largely accorded a biogenic origin (see Cope, Chapter 8, this volume) and in the light of this, the structures in the Synalds Formation may need reevaluation.

Interpretation

The lower part of the Burway Formation contains facies indicative of marine and turbiditic sedimentation (Taylor, 1958; Pauley, 1990b; cf. Greig *et al.,* 1968) within a sedimentary basin estimated to be about 700 m deep (Pauley, 1990a). The mudstones at the base of the formation represent a continuation of the basinal sedimentation that typified the deposition of the Stretton Shale Formation. These wispy-laminated sediments are comparable to hemipelagic sequences (Stow and Piper, 1984; Davies *et al.,* 1997), representing the terrigenous muddy background sediment of slope apron and turbidite systems, deposited on a basin-plain largely beyond the influence of current activity. The locally interbedded thin silt beds represent fine-grained turbidite flows (Stow and Piper, 1984).

The presence of an interbedded subaqueous tuff, the Buxton Rock, at the base of the Burway Formation, is an indicator of the sporadic volcanicity that accompanied sedimentation. Although this tuff is a significant marker horizon, it is debatable whether it represents an appropriate formational boundary as it does not coincide exactly with any major lithological change (cf. Greig *et al.,* 1968). Undoubtedly, the most important factor in its preservation has been its deposition within a hemipelagic facies, with vertical accretion as the most significant process and an absence of current winnowing. The Buxton Rock and other volcanic horizons within the Longmyndian succession have been used as evidence of continuing Uriconian volcanicity (e.g. Greig *et al.,* 1968; Pauley, 1990b). Baker (1973), however, considered that these discrete volcanic events were linked to fault movements not connected directly to Uriconian activity. Whatever the reason, it is possible that this volcanicity was more extensive than has been previously considered, in view of the low preservation potential of much of the Longmyndian succession.

The sandstones that appear in the Burway Formation a short distance above the Buxton Rock are interpreted as a turbiditic facies, each sandstone-siltstone-mudstone unit representing an individual turbidite flow, which deposited a fining-upward sequence as current velocity waned (Bouma, 1962; Walker, 1967; Pauley, 1990b). The types of sedimentary structure within both the thick- and thin-bedded turbidite units are similar, suggesting that broadly comparable types of flow deposited them; the thicker turbidite units are considered to represent flows of greater magnitude. There is, however, no corresponding increase in the coarseness of the sand fraction within these thicker flows, and the common occurrence of fine-grained sandstones suggests that all the turbidites were derived from a common source depleted in coarse material. The range of sedimentary structures within the turbidite units are typical of the complex sequence of divisions (T_{a-e}) found in classical Bouma-style turbidite units (Bouma, 1962) overlying a basal current-scoured surface with flute and groove casts. The normal grading displayed by a few sandstones represents the typical Bouma (T_a) division, recording relatively rapid deposition from a turbulent flow with an initial high coarse-fraction concentration. The structureless sandstones are somewhat different and may be compared to high-density flows in which sediment concentration and sediment support mechanisms, rather than fluid turbulence, was the more important factor in their transporta tion (Lowe, 1982). Deposition of these flows may have resulted from rapid 'freezing' of the flow at critical velocities.

Parallel lamination, representing the typical Bouma (T_b) division, is the commonest structure within the sandstones, indicating that the majority of flows were deposited by traction under upper stage, plane-bed, flow conditions (Bouma, 1962; Walker, 1967). Lower flow conditions as indicated by the ripple cross-laminated Bouma (T_e) division is only rarely developed, suggesting that reworking of the top of the flow by the tail of the turbidity current was limited. The overlying siltstone–mudstone units are-interpreted as Bouma (T_d) and (T_e) divisions respectively, which have been deposited from suspension. The wispy lamination within the mudstones is comparable to the hemipelagic sedimentation that characterizes the lowest part of the formation. The poor development locally of the Td and T_e divisions, and the amalgamation of some sandstone beds within the middle part of the formation, suggests that many flows approximate to top-cut-out flow units deposited by high-flow regime turbidity currents (Walker, 1967; Stow, 1986).

The thickly bedded, massive sandstones, found at intervals within the turbiditic sequence have been interpreted as channel fills (Pauley, 1990b). They do not appear to be adequately covered by the Bouma (1962) scheme, but may be comparable to the coarse-grained deposits described by Lowe (1982) and Davies *et al.* (1997). They appear to have been deposited from high-concentration turbidity currents, the dominantly structureless sandstone units recording rapid sediment fall-out from high-density suspension. The resultant loosely packed sediments were probably susceptible to post-depositional liquefaction and movement, as recorded by slumping and water expulsion features such as dish structures.

The thin-bedded sandstone turbidites, which alternate with units of hemipelagic mudstone, are considered to be a relatively distal facies deposited in an outer fan environment. The thick-bedded turbidites in the middle part of the Burway Formation are comparable to facies deposited in a mid-fan setting. The succession from laminated mudstones with thin fine-grained turbidites to an increasingly sandstone turbidite-dominated sequence in the middle part of the Burway Formation is probably the result of turbidite fan progradation (Walker, 1978). However, the lack of coarsening upwards and gradation between the thin- and thick-bedded turbidite sequences, and the absence of thickening-upward cycles within these facies, led Pauley (1990b) to suggest that the succession does not conform to the classical Walker (1978) model of fan progradation. He favoured instead their deposition as turbidite sheets supplied from multiple small sources rather than a single large system; these sources were considered to be channels on a prodelta slope (Pauley, 1990b).

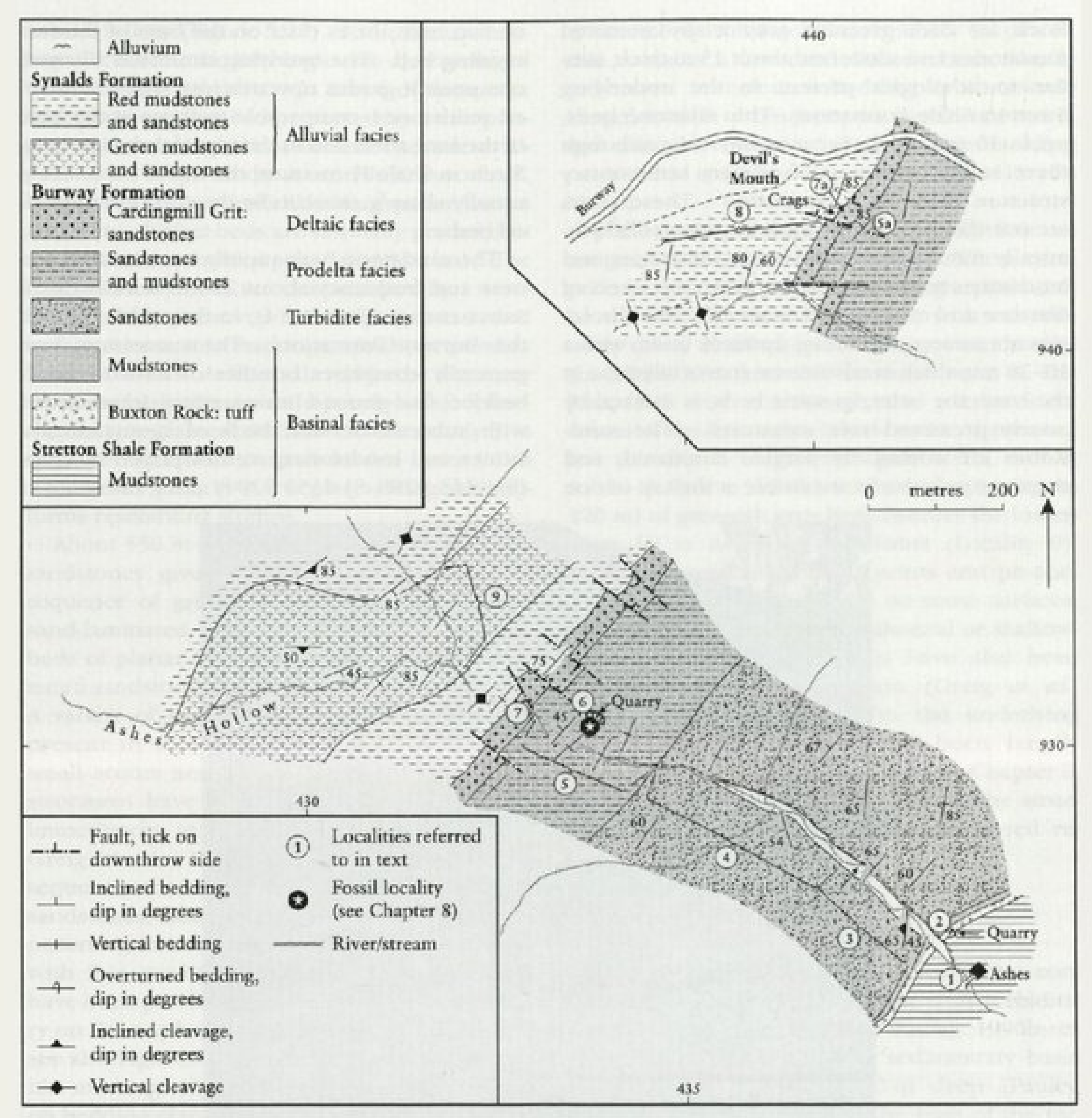
The siltstones and mudstones that succeed the turbidites of the Burway Formation have been interpreted as delta front and delta slope deposits, which were influenced by fluvially-generated bottom currents (Pauley, 1990b). The thicker sandstones that occur at intervals within the sequence may represent periodic delta advance. Progradation of the delta (the 'Cardingmill Delta' of Pauley, 1990b) is recorded by the increasing frequency and thickness of cross-laminated sandstones within the upper part of the formation, culminating in deposition of the Cardingmill Grit. The latter has been interpreted as a shallow marine deposit (Greig *et al.,* 1968), possibly a marine bar, although it was considered more likely to be a fluvial distributary channel fill of the delta by Pauley (1990b), from the absence of any wave-dominated sedimentary structures. Palaeocurrent evidence suggests that the distributary channels flowed in a general north-easterly direction.

The succeeding Synalds Formation, like that observed at The Pike and Long Batch GCR sites, shows a range of structures and facies indicative of the alluvial floodplain environments that prograded across the Cardingmill Delta.

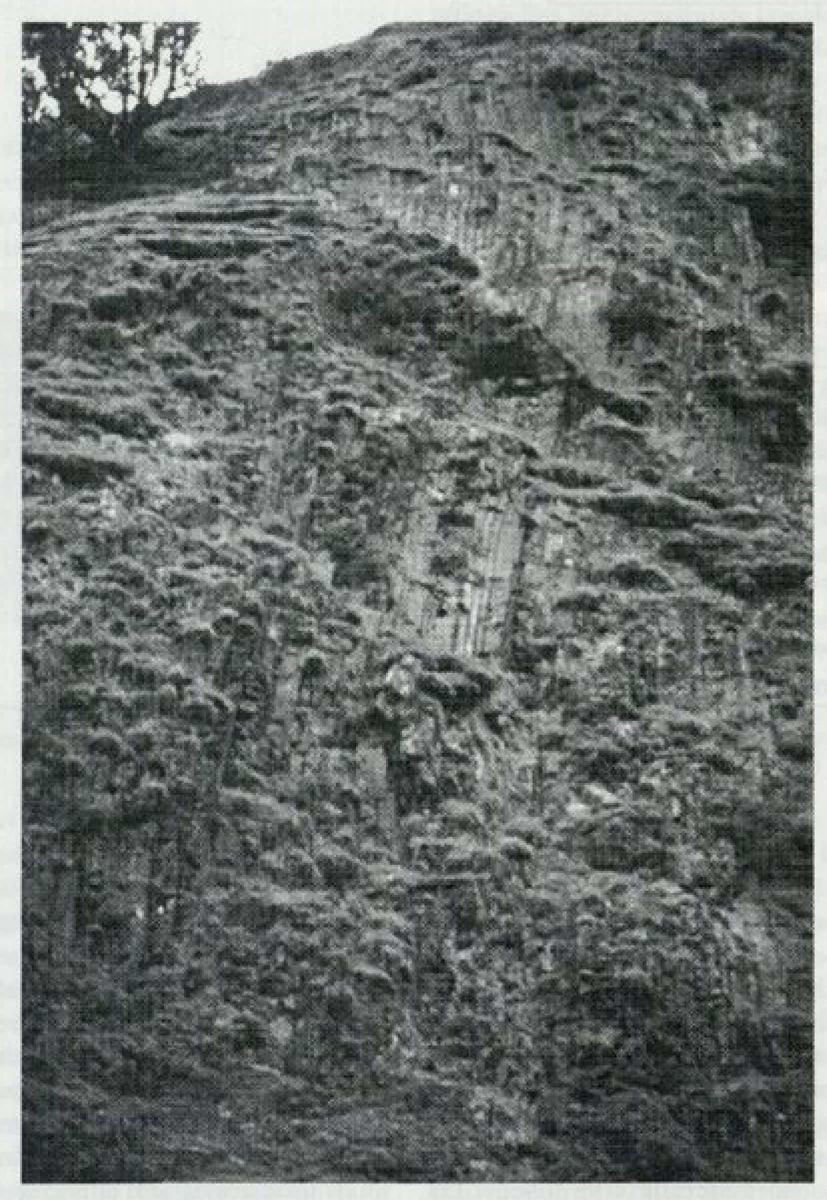
Conclusions

Ashes Hollow provides one of the most complete and well-exposed sections through the Burway Formation, and is highly instructive in showing the evolution of sedimentation within a diverse group of marine beds laid down in basin plain, turbiditic and deltaic environments. It is also one of the few places within the Longmyndian Supergroup that documents the progression from beds accumulated in deep marine environments to those characteristic of fluvial conditions, represented by the Synalds Formation. Not only do these exposures give insights into the early sedimentary history of the Longmyndian basin, but they also provide a palaeoenvironmental framework for the possible organic remains found in these beds (Chapter 8).

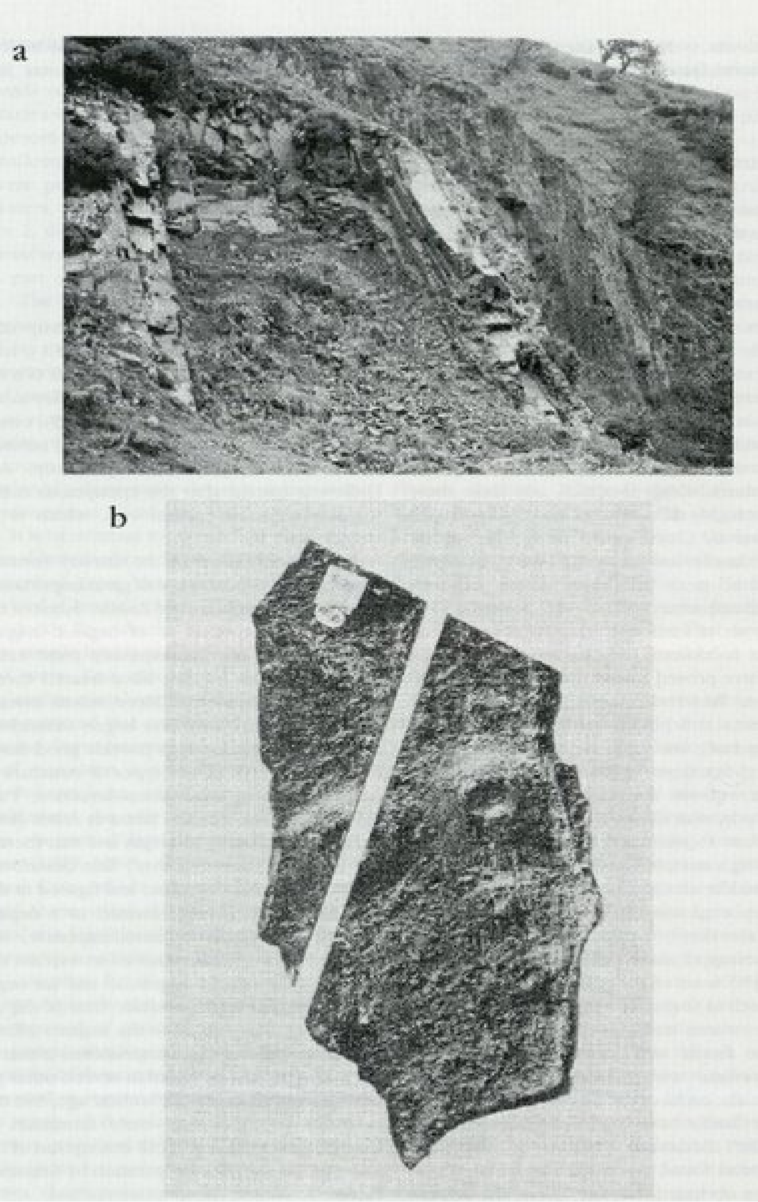
References



(Figure 5.9) Geological map of the Ashes Hollow and Devil's Mouth sites. The range of sedimentary environments in this part of the Stretton Group is indicated on the explanation at top left.



(Figure 5.10) Crags along Ashes Hollow showing vertical beds of rhythmically bedded, thick to thin-bedded tur-biditic sandstones and siltstones of the Burway Formation. (Photo: D. Wilson.)



(Figure 8.9) The fossiliferous locality at Ashes Hollow. (a) View of Ashes Hollow Quarry looking from the northwest. Note the near vertical dip of the beds, and the well-defined joint planes. The sandstone bed has been quarried in the foreground, leaving siltstones exposed at either side of the pit (Photo: J.C.W. Cope). (b) Specimen from Ashes Hollow, featuring probable organic unidentifiable `medusoid' impressions (Plate 5A of Greig et al., 1968).