Frodsham, Cheshire

[SJ 519 781]

Introduction

The Frodsham Soft Sandstone Member, a sequence of sandstones representing the upper part of the Helsby Sandstone Formation, is well exposed at its type locality at Frodsham. Sedimentary structures include large-scale cross-bedding, interpreted as having formed in large dome-shaped and transverse aeolian dunes. Foreset orientations indicate that the contemporary winds blew from the east and south-east. At Pinmill Brow, part of the GCR site, the aeolian dunes are overlain by the Tarporley Siltstone Formation (basal Mercia Mudstone Group), which had a strikingly different, marine intertidal and fluvial origin.

The site has been described by Hull (1860), Thompson (1969, 1970a,b, 1985, 1991), Mader and Yardley (1985), and Macchi and Meadows (1987).

Description

Frodsham lies in the north-west margin of the Cheshire Basin in a series of NNW fault-bounded structures termed the Wigan-Warrington half-graben system' by Macchi and Meadows (1987). This system is continuous with the large East Irish Sea Basin to the north-west that contains the hydrocarbon fields of Morecambe Bay and the Liverpool Bay Complex.

The best exposures are in the railway cutting at Frodsham, the type locality of the Frodsham Soft Sandstone Member, the uppermost division of the Helsby Sandstone Formation, and locally representing the top of the Sherwood Sandstone Group (Figure 3.19). Access to the railway is restricted, but good views of the spectacular cross-stratified sandstones (Figure 3.36)a are available from the footbridge [SJ 519 779] and part of the section can be examined in the car park adjacent to Frodsham railway station.

The sandstones at Frodsham are some 55 m thick. Thompson (1969) noted four lithofacies: interbedded red mudstone and chocolate-red, laminated shale, mudstone and siltstone; interbedded chocolate shale and fine-grained, argillaceous, flat-bedded, ripple-bedded, and cross-bedded sandstone; foxy-red, cross-bedded, fine-grained sandstone in sets commonly less than 1.5 m thick; and a similar sandstone, but cross-bedded in very large sets with very long laminated foresets. Sedimentary structures include cross-stratification, contorted beds, intraset cross ripples, and straight and concave-upwards foresets.

Thompson (1969) identified eight separate cross-stratified dune sets at Frodsham, of which three (Numbers 2–4) occur in the railway cutting (Figure 3.37). These show large- to very large-scale planar-tabular foresets (height up to 10 m or more), with mainly straight, but sometimes slightly curved (both convex-up and convex-down), laminae. Occasionally, asymmetrically infilled trough sets, and rarely wedge-shaped sets, also occur. The foresets are mainly composed of grainfall laminae with minor amounts of grainflow strata and contain internal erosion surfaces of relaxation type. Low-angle to horizontal sheet sands, mainly comprising climbing ripple cross-laminae, are rarely intercalated between the foresets. The erosional boundaries between cosets are horizontal, or slightly scoop-or trough-shaped, or occasionally wavy and irregular.

The main dune at Frodsham (No. 3) can be traced laterally for almost 500 m (Figure 3.37). A key feature of this dune is the upper bounding surface, which is convex-upwards (Figure 3.37)b. In addition, many of the smaller-scale bedforms show convex-upwards stratification surfaces and there is a general absence of discrete grainflow laminations.

The Frodsham dune deposits can be seen elsewhere in and around Frodsham, most notably on Main Street [SJ 518 780], [SJ 519 781]; (Figure 3.38)), and around St Luke's Rectory [SJ 519 781]. At Pinmill Brow [SJ 518 774], there is a small exposure that shows the overlying Tarporley Siltstone Formation (Thompson, 1991).

Interpretation

The Frodsham Soft Sandstone Member is almost entirely aeolian in origin, and the cross-stratification indicates that the unit is built up from sands deposited by straight-crested transverse dunes in a fluctuating wind system. The transverse dunes in places evolved into dome-shaped dunes during degradation by strong winds. Thompson (1969) suggested that the main cross-stratified set (No. 3) represents a dome-shaped dune (Figure 3.37)b because of the convex-upwards upper bounding surface, the convex-upwards stratification surfaces in many of the smaller-scale bedforms, and the general absence of discrete grainflow laminations, a feature that suggests that avalanche slip faces were rare.

There is some evidence for simple migration of large dunes or draas, but in most cases such migration was interrupted. The isolated to abundant intrasets of relaxation type reflect repeated to persistent interruption of migration by modification events that created minor erosional boundaries, and subsequent migration of superimposed smaller bedforms along or around the draa. Palaeowind directions measured from the dip directions of cross-stratal surfaces are consistently from the east, although minor variations between north-east and southeast occur between the different dune units.

Counterdipping intrasets record some crosswinds blowing along or across the foreset slope.

The dunes were also modified by blowout and erosional processes. In the upper parts of the exposed sequence, large troughs, frequently infilled by migrating sinuous-crested transverse bedforms, attest to dune-top blowout (the loss of sand from the top of a dune structure by a sudden burst of wind). Elsewhere, lower bounding surfaces of dune sets show that subsequent dunes cut down into pre-existing bed-forms, destroying the upper parts of the cross-stratification, and reworking the sand.

Occasional intercalations of thin sand sheets show that there were narrow, dry interdune corridors. Occasional small-scale slump structures on foreset laminae, which occur between undisturbed foresets, might indicate movement of animals 'along or across the damp surface of a lee-side slope of the dune' (Mader and Yardley, 1985, p. 173). The generally dry conditions were interrupted by rare, heavy rainfall events, which caused ephemeral floods. Water rushed through the interdune corridors, creating gullies. However, water clearly drained away rapidly into the porous sand, and arid conditions prevailed for most of the time.

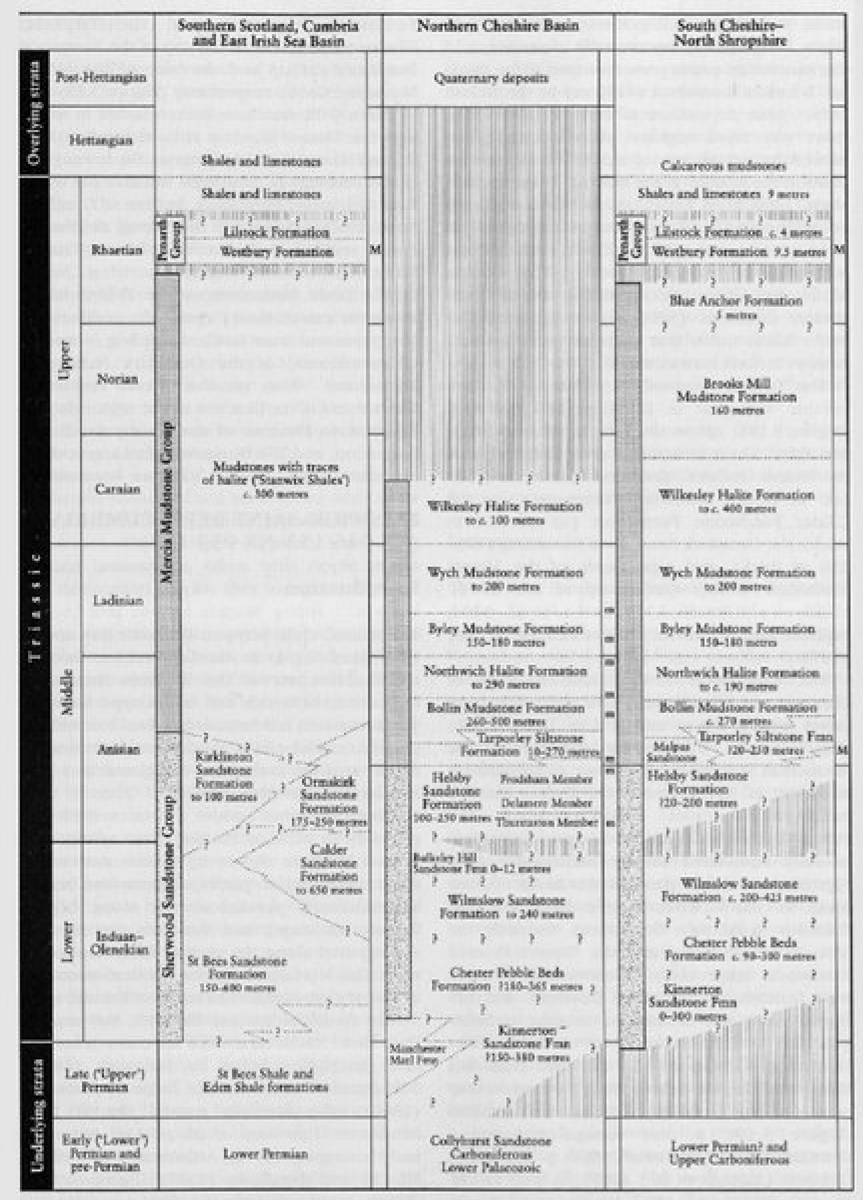
Thompson (1969) related the history of dune development at Frodsham to changes in wind speed. During periods of moderate breezes, sand from dried-out river courses was built into embryonic transverse dunes, which reached considerable heights. The onset of periods of strong breeze and moderate gales degraded the transverse dunes into dome-shaped mounds by stripping off the upper portions. When average winds abated to moderate and fresh breezes, steep foresets built up and transverse dunes developed again.

The Frodsham Soft Sandstone Member documents the end of aeolian deposition in the Cheshire Basin. During the Early Triassic Epoch, dunes formed between river channels over much of the Cheshire Basin, and the Frodsham aeolian unit is one of the last expressions of this desert in Mid Triassic (Anisian) times. Following this, a marine transgression ushered in dominantly intertidal and lacustrine deposition of the Mercia Mudstone Group.

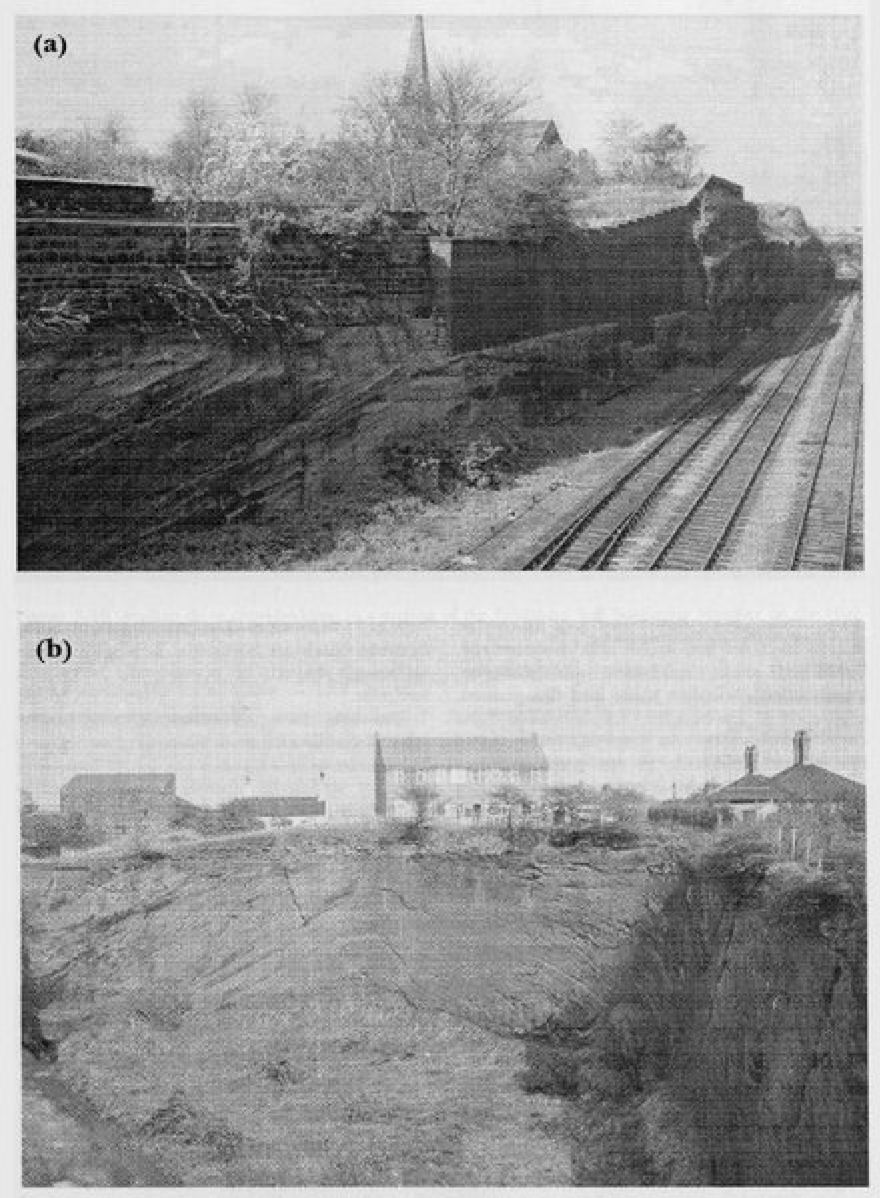
Conclusions

The Frodsham railway cutting displays an excellent section through the Frodsham Soft Sandstone Member, for which this is the type location. The exposures show the internal structure of a huge dune, some 500 m long, as well as associated, smaller, dunes. This is a classic site for the study of aeolian sedimentology, and for understanding British Mid Triassic palaeoenvironments and palaeogeography, especially the major transition from arid inland sand sea deposition, shown here, to marine intertidal and lacustrine conditions in the succeeding Mercia Mudstone Group.

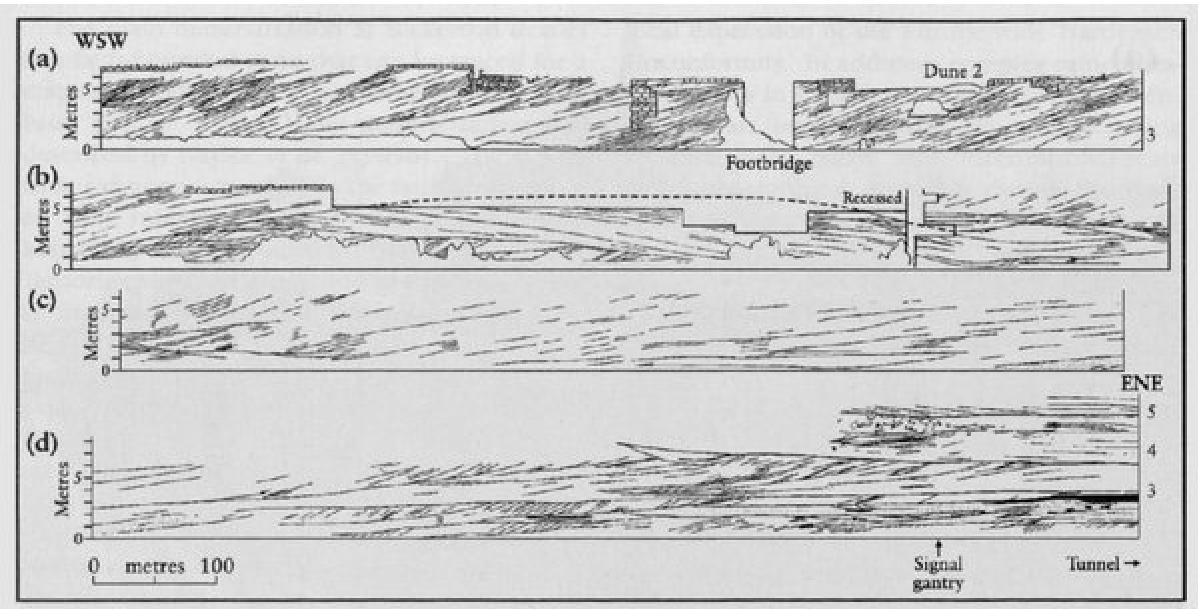
References



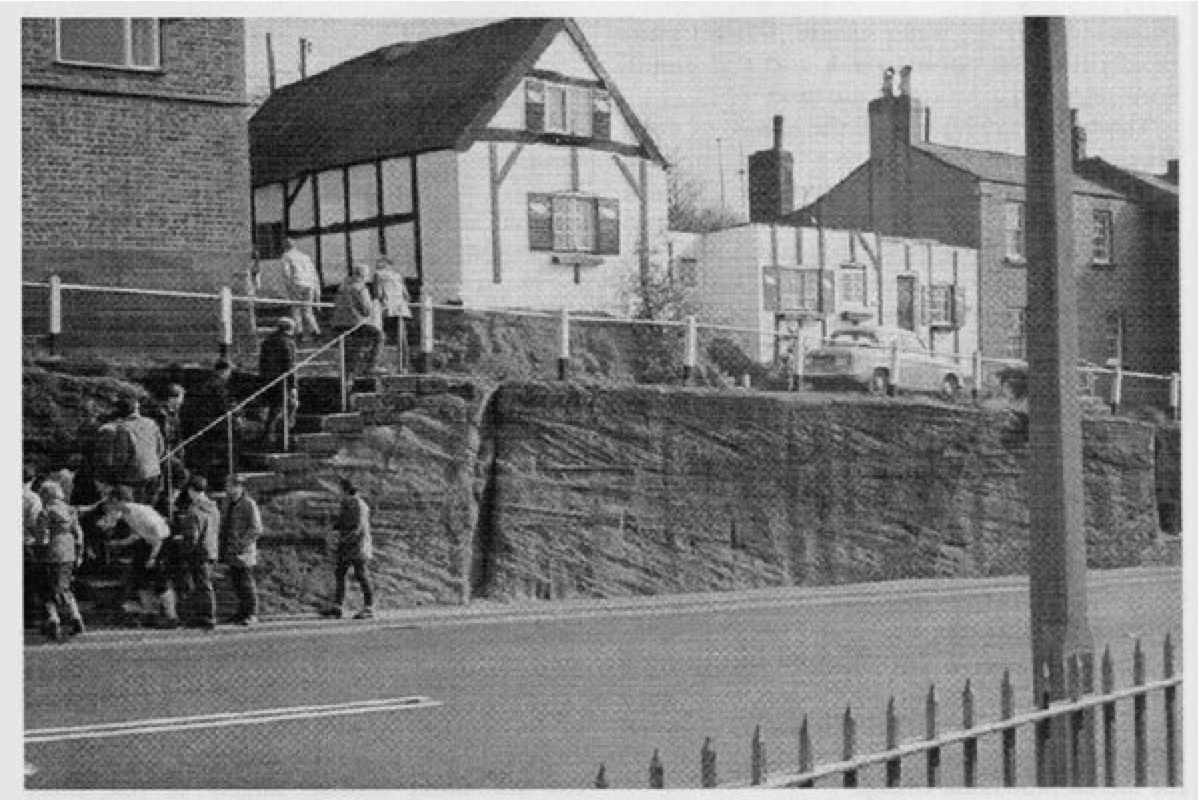
(Figure 3.19) Stratigraphical columns for the Triassic successions of southern Scotland and Cumbria, and the East Irish Sea and Cheshire Basin areas. M, macrofossils; m, microfossils. Based on Warrington et al. (1980), Jackson et al. (1987), Wilson (1993) and Ivimey-Cook et al. (1995), Jackson and Johnson (1996), Akhurst et al. (1997) and Warrington (199713).



(Figure 3.36) The Frodsham site displays (a) aeolian dune cross-bedding in the railway cutting and (b) a spectacular dome-shaped structure in an adjacent quarry (Photos: D.B. Thompson.)



(Figure 3.37) Sections through the aeolian Frodsham Soft Sandstone Member on the north side of the railway cutting at Frodsham. Sections (a) to (d) fit together as a continuous strip running from WSW (a) to ENE (d). These diagrams show the main dune (No. 3) throughout, while dunes No. 4 and No. 5 appear at the right-hand end of strip (d). Joints are omitted. (After Thompson, 1969.)



(Figure 3.38) Aeolian dune cross-bedding in a section of the Frodsham Soft Sandstone Member on the High Street of Frodsham village. (Photo: D. B. Thompson.)