Crime Rigg Quarry, County Durham

[NZ 344 416]

Introduction

Crime Rigg Quarry exposes an excellent section through the Yellow Sands Formation and the overlying Marl Slate and Raisby Formation (Tower Magnesian Limestone'). Large faces in the quarry show the Yellow Sands with typical complex interdigitating cross-bedding. The unit has been interpreted as deposits of seif dunes that were aligned NE–SW, parallel to the dominant wind direction. The crests of these dunes show soft-sediment deformation structures comparable with those in the Weissliegendes of Germany and the southern North Sea.

The Yellow Sands of Durham have been described by Lebour (1902), Versey (1925), Hodge (1932), Shotton (1956), Raymond (1961), Smith and Francis (1967), Pryor (1971), Smith (1974, 1979, 1994, 1995), Kent (1975), Turner *et al.* (1978), Bell *et al.* (1979), Steele (1983), Mader and Yardley (1985), Smith *et al.* (1986), Clemmensen (1989), Price (1996), and Turner and Smith (1997); these authors describe aspects of the geology of Crime Rigg and the neighbouring Sherburn Hill quarries.

Description

Crime Rigg Quarry is currently worked for the Yellow Sands and for dolomites of the Raisby Formation (Tower Magnesian Limestone'). The site is part of the Crime Rigg Quarry and Sherburn Hill Quarries Site of Special Scientific Interest (SSSI). The quarry is situated between the villages of Sherburn Hill and Shadforth, and contains unvegetated quarry faces cut into the Yellow Sands, Marl Slate, and Raisby Formation (Figure 2.13).

A summary section at Crime Rigg Quarry, based on an unpublished Regionally Important Geoligical/Geomorphological Site (RIGS) report, is given below:

	Thickness (m)
Superficial deposits	
Dark carbonaceous soil	0.60
Pale brown calcareous soil with round grit fragments	0.40
Don Group: *Raisby Formation* (Tower Magnesian Limestone')	
Thickly bedded (0.2–0.3m), massive silty dolomite, gradually becoming more dolomitic upwards	10.8
Silty dolomite, with vugs	~8
Don Group: Marl Slate	
Thin-bedded, blocky, fissile sandstone, weathering pale yellow and with many dolomitic, faintly laminated concretions along the bedding planes	1.8
Dark grey and carbonaceous laminated flaggy siltstone	0.05
Brown mudstone, with the texture of fudge	0.14
Yellow Sands Formation	
Cemented sandstones	1.1
Dune bedded sandstone, with large-scale cross-bedding	~25

The base of the Permian succession here is marked by the Yellow Sands Formation, which rests unconformably on Coal Measures (Figure 2.14)a. Offshore, a 1–2 m unit of sandstone, siltstone and mudstone lies beneath the Yellow Sands, but this has not been detected onshore (Turner and Smith, 1997). The Yellow Sands are up to 68.7 m thick (Smith, 1994), and comprise well-sorted, medium- to fine-grained, unconsolidated sands, with generally well-rounded grains and occasional angular and subangular clasts, and large-scale cross-bedding. At outcrop, the sandstones are yellow, although unweathered samples collected from boreholes may be bluish, greenish, or grey. Petrographical analysis of the Yellow Sands from nearby Sherburn Hill Sand Pit [NZ 343 417] shows that the majority of the clasts consist of quartz, with small amounts of feldspar (including orthoclase and microcline), lithic fragments (including chert and sandstone), and rare clay clasts (Pryor, 1971); frosted grains are common. Generally the sandstones are poorly cemented, although the top metre or so is strongly cemented by sparry calcite, and dolomite may be present in lower beds (Pryor, 1971). In places, the interaction between the carbonate cement and sediment produces small spherical concretions (Smith and Francis, 1967). Mineral overgrowths of secondary quartz, carbonate minerals, and clays are commonly observed on many of the clasts.

Steele (1983) subdivided the Yellow Sands into three units, of which only the middle one is seen at Crime Rigg. The lower unit, up to 3 m thick, is characterized by gently dipping and flat-lying sand beds, with wind-ripple and sand-sheet laminations. The middle unit is dominated by large-scale trough cross-bedding in sets typically 4 to 6 m thick, but up to 11 m, and up to 60 m wide (Figure 2.13)b and (Figure 2.14)b. The sets are divided by clearly defined bounding surfaces; a first-order horizontal bounding surface occurs at the base of the section, and common second-order bounding surfaces, typically low- to medium-angle, curved and straight surfaces, are present (Pryor, 1971). Smaller-scale sedimentary structures preserved within the cross-bedded units are wind-ripple, sandflow, and grainfall laminations. Of minor importance are flat-laminated sands. The upper unit is characterized by planar bedding with wind-ripple and sand-sheet lamination. The top of the Yellow Sands is marked by a thin bed of bioturbated fossiliferous sand with a maximum thickness of 0.3 m.

The cross-bedded sets immediately below the Marl Slate are covered by a thin layer of reworked aeolian sand that may display surface-parallel laminations. Small-scale deformation structures are scattered throughout the Yellow Sand sequence; they are generally found towards the top of the aeolian units and are associated with inclined beds located close to the dune axis (Glennie and Buller, 1983).

The overlying Marl Slate is the basal unit of the Zechstein succession (Smith *et al.,* 1986), and there is a well-marked boundary. The Marl Slate is a thin deposit, consisting of laminated, grey ferroan dolomicrite and black or brown bitumen, with some discontinuous bands of siltstone and sandstone, especially near the base (Smith and Francis, 1967). The unit becomes progressively paler upwards as the bitumen content decreases, and crystalline dolomite and rarer calcite occur in thin laminae. At Sherburn Hill Sand Pit the relationship between the Yellow Sands and the Marl Slate is clearly seen. Here, the latter ranges in thickness from 1 and 4 m (Pryor, 1971), commonly infills the hollows in the upper surface of the Yellow Sands, and is absent or thins out on the tops of ridges on that surface.

The Yellow Sands have not yielded many fossils, although isolated *Lingula* valves are known from the thin, bioturbated sandstone bed at the top of the unit, presumably introduced through burrowing from the overlying Marl Slate (Steele, 1983).

Interpretation

The Yellow Sands are thought to represent large-scale seif dunes; the overlying Marl Slate was deposited under predominantly marine conditions, and represents the beginning of the Zechstein transgression.

Although it is now widely accepted that the Yellow Sands are a product of aeolian processes, there has been some debate concerning their origin (Turner, 1980). Early interpretations supported the aeolian theory (for example Dalglish and Forster, 1864; Versey, 1925; Hodge, 1932). More recent analyses of the petrography and geometry of the sandstone units suggested a shallow marine origin. Pryor (1971) considered that the texture of the sandstones, the presence of angular clasts, etched and pitted surfaces, and overgrowths of various clay minerals, as well as carbonates and silica, were evidence against an aeolian mode of deposition. He interpreted the Yellow Sands as deposits of submarine tidal current ridges, but subsequent workers have strongly favoured an interpretation of aeolian deposition.

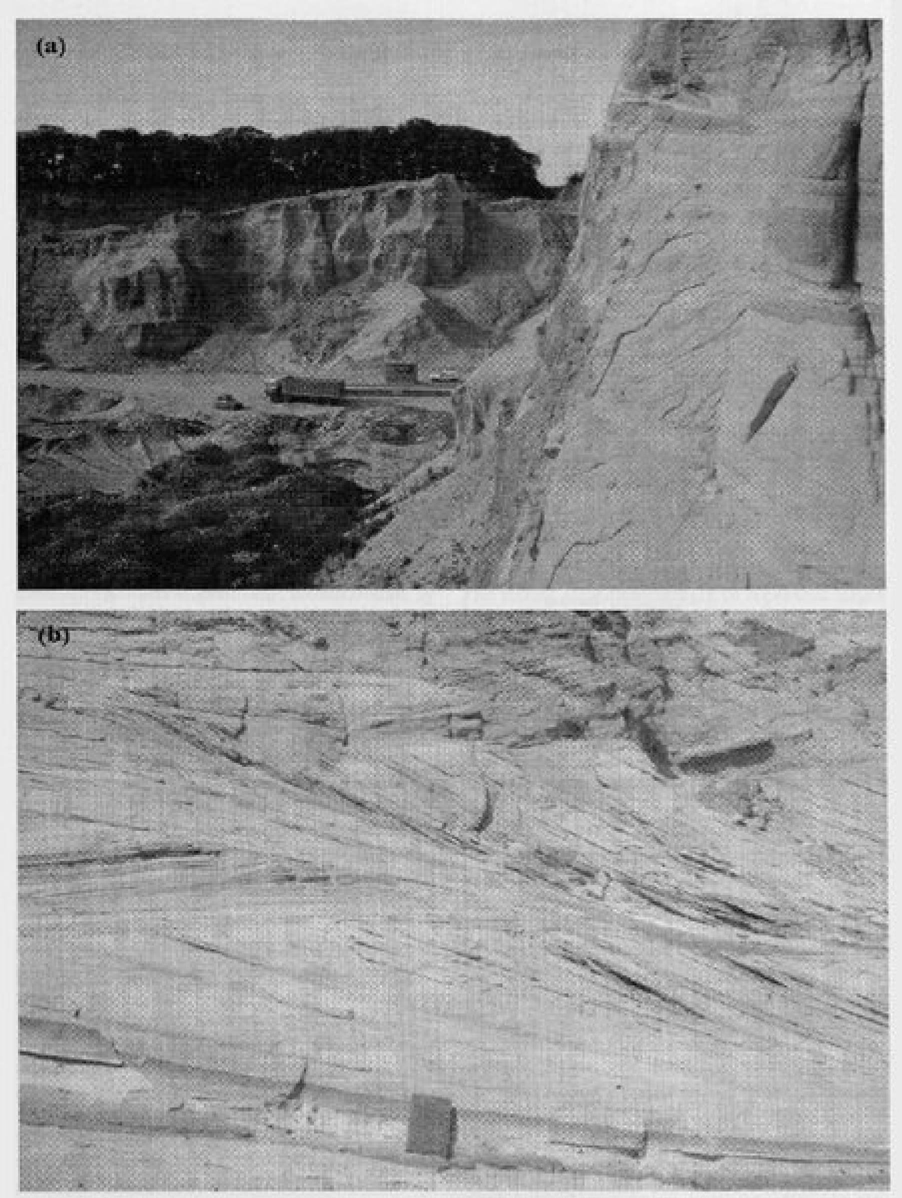
The dunes in the Yellow Sands have been interpreted as longitudinal draa dunes (Steele, 1983), longitudinal seif dunes (Glennie and Buller, 1983), or complex linear features (Clemmensen, 1989). Steele (1983) and Clemmensen (1989) showed that the Yellow Sands in north-east England form nine huge elongate linear features, 20 m thick, 1.5 to 3.5 km wide and more than 13 km long, that are separated by interdune corridors 0.8 to 2 km wide (Figure 2.15). Clemmensen (1989) identified the flat-bedded sands as interdraa and draa plinth deposits in the draa ridges. The interdraa deposits are generally the most coarse-grained, and they are gradationally overlain by low-angle draa plinth deposits. The contact between draa plinth and overlying trough-cross-bedded draa centre deposits is frequently gradational, but can also be characterized by deep aeolian scours. Each draa ridge contains two interdraa–draa plinth–draa centre units, which record an early phase of lateral migration of the draa field followed by a second phase of vertical accretion (Figure 2.16). During the lateral migration phase, the draa–interdraa systems, some 3.1 km across on average, migrated broadly towards the south-east. This movement generated a sequence of basal interdraa, middle draa plinth, and upper draa centre deposits over a basal erosion surface (seen as a first-order bounding surface). Because of lateral migration, only one flank of the draa is preserved. During the vertical accretion phase, additional trough–cross-bedded deposits were formed by the continued down-draa migration of superimposed linear dunes. The migration direction, parallel to the draa ridges, was roughly south-west (Figure 2.15) and (Figure 2.16). Finally, the draa ridges were eroded to some extent, and then covered by sand sheet deposits.

It is worth noting some aspects of the Marl Slate, which immediately overlies the Yellow Sands at Crime Rigg Quarry, since there are possible interactions between the two. The Zechstein Sea probably transgressed rapidly (Smith, 1970, 1979, 1995). The evidence for this rapid inundation comes from the similarity between the lithologies and faunal assemblages on both the topographical highs and lows preserved on the underlying Yellow Sands, although the Marl Slate is generally thinner on the highs than in the lows. Even though the transgression may have been rapid, it did not cause dramatic erosion: the unconsolidated dunes of the underlying Yellow Sands were not destroyed by the encroaching water (Smith, 1979; Steele, 1983), and only a thin layer of reworked sand has been found associated with the sand dunes (Glennie and Buller, 1983). The complex sedimentary structures of the soft and porous Yellow Sands were not destroyed because of the presence of infiltrated clays within the pore spaces between sand grains (Price, 1996).

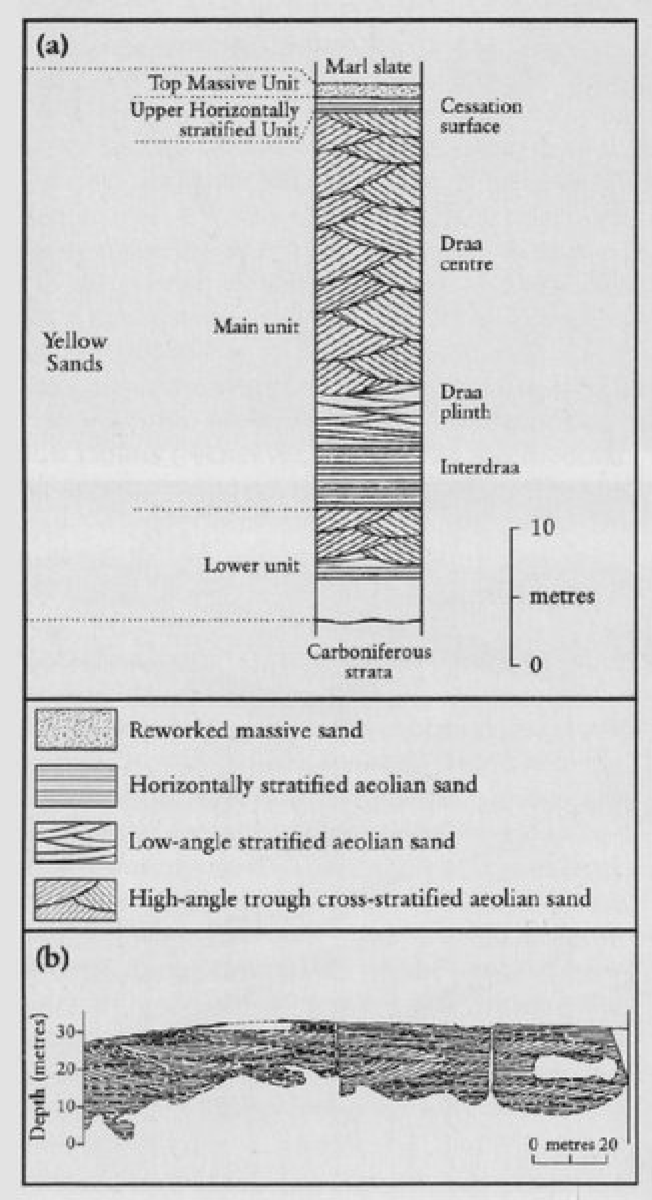
Conclusions

The sediments exposed in Crime Rigg Quarry and the adjacent Sherburn Hill Sand Pit are of Permian age. At the base of the sections the desert sand dunes of the Yellow Sands Formation are clearly exposed. Overlying this unit is the Marl Slate, a marine deposit which infills depressions in the upper surface of the Yellow Sands. The Marl Slate marks the beginning of the inundation of the region by the Zechstein Sea, and the continuation of marine conditions is indicated by the succeeding Raisby Formation (lower Magnesian Limestone'). This locality is of regional, national, and international importance for illustrating the end of continental red-bed conditions and the onset of the Zechstein transgression.

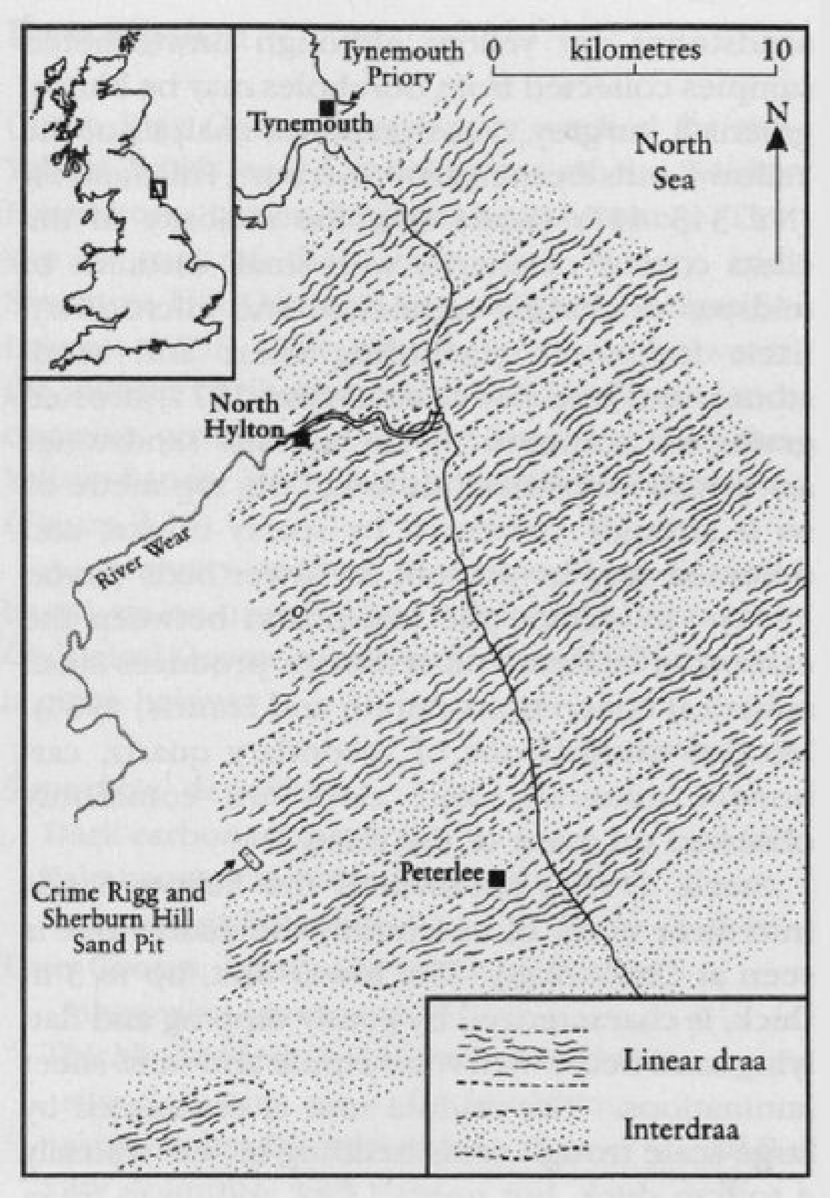
References



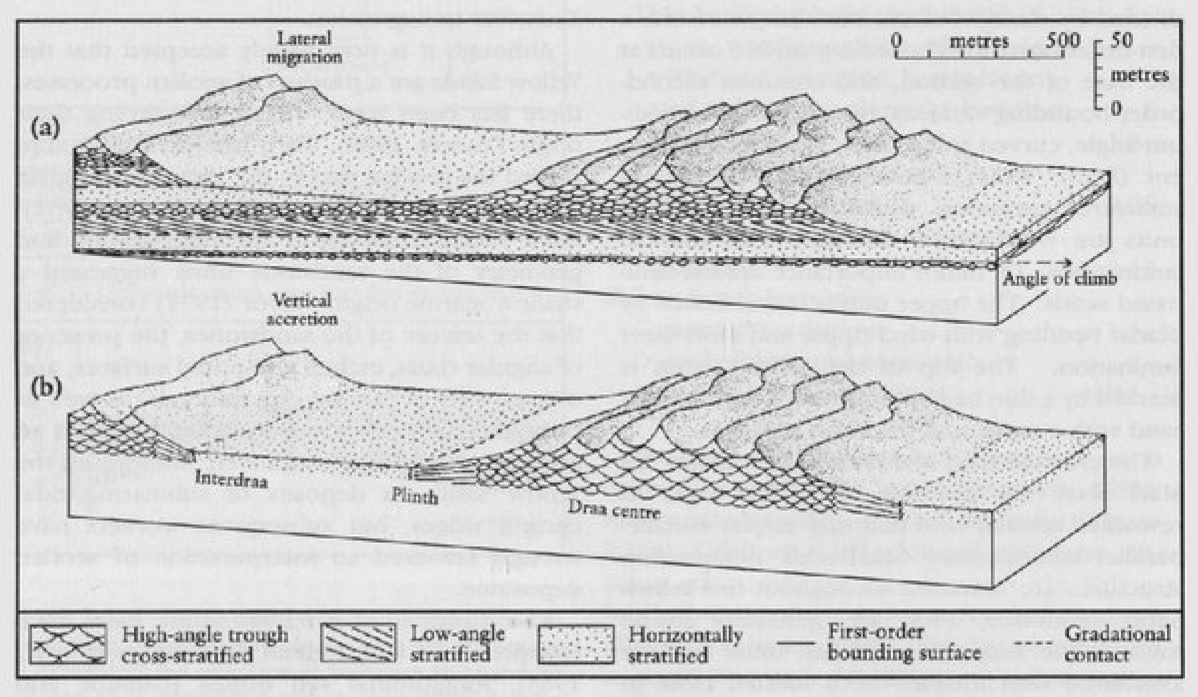
(Figure 2.13) The sequence of the Yellow Sands and overlying Zechstein deposits in the western part of Sherburn Hill Sand Pit, Crime Rigg. (a) General overview and (b) close up. The face in (b) shows a transverse section through a linear mound or draa. Foresets dip to the left and right, and there are numerous third-order bounding surfaces. Exposed thickness of the Yellow Sands here is about 25 m. (Photo: L. B. Clenunensen.)



(Figure 2.14) Sedimentology of the Yellow Sands at Crime Rigg. (a) Summary log through the sequence; (b) drawing of the west face at Sherburn Hill Sand Pit [NZ 344 417], showing a trough-cross-bedded dune set, with part of the face (from 0 to 50 m) transverse to the palaeocurrent, and the other part (from 60 to 140 m) sub-parallel to the palaeocurrent. (From Clemmensen, 1989).



(Figure 2.15) Palaeogeographical map of north-east England during the time of deposition of the Yellow Sands, showing the position of the nine major SW–NE-trending draa ridges. These ridges are wider and more closely spaced than in modern examples of parallel draa ridges, possibly because of the coarse-grain size of the Yellow Sands. (Based on Steele, 1983; and Clemmensen, 1989.)



(Figure 2.16) Proposed structure of the Yellow Sands draas and dunes, showing two stages in their evolution, (a) initial lateral migration, followed by (b) vertical accretion. The vertical scale is exaggerated for illustrative purposes. (After Clemmensen, 1989).