Locharbriggs North Quarry, Dumfries and Galloway

[NX 990 810]

Introduction

The three quarries at Locharbriggs expose an excellent section through lower Permian sediments. Locharbriggs North Quarry is the type locality for the Locharbriggs Sandstone Formation. The 20 m-thick sedimentary sequence is dominated by well-sorted fine- to medium-grained sandstones. Sedimentary structures such as large-scale cross-bedding are well preserved at this site. The sediments have been interpreted as having formed in a substantial dune field. A number of hierarchical bounding surfaces are identified between the individual dune sets and indicate the migration of predominantly transverse dunes over larger-scale bed forms (draas). This is a key site for the understanding of Permian palaeoenvironments, and a classic location for aeolian sedimentology.

The Locharbriggs Permian succession has been described by Harkness (1850), Cameron Smith (1925), Mykura (1965), Brookfield (1977, 1978, 1980, 2000), and Stone (1996).

Description

The Locharbriggs quarries are located 5 km to the north-east of Dumfries, just north of the village of Heathall, in the north-eastern corner of the Dumfries Basin (Figure 2.11)a. The three quarries are aligned from north-west to southeast (Figure 2.11)b: the northern one is Knowehead Quarry [NX 988 814], the middle one is Locharbriggs North Quarry [NX 990 810], and the southern one is Locharbriggs South Quarry [NX 992 808]. The southern quarry is still being worked, and produces building and ornamental stone (Stone, 1996). Locharbriggs North Quarry is selected as the GCR site.

Smith *et al.* (1974) termed the sequence at Locharbriggs the 'Dumfries Sandstone'. However, Brookfield (1978) noted that the sediments in the vicinity of Dumfries consist predominantly of coarser-grained breccias, conglomerates, and sandstones, and that the term 'Dumfries Sandstone' had already been applied to a different stratigraphical unit (Horne and Gregory, 1916). He introduced the formal term, 'Locharbriggs Sandstone Formation', for the unit at this site.

Sedimentology

The sediments exposed in the Locharbriggs quarries belong to the middle part of the Locharbriggs Sandstone Formation, which extends over much of the northern and eastern regions of the Dumfries Basin. The sediments consist of medium- and fine-grained, unimodal or polymodal sandstones (Brookfield, 1977, 1978, 1979, 2000). Grain sorting within individual beds is good, but grain size varies between beds, and clasts on the erosion surfaces tend to be slightly coarser grained. Clasts, dominated by quartz, within the finer-grained beds are generally subangular and those in the coarser-grained beds are very well rounded. Smaller grains are mainly quartz, although a small proportion are composed of highly altered feldspar and lithic fragments, including basalt and cemented siltstones. Frosted grains are present, although the original surface textures are frequently obscured by diagenetic quartz overgrowths (Brookfield, 1979). The rock is cemented by silica and contains iron oxide, which gives the sediments a rich red colour.

The sandstones show well-developed cross-beds, which generally have a concave-up form, and occur in planar and wedge-shaped sets from 0.5 to 2.0 m thick (Figure 2.11)c. Individual beds are 0.1 to 10 m thick, and dip at angles between 10 and 30° to the south-west. Trough cross-bedding is apparent in lower parts of the sequence, but it is rare higher up.

Bounding surfaces are common and clearly defined in the quarry faces; three orders have been recognized (Figure 2.11))c and (Figure 2.12). The first-order surfaces can be traced across many quarry faces, and typically dip south-west at angles of 13° to 15°. These were formed as sub-horizontal surfaces. The second-order bounding surfaces are sub-parallel and planar, and are often associated with accretion laminae and small ripples. The second-order surfaces

are cut by the first-order surfaces. Third-order surfaces cut across sequences of laminae (Brookfield, 1977, 1979).

Smaller-scale sedimentary structures are also common. In many cases the bounding surfaces are covered with small ripples. Laminae are common, and typically consist of very well-sorted grains. Towards the bases of the foresets the tangential sand laminae may be interbedded with silt laminations (Brookfield, 1977, 1978).

Palaeontology

Vertebrate tracks, thought to have been made by dicynodonts and pelycosaurs, have been described from the Lower Permian sediments at Locharbriggs Quarry and nearby Corncockle Muir, Annandale (Sarjeant, 1974), but are rare at both localities. Many of the footprints are well preserved, and occur in thin beds of clay-rich silt or fine sandstone (Sarjeant, 1974; McKeever, 1991, 1994). They have been assigned to four species of the ichnogenus *Chelichnus, C. duncani, C. gigas, C. bucklandi,* and *C. titan,* which differ in shape and in the length of the print (10–25 mm, 25–75 mm, 75–125 mm, and more than 125 mm respectively) in the four forms (McKeever and Haubold, 1996).

Interpretation

The Locharbriggs Sandstone Formation was deposited under continental conditions. Palaeomagnetic data indicate that southern Scotland lay about 10° north of the palaeoequator during early Permian times (Brookfield, 1979).

The well-sorted and polished sand grains are typical of aeolian processes. The large-scale cross-bedding, characterized by tabular sets and foresets with a uniform angle of dip, indicates transverse dunes that were associated with larger-scale features such as transverse draa dunes (Brookfield, 1978, 1979). It is thought that the draa dune was between 110 and 250 m high and had a wavelength of between 1.2 and 3 km. The SW-dipping sandstone wedges indicate that the dominant palaeowind direction was from the north-east.

Certain deposits and structures common in many ancient desert sequences have not been recorded in the Locharbriggs sequence; these include interdune clay deposits, lag sediments, interbedded fluvial deposits, and rain drop imprints. The scarcity of these features suggests that the area experienced little or no rainfall (Brookfield, 1979, 2000).

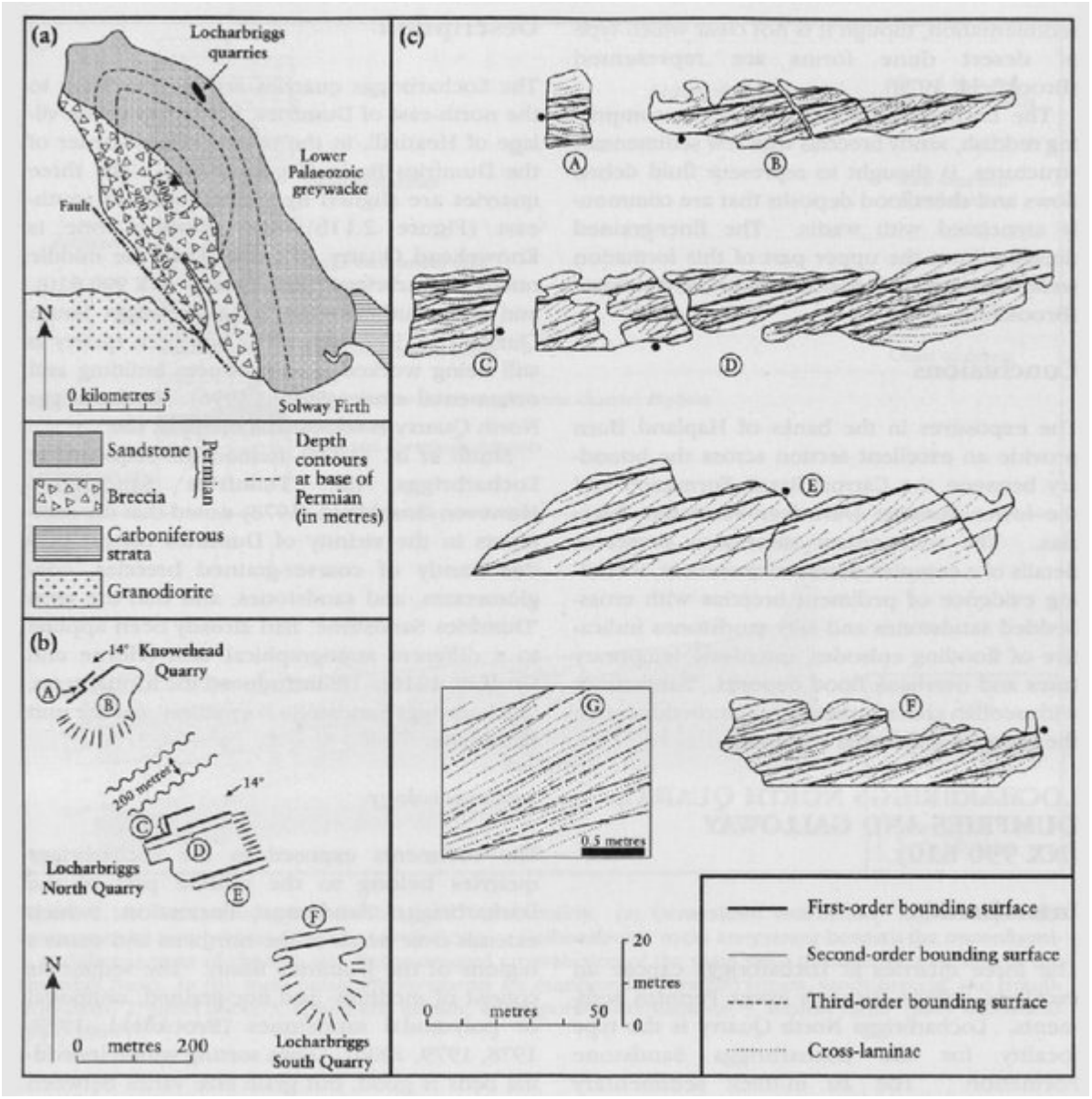
The first-order bounding surfaces are interpreted as the result of migration of the largest, draa dunes. The second-order surfaces were produced by the migration of small-scale structures, for example small dunes, which may be found superimposed on the surfaces of the draa dunes. The third-order bounding surfaces are interpreted as re-activation surfaces, and may have been produced when the direction of dune migration changed (probably a periodic phenomenon, which may reflect the daily change in wind direction common in modern deserts, or seasonal fluctuations), or when the forwards migration of one dune overtook another (Brookfield, 1979).

The clay-rich sandstones on which the vertebrate tracks were impressed are an unusual feature for desert environments. It is likely that the clays were introduced into the system either by the infiltration of rainwater, or by the settling of dust clouds (McKeever, 1991). The interbedded silt laminae common at the bases of the foresets may also have formed as dust settled out of suspension in the lee of the dunes (Brookfield, 1978).

Conclusions

The quarries at Locharbriggs expose an excellent section through the continental lower Permian Locharbriggs Sandstone Formation. These predominantly arenaceous sediments were deposited in a desert and comprise the remains of large transverse dunes or draas with subsidiary dunes climbing up their backs. This graphic example of large desert structures, on the scale of hundreds of metres long, is unique in Britain. The Locharbriggs site is of considerable importance for the understanding of early Permian aeolian environments and palaeogeography, and for its ichnofauna.

References



(Figure 2.11) Sedimentology of the Locharbriggs Sandstone Formation in the Locharbriggs Quarries. (a) The Dumfries Basin, showing location of the Locharbriggs Quarries (arrow). (b) Plan view of the three quarries, the middle one of which is the GCR site. (c) Sketches of the exposures of the cross-bed sets and bounding surfaces in the three quarries; (A) to (F) correspond to the faces marked on the plan views in (b). (All from Brookfield, 1977.)

(Figure 2.12) The working area of Locharbriggs North Quarry (see also Figure 2.11b. (Photo: C. MacFadyen.)