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# Cowraik Quarry, Cumbria

[NY 542 310]

## Introduction

Cowraik Quarry exposes the lower Permian Penrith Sandstone, and shows many of the characteristic features of that unit, including large-scale aeolian dune foresets, which show a variety of lamination types, and indicate palaeowind directions towards the west. The sandstones include sand wedges composed of very coarse, well-rounded grains, with normal graded lamination. The lower part of the sequence is unsilicified, while the upper part has been silicified through the process of authigenic quartz precipitation. This is a key locality for the study of lower Permian aeolian sand dunes.

The Penrith Sandstone has been described by Arthurton and Wadge (1981), Macchi (1981), Steele (1981), and Mader and Yardley (1985, pp. 186–7), and its petrological features by Versey (1939) and Waugh (1965, 1970a,b, 1978).

## Description

Cowraik Quarry is situated on the margins of the wooded southwards-facing escarpment of Beacon Edge, close to the northern outskirts of Penrith. Though the quarry is currently disused, good sections are exposed. The regional dip is about 5° to the east.

Along the southern margin of the quarry, the lower faces expose foresets that dip towards the north-west at about 25°. The sandstone is generally friable and consists of well-rounded coarse grains ('millet seed grains'), and finer more angular grains. The exposure is cut by many small granulation seams.

The northern wall of the quarry exposes better sections. At the eastern end of this face, the sandstones are well cemented, and a suite of sedimentary structures is visible. For example, a bounding surface exists between the cross-bedded sandstone and an overlying unit, 100 to 150 mm thick, of laminated sandstones, which, in turn, are overlain by sandstones with steeply dipping foresets. Towards the top of this face a second, less well-defined, bounding surface is seen.

At the western end of the face, the highest part of the exposed sequence, comprising red, well-cemented sandstones, is seen. Most of the grains are quartz, although there are small quantities of feldspar and reworked rock fragments (Waugh, 1970b). The cement is siliceous, and often occurs as overgrowths in optical continuity with the quartz grains. Overgrowths are also found around the feldspar grains. The red coloration is caused by a thin layer of haematite covering each grain (Waugh, 1965, 1970a,b, 1978). Farther up the face, large-scale, steeply dipping cross-bedding surfaces are clearly visible. The upper parts of the foresets are cut by a bounding surface, marked by a lag of coarse sand grains.

The cross-stratification fabric of the Penrith Sandstone is mainly composed of large-scale to very large-scale tabular-planar and trough sets, which are separated by horizontal or curved bounding surfaces. The foresets are built up mainly of amalgamated coarse grain-flow tongues, which give rise to massive sandstones without distinct internal laminations (Mader and Yardley, 1985, p. 186).

## Interpretation

The Penrith Sandstone in the Vale of Eden Basin ranges from 0 to 500 m thick and was deposited in an inland erg (desert sand sea) by winds blowing over a predominantly dry landscape. The erg developed in the middle of the Vale of Eden basin, and the Penrith Sandstone was deposited contemporaneously with 'brockram' alluvial fans along the basin margins. The sediments in Cowraik Quarry contain very well-rounded and frosted sand grains, which are indicative of aeolian deposition.

The large-scale cross-bedding represents single migrating straight- or sinuous-crested transverse dunes. The presence of bounding surfaces throughout the succession indicates that the upper sections of the dunes were eroded away during dune migration and fine-grained material was blown away, leaving a deflation lag of coarser material. The presence of coarse-grained sandstone on some of the bounding surfaces suggests that these may have supported small-scale wind ripples. Analysis of the orientations of the cross-bedded units indicates that palaeowind directions were towards the west.

## **Conclusions**

Cowraik Quarry exposes good sections of the Penrith Sandstone in which sets of cross-bedded sediments, interpreted as being deposited in a series of migrating sand dunes, are separated by many examples of bounding surfaces. Cowraik Quarry is one of the best sites for study of the Penrith Sandstone, a significant aeolian unit of Early to Mid Permian age.

## **References**