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# George Gill, Cumbria

[NY 719 189]

## Introduction

George Gill provides a series of natural crag exposures in the higher part of the lower Permian Penrith Sandstone. About 10 m of aeolian dune-bedded sandstones are visible and include up to five superimposed dune sets separated by gently inclined bounding surfaces. The sandstones are generally friable and show well-developed sand-flow laminae; cross-beds reflect a palaeowind direction from the east. The aeolian beds overlie fluvially deposited flat-lying beds lower in the Gill. Isolated brockrams in George Gill include one that is famous for containing dolerite clasts, possibly from the Whin Sill. This is a key site for understanding the Vale of Eden Basin, and for a wider understanding of early Permian palaeoenvironments in northern England.

The Penrith Sandstone and George Gill have been described by Burgess and Wadge (1974), Burgess and Holliday (1979), Arthurton and Wadge (1981), Macchi (1981), Steele (1981), Mader and Yardley (1985, pp. 186–7), Macchi and Meadows (1987, pp. 80–2), and Macchi (1990), and its petrological features by Versey (1939) and Waugh (1965, 1970a,b, 1978).

## Description

George Gill is a narrow glacial valley that drains into the Hilton Beck. It is situated along the southern margin of Appleby golf course. The sandstones are cut by a complex system of conjugate fractures manifest as intersecting bands of hard sandstone composed of granulated quartz. The fractures offset the sedimentary structures by 4 mm, and are orientated parallel the Pennine faults, with a trend of 165° (Macchi and Meadows, 1987).

The Penrith Sandstone at this locality is red, somewhat friable, coarse-grained, and composed of well-sorted, well-rounded 'millet seed' grains, which are cemented by calcite and some silica (Versey, 1939). The red coloration is produced by a thin layer (pellicle) of iron oxide coating each grain. Approximately 95% of the grains are quartz, which may be unicrystalline or polycrystalline, derived from veins, metaquartzites, gneisses, and schists. The subordinate constituents include feldspar (orthoclase and microcline) and lithic fragments (Waugh, 1970a,b, 1978). Of particular note are large grains of the accessory mineral rutile (Versey, 1939).

The Penrith Sandstone is exposed in crags along the southern side of the valley. The section here is approximately 10 m high, and is dominated by five clearly defined sets of cross-bedded units (Figure 2.24). The sets range in thickness from 0.3 to 5 m, and are separated by gently dipping second-order bounding surfaces. Cross-bedding foresets are asymptotic and concave-up, and indicate palaeowind directions from the east (Macchi and Meadows, 1987). Low in the sets, the foresets have a low angle, but higher up they steepen to angles of 20° to 33°. The large-scale cross-beds take the form of high-angle, wedge-planar, subordinate tabular-planar, and lenticular trough cross-bedding. Sand-flow laminae with dips up to 29° are seen.

A second exposure, on the northern side of the valley, shows sediments with well-developed cross-bedding. Of particular note in this section are coarse-grained laminae that occur at the base of some sets and have the same orientations as the bounding surfaces (Macchi and Meadows, 1987). This exposure also shows a series of plane-laminated bi-modal sandstones with scour structures and low-amplitude ripple marks, representing aeolian sandsheet deposition.

Farther down the valley, coarse-grained sandstones with tabular cross-bedded units and straight tangential foresets are exposed. These sandstones commonly have frosted and millet-seed grains, and some mudstone clasts occur. Interbedded with the sandstones are rudaceous brockrams (Macchi and Meadows, 1987). The George Gill brockram, at [NY 7167 1900], contains pebbles of decomposed dolerite, probably from the Whin Sill (Burgess and Holliday, 1979, p. 71).

## Interpretation

The Penrith Sandstone consists of variable thicknesses of aeolian sands deposited in an erg in the centre of the Vale of Eden Basin. George Gill shows both the classic aeolian cross-bedded dune fades of the Penrith Sandstone, as well as associated water-laid beds.

The succession exposed in the southern side of the George Gill valley is interpreted as comprising aeolian sand dune deposits; diagnostic features are the type of cross-bedding and well-rounded frosted grains. Five sand dune sets are seen separated by bounding surfaces, representing erosion surfaces that formed when transverse dunes migrated over each other. The unidirectional distribution of the foresets, and the curved surfaces of the foreset slopes, are consistent with features seen in crescentic barchan dunes in modern deserts (Waugh, 1970b). The palaeowind directions from the east may be equated with a trade-wind system.

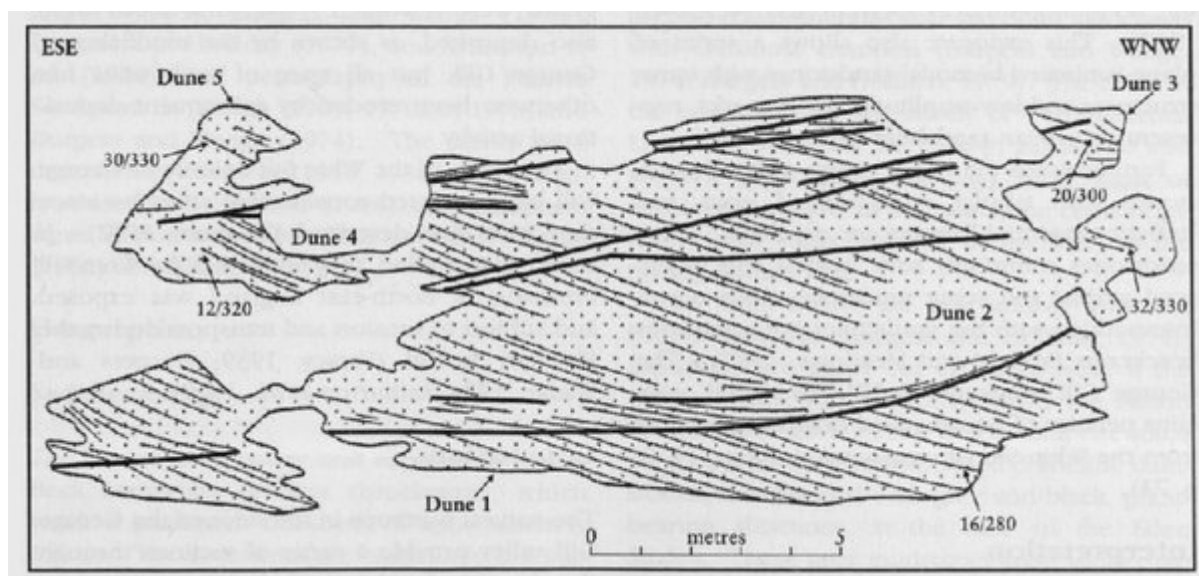
The deposits exposed on the south side of the valley have been interpreted as fluvial in origin (Macchi and Meadows, 1987). These sandstones consist of material reworked, probably during flash floods, from the aeolian beds, as demonstrated by the presence of frosted millet-seed grains of obvious aeolian origin, and include large rip-up clasts of mudstone. The interbedded brockram sediments were deposited on large alluvial fans. These units demonstrate that the Penrith Sandstone erg was intersected episodically by short-lived fluvial channels, presumably following heavy ephemeral rainfall in and around the basin. Rapid outwash formed channels in the dune sands, and the aeolian grains were reworked. Overbank muds were also deposited, as shown by the mudflakes at George Gill, but all trace of such units has otherwise been eroded by subsequent depositional activity.

The clasts of the Whin Sill dolerite at George Gill have attracted considerable attention since they were first described (Dunham, 1932). If correctly identified, they imply that the Whin Sill intrusion of north-east England was exposed and subject to erosion and transport during the Permian Period (Versey, 1939; Burgess and Wadge, 1974; Arthurton *et al.*, 1978).

## Conclusions

The natural outcrops in the sides of the George Gill valley provide a series of sections through the Penrith Sandstone. Sediments present include a sequence of migrating sand dunes and aeolian sand sheets, river deposits (probably deposited during flash floods), and alluvial fan deposits represented by 'brockrams' deposited on the margins of the Vale of Eden Basin. George Gill is critically important for understanding aspects of the aeolian sedimentology of the Penrith Sandstone, and for showing its rare fluvial facies and yielding clasts of the Whin Sill. It is a key site for understanding lower Permian palaeogeography and palaeoenvironments in the north of England.

## References



*(Figure 2.24) The Penrith Sandstone at George Gill, showing aeolian dune cross-bedding (lighter line) and bounding surfaces (heavier line), as exposed in crags on the southern side of the valley. Dune foreset orientations are indicated (dip in degrees/dip direction, degrees from north). (After Macchi and Meadows, 1987.)*