Multidirectional Palaeocurrents as Indicators of Shelf Storm Beds

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Abstract

Distal parts of shelf storm sequences, below the zone of hummocky cross stratification, may differ little from turbidites. Multidirectional paleocurrent indicators are described from the Lower Silurian Hughley Shales of the Welsh Borders of England, and they are proposed as an important criterion for the recognition of storm induced bottom currents.

1. Introduction

Storm events in proximal shelf environments have been well documented in recent literature. They have been recognised primarily by hummocky cross stratification in sediments interpreted as deposited or modified from suspension fallout in lowered (storm) wave base conditions. Storm events on the distal shelf, however, where the depth of storm wave base approaches water depth, are less readily recognised. It is in this zone that bottom currents induced by storm surge ebb events prevail, modifying suspension fall-out, and ultimately continue as density currents into most distal shelf environments. In this paper, we present evidence for storm events on the distal shelf.

We studied the Lower Silurian Hughley Shales (Upper Llandovery, C_5 Substage, *griestoniensis* Zone) which outcrop in the Welsh Borders region of England (Fig. 1a). We examined various localities, and collected extensively and logged sections (Fig. 1b) at localities A (Devil's Dingle temporary dam site) and B (Hughley stream). The sequence consists of mudstones with thin interbedded sandstone units that present many typical turbidite features. However, certain features of the sandstones suggest storm effects.

2. Sedimentology

Maroon to grey-green uniform or finely laminated mudstones form more than 75% of the measured section (Fig. 1b). They contain a diverse benthic fauna, dominated by brachiopods and corals.

The interbedded sandstones vary from 1 to 20 cm in thickness, but are laterally persistent sheets that pinch and swell gently. Each sheet has the basal surface tool-marked by indigenous, unabraded

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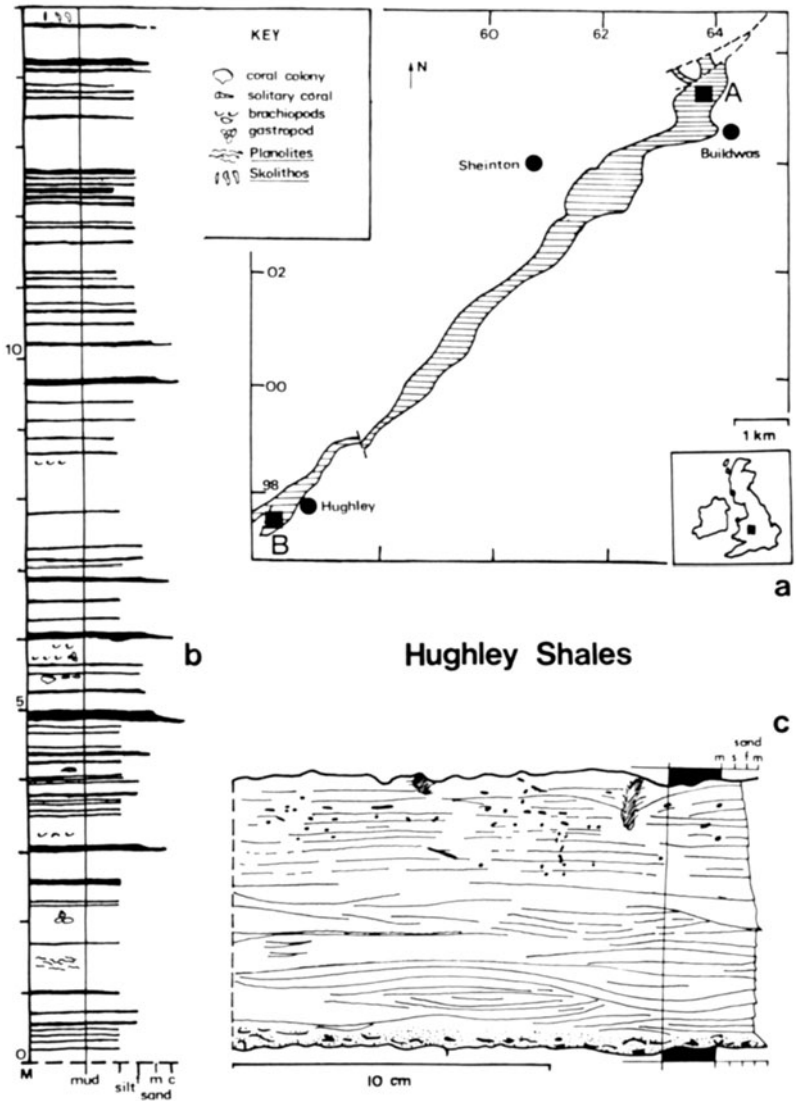

Fig. 1. The Hughley Shales, Upper Llandovery, Welsh Borders. a. Map of outcrop showing sample localities A and B; b. sedimentary log showing position of sandstone units, fossils and trace fossils; c. cross section through single sandstone unit showing coquina, trace fossils, lamination, and ripple lamination

fossils, and a bioturbated top (*Palaeophycus*, *Chondrites*, *Diplocraterion*, trilobite traces). These sheets may contain laterally impersistent basal or centrally placed coquinas and coarse sand layers, but the remainder of the bed is 20-100 um laminated sands and silts. Internal tool-marked surfaces may also occur.

The sand sheets are dominated by millimeter-scale parallel and ripple lamination. Ripple lamination is most common in the middle and basal parts of the beds, as poorly developed types 1, 2, and in-phase climbing ripples. Many beds contain scour and fill cross laminated sets, and flaser silt drapes may accentuate this cross lamination. There are no unequivocally wave-produced sedimentary structures.

3. Palaeocurrents

Two oriented slabs, each about 1m square, were collected from localities A and B (Fig. 1a). Palaeocurrent measurements were made from unidirectional biogenic tool marks (prod and groove marks) on each slab, and plotted in 20° segments on a rose diagram. The deepest part of the tool mark was assumed to point downstream (Fig. 2).

The results are rather different from what would be expected in a typical palaeoslope turbidite model. Slab A, containing a confused mass of cross-cutting tool marks, has no dominant current direction. Slab B has a less confused array of tool marks (Fig. 2), and shows two major directions - one directed SSW (from 020°), and the other running WSW (from 070°). Neither direction can be said to have occurred first over the whole slab.

4. Environment of Deposition

Current paleogeographic models place the uppermost Llandovery coastline up to 150 km to the east, and the shelf margin roughly 40 km west of the study area. Although the sandstone units resemble turbidites, evidence for deposition induced by shelf storm events includes:

1. The shelf setting with locally derived benthic organisms.
2. The wide directional spread of the tool marks.
3. The presence of internal coquinas and coarse layers, both above and on the bed base, that attest to storm surge currents.
4. Well sorted nature of the sands and silts, reflecting suspension load in the overlying water column.
5. Abrupt transition to background mud deposition on bed tops.

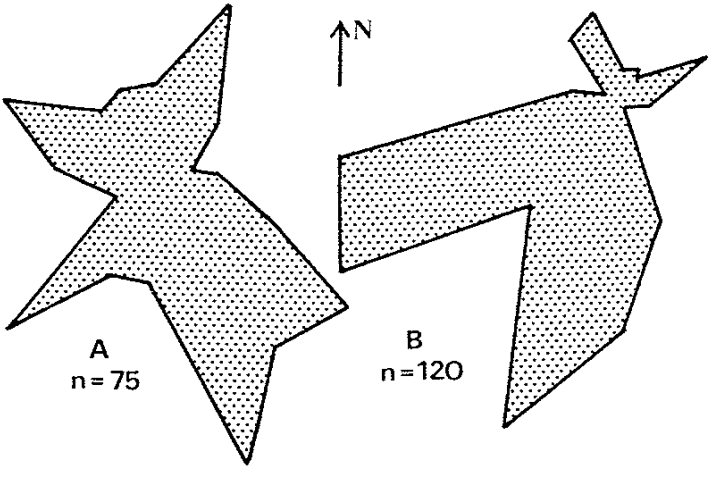

Fig. 2. Photograph of part of tool-marked base of sandstone unit from sample locality B; rose diagrams for palaeocurrents based on unidirectional tool marks for localities A and B