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Architectural analysis of a Triassic fluvial system: The Sherwood Sandstone of the East Midlands Shelf, UK

Oliver J.W. Wakefield [a,*], Edward Hough [a], Alex W. Peatfield [b]

[a] British Geological Survey, Keyworth, Nottingham NG12 5GG, UK
[b] Earth Sciences and Geography, Keele University, Staffordshire ST5 5BG, UK

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ABSTRACT

The Sherwood Sandstone Group of the northeast UK (East Midlands Shelf) has hitherto never been studied in detail to ascertain its palaeoenvironment of deposition, largely because it is poorly exposed. As such, this paper aims to provide the first modern sedimentological interpretation of the Sherwood Sandstone in the east of England based on a field outcrop at the disused quarry at Styrrup. This is in stark contrast to the western parts of England where the Sherwood Sandstone is well exposed and offshore in the North Sea Basin where it is represented by a substantial library of core material where it is also relatively well understood. The outcrop at Styrrup Quarry allows contrasts to be made with the style and expression of the Sherwood Sandstone between eastern and western England. Specifically, this highlights differences around the variation in fluvial discharge (between lowstand and highstand) and the absence of aeolian facies types. It is interpreted that these differences relate to discharge variations between ephemeral and perennial systems with a perennial model proposed for Styrrup Quarry. This model draws upon inferences of additional water input from more local areas, likely topographic uplands of the London–Brabant and Pennine Highs which supplement the primary source of the Variscan Mountains in France with additional water and sediment.

1. Introduction

The Sherwood Sandstone Group (Lower Triassic) is of great importance in the UK for a number of applied, including economic, reasons: i) it one of the largest producing aquifers in the country (Allen et al., 1997), with groundwater being exploited for use in agricultural and industrial practices in addition to a potable supply, ii) the unit is actively mined as both a source of aggregate and sandstone for the construction industry, iii) the interval is hydrocarbon-producing in the East Irish Sea Basin (Meadows and Beach, 1993b), iv) the lateral equivalent within the North Sea Gas Province – the Bunter Sandstone Formation – has produced 5.5 tcf of gas (~12% of gas produced to date; Gray, 2014), and, v) the Sherwood Sandstone underlies numerous urban centres (including Nottingham, Doncaster, York and Middlesbrough) which are at risk from a legacy of historic industrial contamination (Hough et al., 2006). Given the range and importance of the applications for the Sherwood Sandstone Group there currently exists a gap in our knowledge over the detailed internal composition of the facies and architectural elements within the group and any heterogeneity arising from them. This is most keenly felt in the north eastern locations of the Sherwood Sandstone (Fig. 1) where a lack of good-quality outcrop hampers characterisation, including even attempts at formational sub-division of the Group (Howard et al., 2009). It is however not necessarily appropriate to supplement a lack of understanding in north-eastern England, with the comparatively well exposed Sherwood Sandstone in western England as there are known spatial variations in character between them (Barnes et al., 1994). For example, there are readily identifiable differences in the depositional environments, including; i) an absence of identified aeolian facies in the eastern Sherwood Sandstone contrasting the mixed aeolian–fluvial formations of the group in the north east of England (Cowan, 1993; Mountney and Thompson, 2002; Bloomfield et al., 2006), and ii) an absence of well-developed/regionally pervasive palaeosols (pedogenic processes) in the eastern parts of England compared to western and southern England. As such, there is a need to better understand the spatial variations in the Sherwood Sandstone, with examples pertaining to each region. Such outcrop-driven studies will provide data and application at a resolution beyond geophysical techniques for applications where direct observation is not always possible, e.g. for reservoir characterisation. An understanding of the internal heterogeneity of the sandstone that places it in a modern sedimentological context could then be up-scaled and used to parameterise models using a prediction of sandbody geometry will be relevant to a wide user community.

Although the Sherwood Sandstone Group has been the focus of numerous previous studies throughout the UK and offshore (Warrington, 1970; Benton et al., 2002; Hounslow and Ruffell, 2006) there are relatively few descriptions of the Group on the East Midlands Shelf.

* Corresponding author.
E-mail address: oliverw@bgs.ac.uk (O.J.W. Wakefield).

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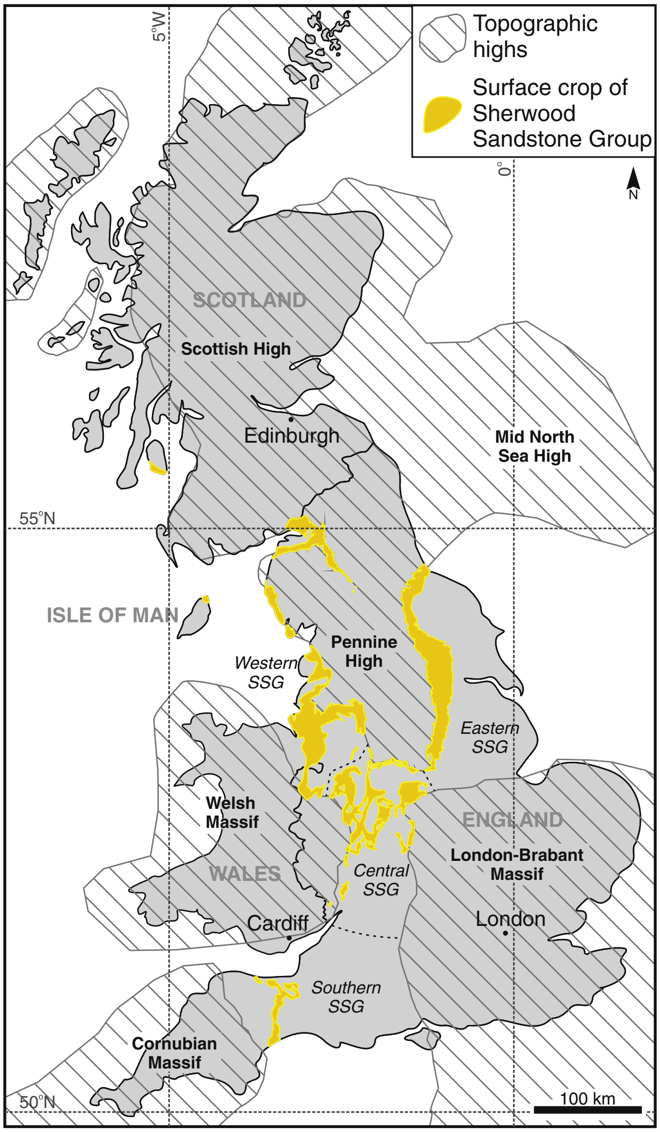

Fig. 1. Map depicting surface expression of the SSG (highlighted in yellow) with topographic highs (areas of non-deposition) during the Triassic. Note dashed lines that delineate informal geographic divisions of the Sherwood Sandstone Group into eastern, western, central and southern areas.

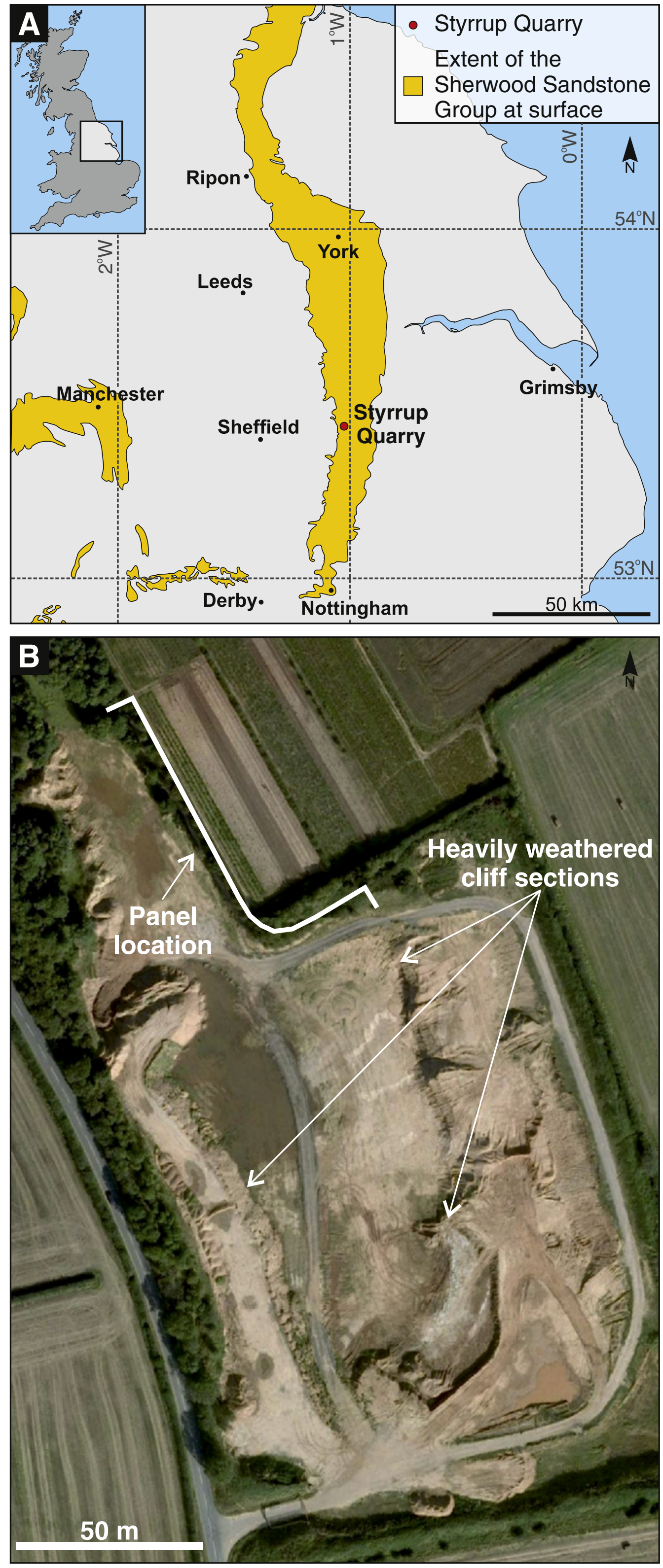

Fig. 2. Location map. A) Map of the northern England depicting the surface crop of the Sherwood Sandstone Group. B) Aerial photograph of Styrrup Quarry. DiGMapGB data, BGS © NERC. Contains Ordnance Survey data © Crown Copyright and database rights 2015.

Research within this area has primarily been focussed on the applications related to groundwater extraction and contaminant transport (e.g., Bath et al., 1987; Green, 1989; Smedley and Edmunds, 2002). Diagenesis and deformation are also important aspects when understanding the petrophysical properties of aquifers or hydrocarbon reservoirs, but these secondary processes are influenced by the primary sedimentology of the host rock. For instance at Styrrup Quarry, McKinley et al. (2013) have linked diagenetic processes (secondary processes) to specific architectural elements (primary depositional). Indeed such facies control on deformation is also widely acknowledged (Fossen et al., 2007). This implication of primary sedimentary control/influence on secondary processes only validates more the need to address the relatively little work conducted to characterised the sedimentology of the group beyond its primarily fluvial origin (Warrington et al., 1980) and address this gap in our knowledge. As such, this study aims to produce the first modern high-resolution sedimentological study of the Sherwood Sandstone Group in the East Midlands Shelf based on a quarry outcrop at Styrrup (Fig. 2). Specifically, this study identifies the facies and architectural elements, assemblages, relationships and distributions to create an idealised conceptual palaeogeographical model to account for the Sherwood Sandstone at Styrrup Quarry.