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Provenance of late Carboniferous sandstones in the Pennine Basin (UK) from combined heavy mineral, garnet geochemistry and palaeocurrent studies

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Abstract

Analyses of heavy mineral assemblages, garnet geochemistry and palaeocurrent directions may each independently provide useful information on the provenance of sandstones, but when such datasets are combined the number of options on the location of possible source areas can be greatly reduced. Also, variations in heavy mineral signatures through a stratigraphical section can be explained in terms of switching between source areas, rather than due to unroofing events in a single source area, if palaeocurrent directions change at the appropriate levels. Likewise, seemingly random changes in transport direction indicated by palaeocurrent variations through a short stratigraphical section can be shown by the heavy mineral data to be systematic and related to shifts between source areas. Illustrations of the mutual constraints provided by such combined datasets are drawn from late Carboniferous successions of the Pennine Basin, northern England, where the contributions of detritus from several distinct source terrains and sediment pathways are well documented [Hallsworth, C.R., Morton, A.C., Claoué-Long, J., Fanning, C.M., 2000. Carboniferous sand provenance in the Pennine Basin, UK: constraints from heavy mineral and detrital zircon age data. Sedimentary Geology 137, 147–185; Chisholm, J.I., Hallsworth, C.R., 2005. Provenance of Upper Carboniferous sandstones in east Derbyshire: role of the Wales–Brabant High. Proceedings of the Yorkshire Geological Society 55, 209–233]. Examples are given of how mineralogically distinct and geographically separated provenances can be identified, how variations in heavy mineral suites can be used to identify whether variations in palaeoflow represent variations in provenance, and how localised mixing/recycling in incised channels can be inferred. The final example defines the regional extent of the widespread northerly-derived fluvial Yeadonian sandstones and provides evidence for the mixing of more local sediment supplies at the basin margins.

Keywords: Provenance; late Carboniferous; UK Pennine Basin; Heavy minerals; Palaeocurrents

1. Introduction

1.1. History

We deal here with provenance studies relating to sandstones of late Carboniferous (Namurian and Westphalian) age in the Pennine Basin (Figs. 1 and 2), using data mainly from outcrop but extending the regional basis of the study with borehole data. Sedimentology of this succession has been summarised by Collinson (1988) for the Namurian and by Guion and Fielding (1988) for the coal-bearing part of the Westphalian. Sandstones are of fluvial and deltaic origin, having been deposited in a coastal plain setting that at times extended across most of northern Europe (Maynard et al., 1997). Northern provenance of most Namurian sandstones has been established for over a century (Sorby, 1859; Gilligan, 1920), and it was until recently supposed that most of the Westphalian sediment was brought in by the same major transport system (e.g. Cliff et al., 1991; Guion, 1992). However, large-scale inputs from other directions have been recognised, on the basis of palaeocurrents (Collinson and Banks, 1975; Chisholm, 1990), sandstone channel trends (Rippon, 1996), heavy mineral studies (Hallsworth, 1995, 1998, 2001), reworked palynomorphs (McLean and Chisholm, 1996),

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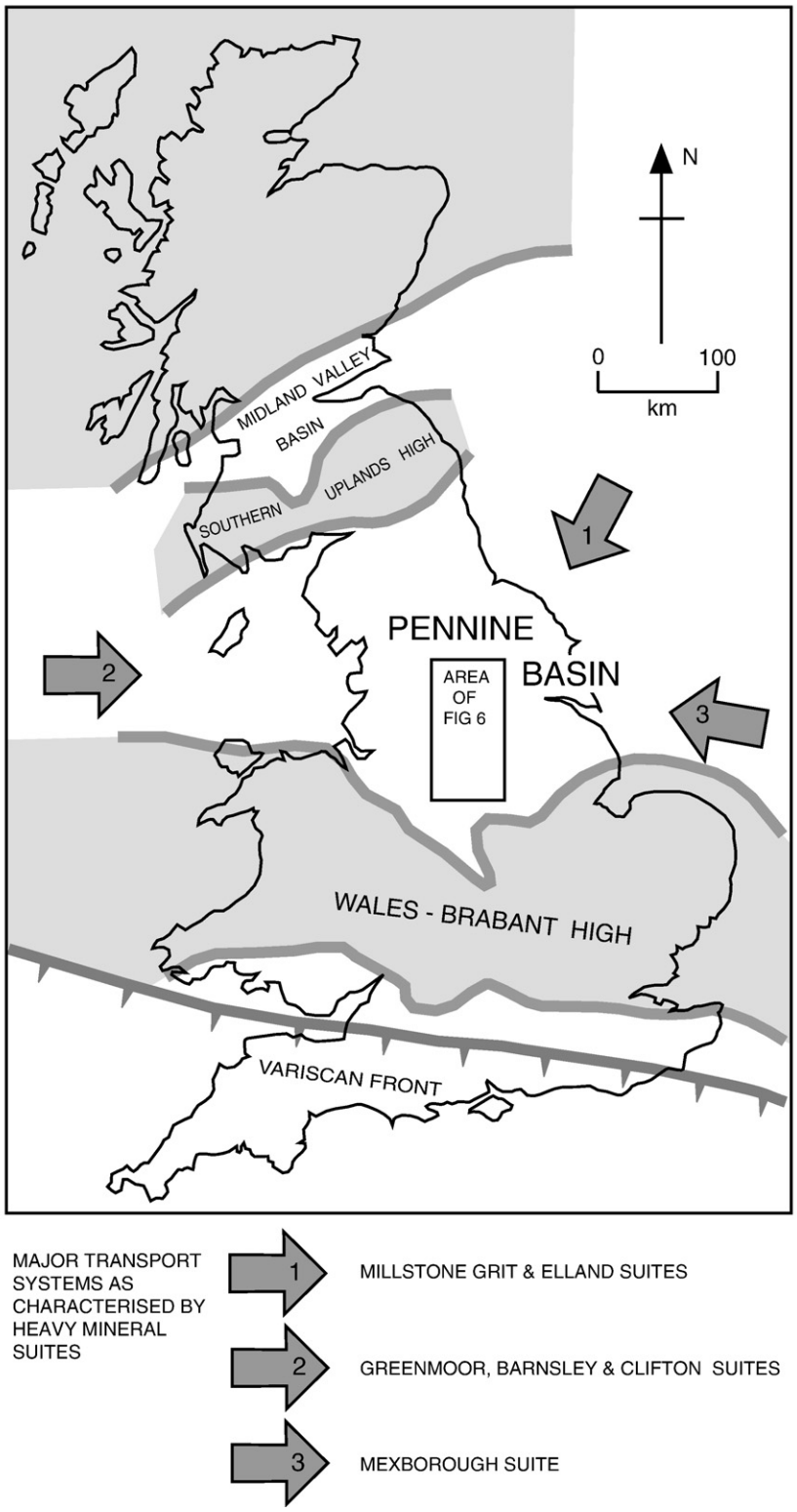

Fig. 1. Palaeogeography of Westphalian times, based on Guion (1992) and Hallsworth and Chisholm (2000). Areas of non-deposition are shown ornamented. Stratigraphical range of transport systems is shown in Fig. 2.

and radiometric dating of detrital minerals (Glover et al., 1996; Leng et al., 1999; Hallsworth et al., 2000; Evans et al., 2001; Dahlgren and Corfu, 2001). However, it is the combination of palaeocurrent and heavy mineral studies (Chisholm et al., 1996; Hallsworth and Chisholm, 2000; Chisholm and Hallsworth, 2005) that has proved most useful in the elucidation of the complexities of provenance, as we illustrate here.

Palaeocurrent data and sandstone lithology have previously been used to establish that the Rough Rock sandstones of late Namurian (Yeadonian) age have a northern provenance, with