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Recognising different sediment provenances within a passive margin setting: Towards characterising a sediment source to the west of the British late Carboniferous sedimentary basins

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ABSTRACT

To investigate whether sediments with subtly different provenances could be recognised within a passive margin setting, samples were taken from Westphalian sedimentary rocks of the Pennine Basin, South Wales Coalfield, Culm Basin of Britain and from Northern Ireland. Although previous work has shown that 3 major source areas were responsible for the infill of the Pennine Basin, this study is restricted to sediments believed to have been derived from the west. Their nominally similar western provenance was confirmed using Sm–Nd isotope techniques and their deposition in a passive margin setting was established using elemental discrimination diagrams. While the overall sediment provenance may have been from the west, the trace element geochemistry indicates that at least two major sediment pathways can be distinguished. Plots of Eu/Eu*–Gd_N/Yb_N, along with ternary plots of Cr/V–Ti/Zr–Gd_N/Yb_N or Sc/Cr suggest different source areas for the Culm Basin and the South Wales Coalfield. In the Culm Basin the Cr/V ratio generally exceeds 1.25, with a small Eu anomaly and a low Gd_N/Yb_N ratio. The Cr/V ratio is less than 1.25 in the South Wales with a larger Eu ratio and a higher Gd_N/Yb_N than the Culm Basin. Significant separation of the Culm Basin and the South Wales Coalfield during the early Westphalian by the Bristol Channel–Bray Fault may have been a factor contributing to the provenance differences. Late Carboniferous dextral displacement along this fault brought these basins into close juxtaposition, and it is unlikely that the 'Bristol Channel Landmass' formed a common source area for these two basins.

1. Introduction

The passive margin represents one of the most important settings for sedimentation and systems can be extremely long lived. Being able to recognise variations in sediment provenance in an environment where the material does not show obvious lithological or elemental changes can be very important in determining events in the geological past. Radiogenic isotopes and elemental geochemistry have been used to elucidate sediment provenance within a number of ancient and modern successions with varying degrees of success (e.g. Leng and Evans, 1994; Bock et al., 1998; McLennan, 2001; Hurowitz and McLennan, 2005; Chakrabarti et al., 2007). Despite this, sediment provenance differences in a passive margin setting remain difficult to identify due to significant reworking and homogenisation of detritus.

The significance of sediment geochemistry in elucidating the provenance of sedimentary suites, their evolution and source weathering is well established (Bhatia, 1983; Roser and Korsch, 1986, 1988; Cullers et al., 1987; McLennan et al., 1990, 1993; Cullers, 1994, 2000; Condie et al., 1995; Hurowitz and McLennan, 2005; Campos-Alvarez and Roser, 2007; Ryan and Williams, 2007; Huntsman-Mapila et al., 2009). The relationship between the tectonic setting and variables such as provenance, relief, physical sorting and weathering ultimately controls the composition of sediments. Immobile trace element compositions and especially rare earth element (REE) abundances of sediments are considered good indicators of source rock chemistry, since these elements are little-fractionated by sedimentary processes and low grade metamorphism (Taylor and McLennan, 1985, 1995; McLennan, 1989). Sediment provenance is considered to be the single most important factor contributing to the REE content of clastic sediment (Fleet, 1984; McLennan, 1989), because the REEs are comparatively insoluble and present in very low concentrations in sea and river water;

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thus the REEs in sediments are chiefly transported in particulate matter. The effects of weathering and diagenesis are considered to be minor, with some exceptions noted in very anoxic environments (e.g. Milodowski and Zalasiewicz, 1991; Bock et al., 1994; Lev et al., 1998). Major element (e.g. Bhatia, 1983; Roser and Korsch, 1986, 1988; Huntsman-Mapila et al., 2009) and other trace element (e.g. Bhatia and Crook, 1986; Ryan and Williams,

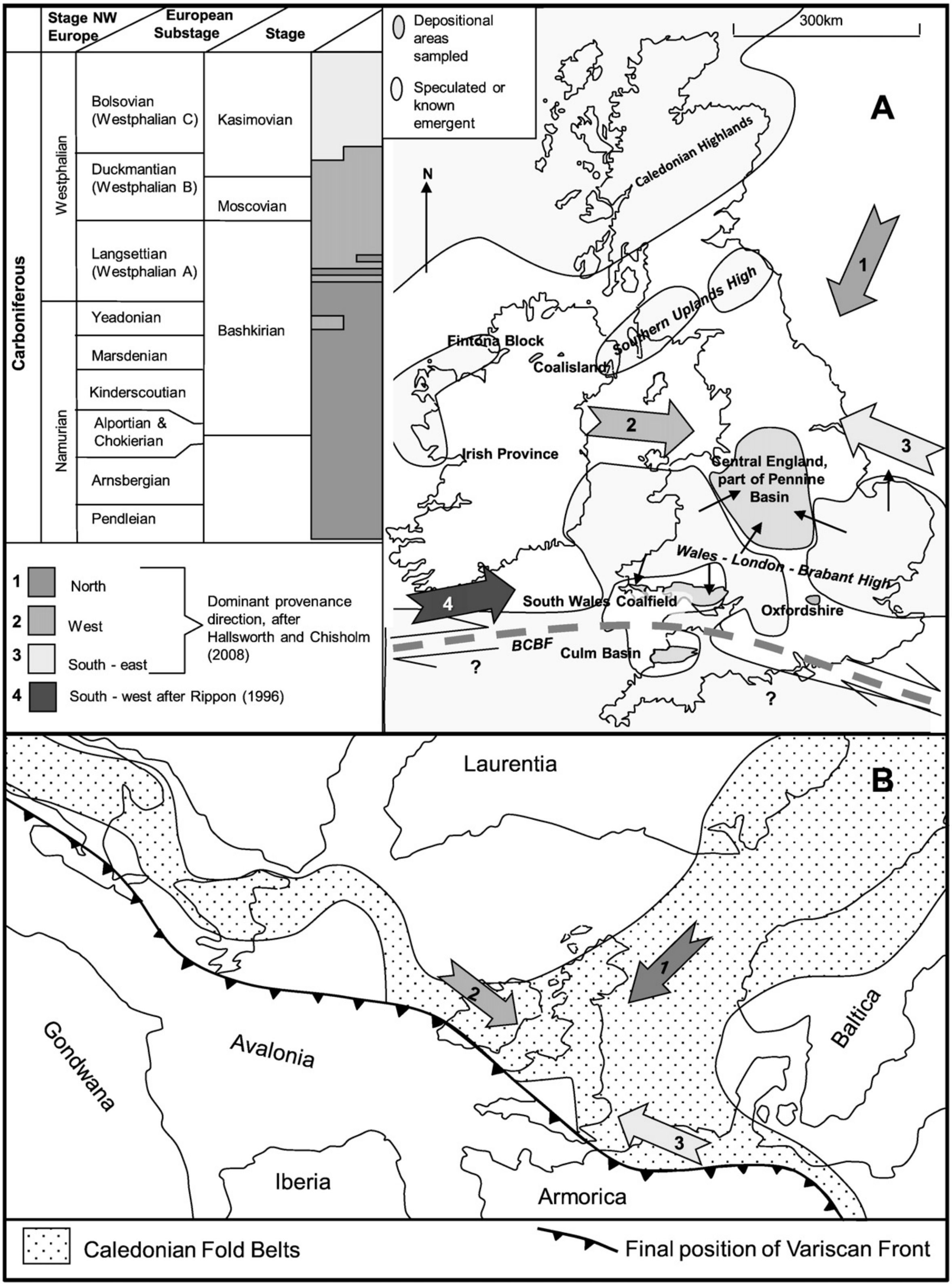

Fig. 1. A) Location map showing Westphalian depositional basins of the British Isles sampled in this study, showing dominant provenance directions over time and local input into Pennine Basin from Wales–London–Brabant High (based on Rippon, 1996; Chisholm and Hallsworth, 2005; Hallsworth and Chisholm, 2008). Position of Bristol Channel–Bray Fault after Shail and Leveridge (2009). Carboniferous Stratigraphy based on Heckel (2008); B) outline of the late Carboniferous regional palaeogeography, showing potential source terranes and major sediment transport path into the Pennine Basin. After Hallsworth and Chisholm (2000). Reproduced by permission of the Yorkshire Geological Society Council.