Managing European Shorelines and Sharing Information on Nearshore Areas

messina

A Case Study Documenting the use of Magnetic Concentration Data as an Innovative Method of Coastal Monitoring.

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1. INTRODUCTION

The use of mineral magnetic concentration data as an innovative means of monitoring sediment transport and sediment properties in marine, estuarine and fluvial environments has been well documented in the past. Mineral magnetic measurements are now considered a routine form of analysis when investigating the compositional properties of rocks, sediments and soils (*Thompson and Oldfield, 1986; Walden et al., 1999; Mather and Thompson, 1999).*

Sediment-related analytical data can, however, be strongly affected by particle size effects. For example, it is often the case that the finer a sediment the greater its concentration of pollutants and thus its mineral magnetic concentration. In other words, high magnetic concentration measurements can be associated with large amounts of fine-grained sediments and an inverse relationship with coarse-grained sediments (*C.A. Booth et al., 2005)*. This irregularity in distribution of pollutants between different sediment types and compositions makes it necessary for a correction to be introduced in order to normalise the findings. The need for a correction factor to be introduced means that generally, most methods of practical analysis are relatively time consuming and costly.

Recent studies, such as that undertaken by *C.A. Booth et al., 2005,* have attempted to highlight the advantages of using mineral magnetic concentration data to indicate a correlation between magnetic concentration and particle size. The study suggests that there is considerable potential for using magnetic concentration data as a particle size proxy for particular sedimentary environments (*C.A. Booth et al., 2005)*. Given the speed, low-cost and sensitivity of the method, it may offer some advantages over other compositional signals (*C.A. Booth et al., 2005)*.

2. GEOGRAPHICAL OUTLINE

The study undertaken by *C.A. Booth et al., 2005,* was carried out within Camarthen Bay, South Wales, U.K (Figure 1). The field setting included large areas dominated by marine (Camarthen Bay), estuarine (Gwendraeth Estuary) and fluvial (Gwendraeth Fach and Gwendraeth Fawr Rivers) sediments.

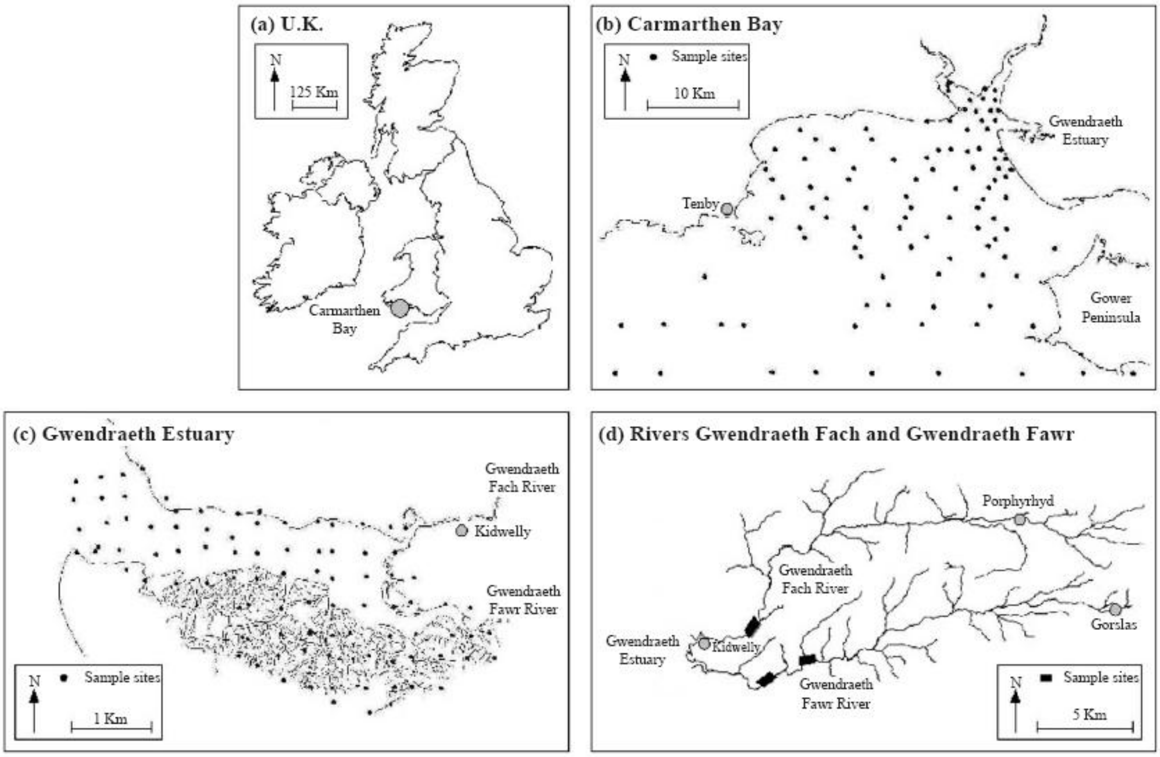


Figure 1. Location maps (a) U.K; (b) Carmarthen Bay; (c) Gwendraeth Estuary; and (d) the rivers Gwendraeth Fach and Gwendraeth Fawr (*C.A. Booth et al., 2005)*.

2.1. METHODOLOGY

A total of 308 samples were collected and analysed at the different field locations. Marine samples were collected from Carmarthen Bay, estuarine samples from the Gwendraeth Estuary and fluvial samples from the Gwendraeth Fach and Gwendraeth Fawr rivers. The textural properties of the sediments were measured by laser defraction in order to establish whether a relationship exists between mineral magnetic measurements and textural properties. Following this, a standard range of magnetic parameters was measured on all samples to determine their mineral magnetic concentration. The parameters used ranged from a low magnetic field to a saturation point where most mineral types will become saturated.

2.2. RESULTS

The results of the study indicate considerable variation between Carmarthen Bay, the Gwendraeth Estuary and the Fawr River although most exhibit a low to moderate concentration of magnetic minerals. However the Gwendraeth Fach River shows a moderate to high concentration of magnetic minerals (Table 2).

Table 2
Mineral magnetic concentration data for Carmarthen Bay (n=113), Gwendraeth Estuary (n=95), Gwendraeth Fach River (n=50) and Gwendraeth Fawr River (n=50)

Sedimentary environments	Parameters	χ_{LF}	χ_{ARM}	SIRM
Carmarthen	Mean	0.86	0.09	114.55
Bay	S.D.	0.51	0.10	67.11
Gwendraeth	Mean	2.10	0.66	309.51
Estuary	S.D.	1.22	0.54	192.44
Gwendraeth	Mean	11.01	0.51	2013.99
Fach River	S.D.	6.10	0.25	1033.65
Gwendraeth	Mean	3.01	0.25	492.48
Fawr River	S.D.	0.50	0.02	112.46

Table 2. Mineral magnetic concentration data collected from the three field sites. Taken from *C.A. Booth et al., 2005.*

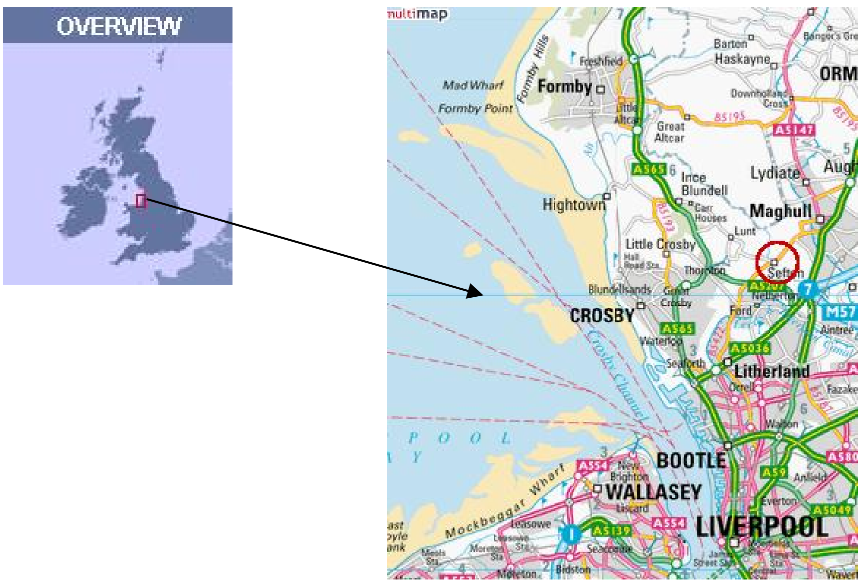
Following analysis by the Pearson's correlation coefficient, it was noted that significant negative correlations existed between each of the mineral magnetic concentration parameters and the percentage sand (i.e. the textural parameter; sand, silt or clay).
Both the Gwendraeth Estuary and the Gwendraeth Fawr River samples suggest modest differences in the concentration of minerals and could therefore be used, with caution, as a proxy for the proportion of sand. In contrast, both Carmarthen Bay and the Gwendraeth Fach River samples, as suggested by lower correlations coefficients, show greater scatter and, while the relationship between sand content and magnetic susceptibility is significant for the Carmarthen Bay sample set, the data distributions would not give high levels of confidence in susceptibility as a sand content proxy in either case (*C.A. Booth et al., 2005)*.

The results do indicate that mineral magnetic data can be used as a particle size proxy. However, this should only be attempted with caution as the relationship between magnetic concentration parameters and particle size properties are not necessarily universal. The data demonstrate the relationship between mineral magnetic concentration measurements and textural properties can be different for particular sedimentary environments even within the same overall sedimentary system and, in some circumstances, the mineral magnetic approach can be unsuitable as a particle size proxy. As a consequence, there is a need for a preliminary study to be undertaken for the particular sedimentary environment in question in order to validate the methodology. If such a study demonstrates that a strong correlation exists, mineral magnetic measurements can then offer considerable potential as a particle size proxy of use in geochemical, sediment transport and sediment provenance studies (*C.A. Booth et al., 2005)*.

3. COASTAL MAGNETICS AS A TOOL FOR MODELLING SEDIMENT DYNAMICS

A study currently underway is that of *Holden, 2005,* which is looking at modelling the geomorphology and sediment dynamics of the North Sefton coast, UK. Recent changes in the sedimentation balance of the area have caused concerns, with an influx of mud in a southerly direction creating potentially serious environmental, social and economic implications for the area. It is hoped that by using coastal sediment magnetics, amongst other factors, past, present and future sea-level changes can be derived and management policies can be put in place as a result.

3.1 GEOGRAPHICAL OUTLINE



(www.multimap.co.uk, 2005)

The Sefton Coast lies between the estuaries of the Mersey and Ribble in north-west England. The sand dunes, beaches and marshes of the Sefton Coast are one of the most important areas for nature conservation in Europe. The Sefton Coast is also an important visitor destination with popular bathing beaches, open countryside, and the seaside resort of Southport (http://www.seftoncoast.org.uk, 2005). The study area in question covers the coastline north of Southport Pier into the southern part of the Ribble estuary. The research project aims to provide a high-resolution analysis of the contemporary coastal processes occurring on the north Sefton coast. Investigation of contemporary sediment characteristics will aid subsequent modelling of potential future changes.

3.2 METHODOLOGY

A range of fieldwork based data collection techniques are currently being employed to obtain primary sedimentological data via various analytical techniques (notably environmental magnetics); to monitor spatial accretion rates; and to determine the historical nature of the sediment *(Holden, 2005)*. The contemporary sediment samples were collected and a sub-sample of the bulk sediment was retained from each sample to undergo environmental magnetics testing (Walden and Slattery, 1993). A portion of the remaining sample was separated into specific grain size fractions, namely sand (2mm to 63µm), silt (63µm to 4µm) and clay-sized (less than 4µm) materials. This was followed by a series of environmental magnetics tests on the bulk and individual size fractions of each original sample *(Holden, 2005)*. Further sediment samples were also collected from other regional sources (marine-based samples from the Irish Sea, Mersey estuary, Liverpool Bay, Formby Point, Dee Estuary, and terrestrial sources from the River Ribble, the River Yarrow and the River Douglas) . By fractionating these 'source' samples in an identical manner to the contemporary 'Southport' samples, and by then carrying out an identical set of magnetics measurements on these samples, it is then perceived that it will be possible to carry out a provenance analysis of the contemporary sediments from the salt marsh surface (Yu and Oldfield, 1993; Lees and Pethick, 1995; Walden *et al.*, 1997; and Lees, 1999). From there, it is envisaged that the origin of the contemporary sediments can be identified, allowing high resolution mapping of the sediment dynamics of the coastline *(Holden, 2005)*.

4. DISCUSSION

Previous magnetic studies of coastal and estuarine sediments have noted significant correlations between magnetic susceptibility and particle size. It is also hoped that with current studies such as that of *Holden, 2005*, sediment transport, as well as morphology will be able to be accurately modelled and provide a useful tool to coastal engineers and planners when implementing Integrated Coastal Zone Management.

5. CONCLUSION

The studies that have been described in this report indicate the value of the potential use of coastal magnetics in sediment transport and sediment morphology modeling.
It is imperative that because of their social, economic and environmental significance, coastal sediment dynamics are fully explored and understood, and are therefore able to be included in the strategies of coastal engineers, commercial activities, and conservation management plans (Viles & Spencer, 1995; French, 1997; Haslett, 2000).

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