Puglia 2003 - Final Conference
Project IGCP 437

Coastal Environmental Change
During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

Otranto / Taranto - Puglia (Italy) 22-28 September 2003
Quaternary coastal morphology and sea level changes

Project 437

Wilson G.[1], Lamb A.[1], Gonzalez S.[1], Leng M.[2], Huddart D.[3]

The Potential of Stable Carbon Isotope Analysis for Reconstructing Holocene Coastal Palaeoenvironmental Change in the Mersey Estuary, North West England.

[1]School of Biological and Earth Sciences, Liverpool John Moores University,
Liverpool L3 3AF E-mail: besgwils@livjm.ac.uk
[2]NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, Nottingham NG12 5GG
[3]School of Education and Community Studies, Liverpool John Moores University, Liverpool L17 6BD

Keywords: *Stable carbon isotopes, Mersey Estuary, Holocene coastal evolution, diatoms.*

Abstract

In light of the widespread evidence for global climate and sea-level change, reconstructing Holocene coastal evolution occupies a central role in the effort to predict future responses of coastlines to accelerating sea-level rise. Due to the value of coastal sediment deposits in understanding and therefore enhancing our predictive capability of coastal environmental change, much work has focused on ways to increase the accuracy of existing techniques, for example diatom analysis (Zong and Horton, 1999) and the pursuit of new techniques, for example testate amoebae analysis (Charman et al., 1998).

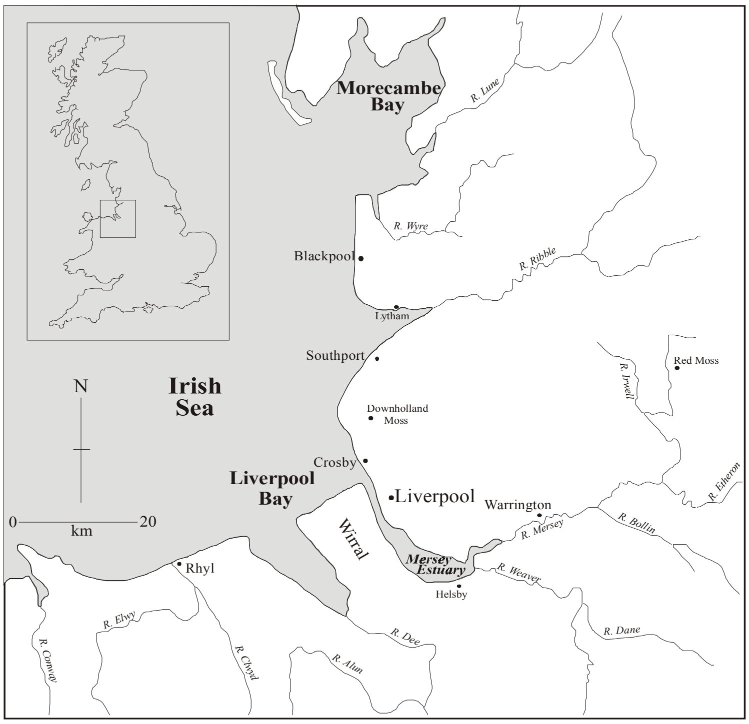

Figure 1. Location of the Mersey Estuary, North West England

Although diatom, foraminifera and pollen analysis have been widely and successfully used to accurately reconstruct sea-level change and associated coastal environments, they suffer several disadvantages. These may include dissolution, chemical and mechanical damage, varying degrees of preservation and occasional absence in the sediment record. Stable carbon isotope analysis has the potential of becoming an effective technique in the field of Holocene coastal reconstruction. The technique is free from some of the inherent difficulties of microfossil analysis outlined above, carbon is present in all coastal sediments for example, and its application in America has demonstrated great potential (Chmura and Aharon, 1995).

The salinity gradient evident in salt marshes promotes a zonation of vegetation governed by tolerance to tidal inundation. The succession from zones of freshwater species above the highest astronomical tide limit through to more salt tolerant species in the tidal zone is accompanied by a change in the carbon-12 to carbon-13 ratio ($\delta^{13}C$) of the vegetation. Freshwater plant species utilizing the C-3 photosynthetic pathway have $\delta^{13}C$ values which vary from -22 to -33‰, whilst salt tolerant species utilizing the C-4 photosynthetic pathway have $\delta^{13}C$ values which vary from –9 to –15‰. It follows that the bulk $\delta^{13}C$ value of coastal sediment deposits can be used to distinguish between a tidal or peritidal origin because the $\delta^{13}C$ value of the sediment corresponds to the vegetation that it supported (Malamud-Roam and Ingram, 2001). In the UK, C-4 plant species currently present in some salt marshes are not native.

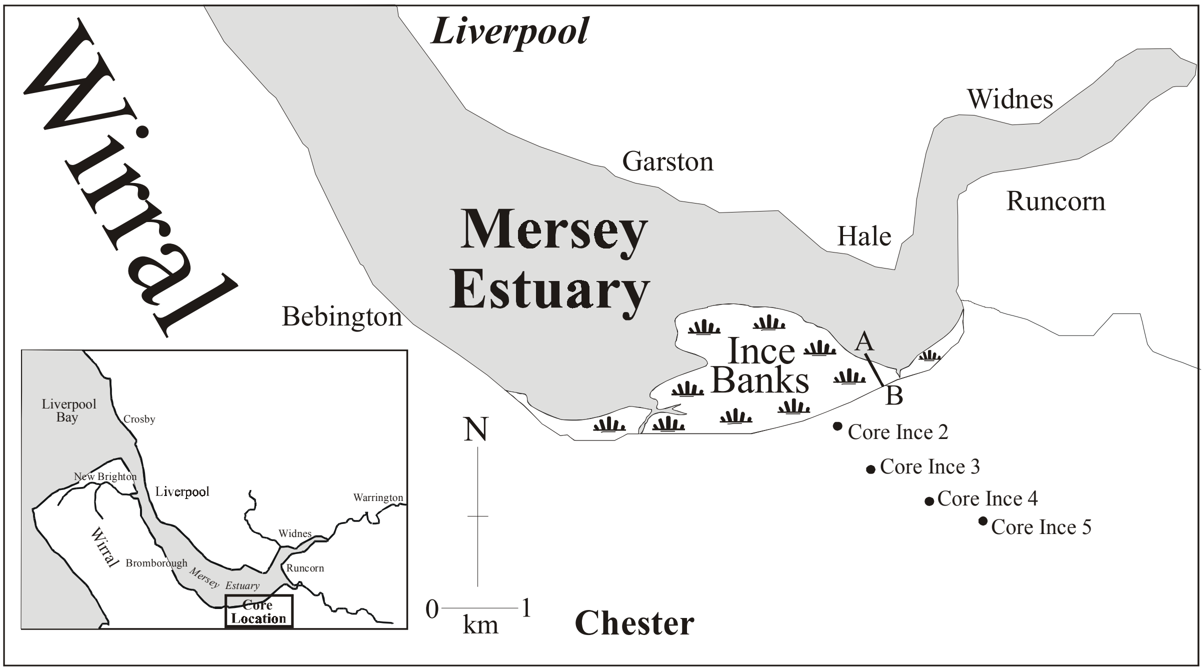

Figure 2. Location of core sites and Ince Banks sample transect

Therefore, UK Holocene coastal sediment deposits only exhibit stable carbon isotope ratios in the C-3 range. Although the range in stable carbon isotope values within C-3 species is still largely governed by salinity at the coast, the narrower range does make post-depositional changes in bulk δ^{13}C values more relevant. During decomposition, for example, the bulk δ^{13}C value of the sediment may shift by several per mil reflecting the concentration of the more resistant, and isotopically 'lighter', lignin fraction of the sediment.

This research aims to refine the use of stable carbon isotope analysis as a tool for coastal reconstruction. The stable carbon isotope composition of both the vegetation (whole plant and plant lignin) and the underlying surface sediments of Ince Banks, a salt marsh bordering the Mersey Estuary in North West England (Figure 1, 2), have been measured. The purpose of this is to determine whether the δ^{13}C value of the vegetation corresponds to the δ^{13}C value of the salt marsh sediment that supports it, and also to determine if each salt marsh zone has a characteristic carbon isotope value. This modern data set has been used to interpret the bulk sediment δ^{13}C values of several radiocarbon dated Holocene sediment cores taken from the marginal sediment deposits of the Mersey Estuary by the British Geological Survey (Figure 2). The accuracy of using stable carbon isotope analysis as a tool for elucidating Holocene coastal palaeoenvironments is assessed by comparison with diatom, pollen and particle size analysis of the sediments. The results of this research will determine whether stable carbon isotope analysis can be successfully applied to coastlines limited to C-3 plants. If so, this technique will provide a further proxy of relative sea-level change free from many of the problems associated with microfossil analysis.

References

Charman D.J., Roe H.M., Gehrels W.R. (1998). *The use of testate amoebae in studies of sea-level change: a case study from the Taf Estuary, south Wales, UK*. The Holocene, 8, (2), 209-218.

Chmura G.L., Aharon P. (1995). *Stable carbon isotope signatures of sedimentary carbon in coastal wetlands as indicators of salinity regime.* Journal of Coastal Research, 11, (1), 124-135.

Malamud-Roam F., Ingram B.L. (2001). *Carbon isotope compositions of plants and sediments of tide marshes in the San Francisco Estuary.* Journal of Coastal Research, 17, (1), 17-29.

Zong Y., Horton B.P. (1999). *Diatom-based tidal-level transfer functions as an aid in reconstructing Quaternary history of sea-level movements in the UK.* Journal of Quaternary Science, 14(2), 153-167.