Micropalaeontological Discrimination of Contourite and Turbidite Depositional Systems

Mike Rogerson[1] and Stuart Fielding[1]

1 Department of Geography, Environment and Earth Science, University of Hull, Cottingham Road, Hull, HU6 7RX, Hull, UK. M.rogerson@hull.ac.uk

Abstract: *Unambiguous recognition of ancient contourites remains problematic on sedimentological grounds alone. Identification of clear, unambiguous and simple tools that could be applied to depositional systems on multiple scales from outcrop to drill stem cuttings would have major application in both academic and industrial research. Benthic foraminiferal micropalaeontology appears to offer such a tool. Comparison of similar materials from a turbidite system (El Buho canyon and fan, Tortonian, Tabernas Basin, Spain; EB) and a contourite system (Gulf of Cadiz Contourite, southwest of Iberia; GC) provides three key points of difference: 1) most medium and coarse sand deposits in EB are barren of tests, whereas barren samples GC are rare; 2) diversity is higher in muds than in silts in EB, but the opposite is true for GC; 3) EB taxa show a tendency towards opportunism, whereas GC taxa contain abundant filter-feeding specialists. Considerably more data is needed before these differences can be concluded to be general and diagnostic, but the potential for micropalaeontology to provide strong support for traditional sedimentological approaches is clear.*

Key words: *Micropalaentology, ancient contourite, palaeo-ecology.*

INTRODUCTION

The record of ancient contourites is very limited, primarily because no simple, unambiguous basis for their identification has been established. This is problematic for the study of the geological record of contourites, but also for analysis of ancient oceanic sedimentation and for industrial studies of ancient sand deposits on the slope, the origin of which remains ambiguous. New tools for distinguishing contourite and turbidite depositional systems therefore remain key to unlocking the unique potential of contourite depositional systems.

One major environmental difference between channelized systems originating from turbiditic and contouritic processes is the variance of bottom velocity. Whereas in contourite systems bottom velocity at single sites varies over millennial timescales e.g. (Toucanne et al., 2007), in a turbidite system the passage of a single gravity flow event results in energy changes over the timescale of hours to days (Anschutz et al., 2002). Consequently, the bottom ecology in contourite systems will be in equilibrium with the bottom energy throughout deposition (Schönfeld, 2002), whereas in a turbidite disequilibrium ecologies will arise subsequent to sand emplacements events (Rogerson et al., 2006). This raises the possibility of discriminating the resulting deposits using benthic microfossils such as foraminifera.

RESULTS

Comparison of two depositional systems of similar water depth (500-1500m) and latitude (~35^{o}N) allows an initial investigation into the key points of difference between the benthic foraminiferal record of downslope-oriented channelized turbidite and contourite sequences. The channelized turbidite used here is the El Buho Canyon and Fan system (EBC; (Rogerson et al., 2006) of the Tortonian Tabernas Basin (SE Spain) and the contourite is the unusual downslope-oriented Gil Eanes Channel and Drift (GEC; (Rogerson et al., 2011) of late Quaternary-Holocene age in the Gulf of Cadiz (SE Spain).

Assemblages from both settings reveal more than one type of assemblage within deposits of the same age, depending on energy (i.e., grain size). On low-energy slopes, infaunal taxa dominate with high abundance of the epifaunal genus *Cibicidoides* (Table 1), indicating that background conditions in both settings are similar. Greater differences are found in sandy materials within the channels. Proximal sites in the GEC host a low density, low diversity assemblage dominated by elevated epibenthos such as *Cibicides lobatulus* (Schönfeld, 2002). In contrast, in the EBC all samples in the proximal canyon were found to be barren of all tests: it must be emphasised that mud-rich as well as non-muddy samples were inspected.

Sites within the channel axis from the GEC contain significantly more tests (>500 tests.g^{-1}) than similar deposits in the EBC (<150 tests.g^{-1}) and a different assemblage, dominated by either elevated epifauna such as *C. lobatulus* or taxa typical of much shallower water, such as the epiphyte *Planorbulina mediterranensis*.

Comparing muddy drift / fan settings, both settings display assemblages dominated by deposit feeding infauna, but the EBC assemblages contain more of the facultative anaerobe *Globobulima* spp.

Finally, the number of tests per gram are generally higher in the GEC.

Environment		Barren Samples %	Test density in tests.g^{-1}	Dominant Taxon
Proximal Channel	EBC	**100**	**0**	N/A
	GEC	14	117	***C. lobatulus***
Channel Axis	EBC	5	138	*Cibicidoides* spp.
	GEC	0	590	***P. mediterranensis***
Distal Channel	EBC	14	350	*C. laevigata*
	GEC	0	348	*C. laevigata*
Fan / Muddy Drift	EBC	5	500	***Globobulimina* spp**.
	GEC	0	488	*U. mediterranea*
Slope	EBC	0	450	*Cibicidoides* spp.
	GEC	0	10947	*C. dutemplei*

TABLE 1. Basic micropalaentological characteristics of similar environments in GEC and EBC. Highlighted text indicated potential diagnostic criteria.

DISCUSSION

The two systems show significant micropalaeontological differences, particularly in the higher energy environments. Below, we summarise the most important diagnostic criteria.

1) Barren or very low density assemblages in muddy, proximal turbidite settings

Whereas in the GEC, only one sample was found to be barren of benthic foraminifera not a single test was found in the proximal channel at EBC. Other samples in high-energy settings from the EBC show very low densities of ~10 tests per gram. This likely reflects exclusion of benthic fauna from the proximal channel due to disturbance, combined with export of tests during sand emplacement. Similar samples from the GEC are rarely barren, but contain an assemblage dominated by taxa adapted to living under strong bottom currents.

2) Abundant transported taxa in contourite channel sand.

Shallow-water taxa such as *P. mediterranensis* or *Elphidium* spp. occur in both systems, but only become common or even dominant taxa in GEC. Transported assemblages in GEC also vary down- channel, with heavier taxa (e.g. *E. crispum*) in [proximal settings and lighter taxa (e.g. *E. macellum*) in more distal settings. Experimental investigation into postmortem transportation of representative taxa confirms this pattern of spatial fractionation is reproducible and reflects the turbulent kinetic energy of the flow (Kelham et al., in prep).

The abundance of transported taxa on the GEC reflects sorting and concentration of these tests, which are supplied from the shelf alongside clastic sediment. The EBC does now show this concentration affect.

3) High organic matter deposition in proximal turbidite settings

The impact of transported refractory organic matter in turbidity-current dominated settings is well known (Fontanier et al., 2005), and in these settings high organic content can exclude all benthic taxa other tan facultative anaerobes. This is rare in GEC, which rarely become more eutrophic than indicated by *Uvigerina* spp. dominated assemblages. Recognition of these “anoxic pockets” in the distal channel and fan settings of turbidites is thus a useful diagnostic criterion.

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