

MICROPALAEONTOLOGY NOTEBOOK

Coiling directions in some Miocene planktonic Foraminifera

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ABSTRACT – We have measured the coiling directions of approximately 14 000 Miocene planktonic Foraminifera shells belonging to three lineages (*Dentoglobigerina altispira*, *Paragloborotalia mayeri* and *Fohsella* spp.) from sites in the Pacific (ODP Site 871) and Atlantic (ODP Site 925) oceans. Stratigraphic patterns in the preferred direction of coiling of these forms are assessed and their potential utility for biostratigraphic correlation is discussed. We find that all three lineages show a transition from approximately random coiling (although with a slight discernible sinistral bias in *D. altispira*) to sinistral predominance in both oceans, although the timing and pattern of change is different in each case. *J. Micropalaeontol.* 20(1): 29–30, July 2001.

INTRODUCTION

The ratios of dextral to sinistral coiling in trochospiral planktonic Foraminifera are potentially of use as biostratigraphic indices. Much of our knowledge of coiling trends in the most important lineages comes from the work of Bolli (1950, 1971) and Bolli *et al.* (1985), who suggested that lineages are typically characterized by an initial phase of random coiling, which is often followed by the development of a preference for either direction. Unfortunately, the trends indicated by Bolli in his synoptic text-figures are not supported by published data counts or sample locations, hence it is difficult to assess their significance and reliability. We note that the transitions in Bolli's papers are generally depicted as smooth and continuous which, if literally true, would imply very high potential for high-resolution biostratigraphy. More likely Bolli's figures were merely intended to show the general long-term pattern of change. In this contribution, we focus on the middle Miocene interval and present data for three prominent lineages (*Dentoglobigerina altispira*, *Paragloborotalia mayeri* and *Fohsella* spp.), with a view to testing the supposed trends and investigating their potential for biostratigraphic correlation.

We selected samples from two tropical Ocean Drilling Program sites, in the Atlantic and Pacific oceans (Site 871, Limalok Guyot, west Pacific [5°33.432'N, 172°20.658'E] and Site 925, Ceara Rise, western Atlantic [4°12.26'N, 43°29.35'W]). Samples range in age from 25.1 Ma (early Miocene) to 11.6 Ma (middle Miocene), and were assigned absolute ages according to the planktonic foraminiferal biostratigraphies of Pearson (1995) and Pearson & Chaisson (1997). From each sample, 150 individuals of each species were picked and their coiling directions recorded. The proportion of dextral individuals was recorded and the 95% confidence interval calculated.

RESULTS

D. altispira

The early evolution of this lineage is not characterized by strictly random coiling (as implied by Bolli *et al.*, 1985) because the early Miocene populations all show a significant sinistral bias, although this becomes more marked in later populations. The

transition to strong sinistral dominance begins about 18 Ma, approximately two million years before that indicated by Bolli *et al.* (1985). The transition is quite gradual, so it is probably of less utility for correlation than the other events considered in this study. There is a suggestion that the Pacific site may have a more pronounced sinistral bias in Zone N8 (which corresponds to approximately 16 Ma) than the Atlantic site, but high-resolution sampling of both sites would be required to confirm this.

P. mayeri

The initial coiling direction of this lineage may be random or slightly biased toward a sinistral preference. The main transition to populations <20% dextral occurs within Zone N8 in both Atlantic and Pacific cores and may provide a means of subdividing that biozone. The transition may have been slightly earlier in the Pacific, but increased sampling will be needed to confirm this. We also note that at the Pacific site a statistically significant but transient fluctuation towards a greater percentage of sinistrally coiled individuals was observed within Zone N7, corresponding to a time interval *c.* 1 million years before the main transition. This was not detected in the Atlantic.

Fohsella

This lineage shows substantial morphological evolution during the middle Miocene (Norris *et al.*, 1993) and has been used extensively in biostratigraphy, but its coiling preference has received little attention. In both Atlantic and Pacific cores, the transition from near-random coiling to a marked sinistral preference occurred near the base of Zone N12, which is the first appearance datum of the keeled *Fohsella fohsi* morphospecies. Although the utility of this gradual transition to correlate precisely between the Atlantic and Pacific is in doubt, the coiling shifts clearly post-date the coiling transition in *P. mayeri* in both instances. This observation contrasts with the suggestion of Bolli *et al.* (1985), who depict the coiling transitions of the *D. altispira* and *Fohsella* lineages as occurring nearly simultaneously. The coiling transition in the *Fohsella* lineage may coincide with a change in its depth habitat (e.g. Norris *et al.*, 1993).

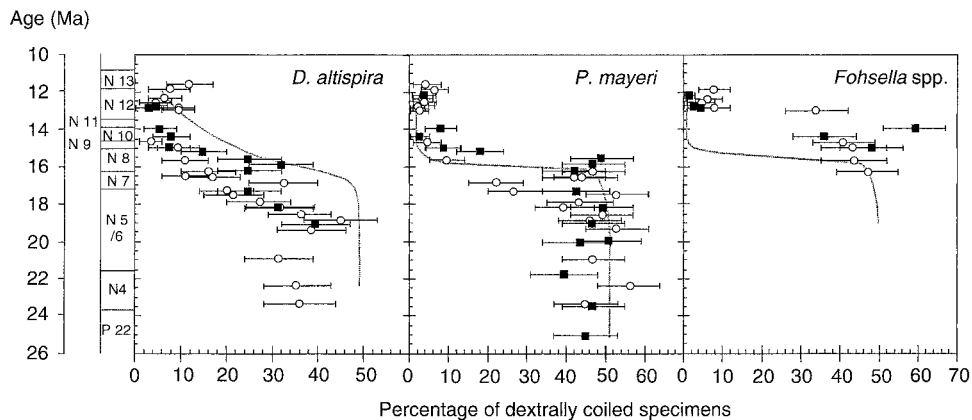


Fig. 1. Percentage of dextrally coiled specimens of three lineages of Miocene foraminifera from ODP Holes 871A, 925A and 925B. Error bars represent 95% confidence intervals of the proportions of dextrally coiled individuals. Also shown are the trends suggested by Bolli *et al.* (1985).

BIOLOGICAL MEANING OF COILING RATIOS

It is difficult to see what biological advantage there may be for a foraminifer to coil in a particular direction. The coiling direction of an individual foraminiferal shell is probably influenced by both genetic and ecophenotypic factors; the degree to which these factors are important may differ between species. Permanent global changes in coiling ratio seem to be best explained by genetic mechanisms, in the broadest sense. The 'species' identified in this study are broad morphological taxa used in biostratigraphy that may or may not represent 'biological' species, insofar as the concept can be applied to planktonic Foraminifera. Recent DNA sequencing research has suggested that modern planktonic foraminiferal morphospecies often constitute multiple cryptic 'species' that may have different characteristic coiling directions (e.g. De Vargas *et al.*, in press). Therefore, one genetic explanation for a permanent change in coiling ratio could be changes in the relative abundances of cryptic species through time, perhaps through competitive exclusion. The other end-member explanation would be to hypothesize a change in the shifting balance of coiling-determinant genes within a single evolving ancestral-descendant lineage. An intermediate model would be to hypothesize changes in the frequency of genetically distinct but not fully isolated demes having different characteristic coiling directions. These models cannot be tested here, except that we note there are no obvious morphological differences between right- and left-handed specimens of each lineage.

CONCLUSION

The coiling events identified in this contribution may prove to be of use in biostratigraphic correlation, despite the fact that they are not smooth and continuous as implied in Bolli's illustrations. The trends appear to be global and genetically controlled,

because it is difficult to envisage an ecophenotypic mechanism for driving them in populations that inhabit different oceans. The fact that all three lineages show a transition to sinistral dominance is probably coincidental. Certainly, the timing of the transitions is not precisely the same and we note that other lineages at other times show preferences for dextral coiling (Bolli *et al.*, 1985).

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