

# matters arising

## Corrected age of the Pliocene/Pleistocene boundary

THE recent report of Haq *et al.*<sup>1</sup> prompts the following criticisms.

*Gephyrocapsa oceanica* first appeared shortly after the Olduvai event in cores RC11-220, CH61-171, V16-205 and V12-18 (their Fig. 1). In the Le Castella type section it appeared well below the 'marker bed' (their Fig. 2), but in the compilation (their Fig. 5) it starts at the base of the 'marker bed'. Also *Globigerinoides obliquus* became extinct just after the 'marker bed' in the Le Castella section but in the compilation (their Fig. 5) it became extinct at or just below the 'marker bed'.

The following problems remain in spite of the slightly misleading title of their paper: first, there seems to be no reliable palaeomagnetic or radiometric date on the type Calabrian and until these data are forthcoming, unreliability will surround the positioning of the Pliocene-Pleistocene boundary.

Second, Haq *et al.* have failed to make a convincingly accurate correlation of the biostratigraphic events in the type section at Le Castella with some selected deep-sea cores. This is not surprising because in the Le Castella section two key species have stratigraphic ranges which clearly overlap *G. obliquus* and *G. oceanica*—while in all their examined deep-sea cores there is no such overlap. Is the Le Castella section therefore biostratigraphically atypical? Are Haq *et al.* hammering a square golden peg into a round hole at the top of the Olduvai event to make things fit? If the 'marker bed' at the Le Castella section is to be fixed by a golden peg then it will present us with nearly insurmountable problems of correlation. Therefore serious consideration must be given to the abandonment of the type section.

What we need is the judicious selection of a land section of marine rocks covering a period of 1–3 Myr which contains reasonably good microfossil fauna and flora as well as sediments which can be palaeomagnetically dated. With regard to this, we await the results of the long deliberations of the INQUA sub-commission on the Pliocene/Pleistocene boundary with mounting impatience.

Meanwhile, Selli's<sup>2</sup> estimate of the Pliocene/Pleistocene boundary of 1.85 Myr is apparently just as valid as the

Haq *et al.* estimate of 1.6 Myr; but neither is scientifically acceptable.

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1. Haq, B. U., Berggren, W. A. & Van Couvering, J. A. *Nature* 269, 483–488 (1977).
2. Selli, R. *Progr. Oceanogr.* 4, 67 (1967).

HAQ *et al.* REPLY—Jenkins draws attention to the inconsistency between some of the deep-sea cores and the Calabrian sections that we studied<sup>1</sup>, in that the upper stratigraphic range of *Globigerinoides obliquus* is not the same relative to the lower stratigraphic range of *Gephyrocapsa oceanica*. He concludes that we have "... failed to make a convincingly accurate correlation of the type section at Le Castella with some selected deep-sea cores..."

Sedimentation rates at Le Castella were moderately high, so that the 25–30 m of upward displacement of the *G. obliquus* LAD (last appearance datum) at Le Castella relative to its position in the biostratigraphy in the deep-sea cores is of the order of 0.1 Myr in equivalent time. The stratigraphic range limits of 10 other taxa that appear in more than one of the cores we studied (see our Fig. 1) show variations of comparable or greater (chronological) magnitude in several instances, but most experienced micropalaeontologists would hardly be surprised at this. Local discrepancies of this degree are the 'noise' or uncertainty that is inherent in biostratigraphy. Nor should it be necessary to point out that the observed last occurrence of any fossil, microfossils in particular, is more liable to vary from one place to another than its first appearance, due either to isolation of relict populations or to upward reworking.

It is, therefore, far more significant that the FAD (first appearance datum) of *G. oceanica* invariably occurs immediately above that of *G. caribbeanica* in the deep-sea cores and also at Le Castella, and that in every one of the cores in which these closely spaced FADs were observed, they bracket the upper boundary of the Olduvai Event. This is unequivocal evidence for the close correlation of the top of the Olduvai Event to the Pliocene/Pleistocene boundary, because the 'marker bed' at Le Castella is only 25–30 m higher than this pair of FADs in the boundary-stratotype section.

In view of the internal consistency of the combined planktonic microfossil data with a calibration of the boundary to an age of 1.6 Myr, we would answer Jenkins' rhetorical question: no, the slight overlap of the range of *G. obliquus* and *G. oceanica* at Le Castella but not in two deep-sea cores does not appear to be 'biostratigraphically atypical' any more than a four-leaf clover is biologically atypical.

Jenkins also wonders why we show the *G. oceanica* FAD and the *G. obliquus* LAD at Le Castella differently in two of our Figs. Our Fig. 2 represents the biostratigraphy as we found it in our samples from Le Castella. In Fig. 5, however, we depicted the 'marker bed' as a disproportionately thick band, equivalent to 0.05 Myr, to suggest our limits of biostratigraphic certainty and thus to give our summary a higher degree of probability. Therefore, the two datum events are pictured to coincide at the base of this 'fuzzy zone' because we cannot be certain that the true range of *G. obliquus* extends any higher, despite our observation. We regret that this change in viewpoint was not explained in detail.

We are accused of unscientifically trying to make the palaeontological data fit our preconceptions, which Jenkins describes as an attempt to force a round golden peg into a square hole. On the contrary, our philosophy is that gold is where you find it: our only preconceptions were that the boundary is already defined by the 'marker bed' at Le Castella, and that more micropalaeontological data from the critical Calabrian sections would help to resolve obvious anomalies in the published accounts that focused on fewer taxa. Dr Jenkins' preconception is apparently that all this effort is wasted because the Le Castella and Santa Maria di Catanzaro sections do not have palaeomagnetic control. We note in this context unceasing problems that have plagued palaeomagnetic correlations of the antipodeal Neogene in the absence of adequate micropalaeontological control<sup>2,3</sup>. The use of multiple overlapping biochronological criteria, which demonstrably reduces or overcomes the biostratigraphical 'noise' in correlation, is the fundamental tool in linking palaeontological and geophysical data in a stratigraphic time-scale<sup>4</sup>. To seize upon inconsistency in the range of one element in such a synthesis as evidence that we do not know what we