Variations of organic matter preservation documented in sediments from the tropical Indian Ocean

S. Schulte
F. Rostek
E. Bard

CEREGE, Université Aix-Marseille III et CNRS, Europole de l'Arbois, BP 80, 13545 Aix- en-Provence cdx 4, France

The causes of organic matter enrichment in recent marine sediments have been examined in some detail during the last two decades. Several studies have shown that total organic carbon (TOC) maxima often occur at intermediate depth on many continental slopes which often coincides with the depths where an oxygen minimum zone intersects the sea floor. This led to the simple view that the preservation of organic carbon is chiefly controlled by low bottom water oxygen levels (e.g. Paropkari *et al.*, 1993). By contrast other workers have proposed that organic enrichments are mainly a response to high biological productivity in surface waters leading to a high flux of biogenic material down to the sediments (e.g. Pedersen and Calvert, 1990).

In order to study the relationships between primary productivity, burial and preservation of organic carbon, we measured several biomarkers in core MD90963 which is characterized by large palaeoproductivity fluctuations as evidenced by means of transfer functions based on coccoliths and foraminifera distributions. This core was recovered near the Maldives platform (05°04′N, 73°53′ E; 2450 m water depth) during SEYMAMA expedition in 1990 (RV *Marion Dufresne*) and the overlying bottom waters are well oxygenated (3 ml/l).

We measured the concentrations of organic carbon (TOC wt.%) and of C_{37} alkenones (Tot-C_{37}alk), which are synthesized by a particular phytoplancton group (haptophytes). The total organic carbon content of core MD900963 varies between 0.2 and 0.9 wt.% during the last 330 kyr with highest values during glacial oxygen isotopic stages and lowest values during interglacial stages. The TOC-record is strongly correlated with the total C_{37}-alkenone (Tot-C_{37}alk) concentration record suggesting an enhanced primary productivity during glacial stages. This interpretation is strengthened by considering the high correlation between TOC and Tot-C_{37}alk profiles with two other palaeoproductivity records based on statistical transfer functions using coccoliths and foraminifera distributions. The correlation between TOC and Tot-C_{37}alk also confirms that the TOC variability is mainly related to marine productivity and not to the supply of terrestrial detritus. This finding is supported by the fact that the TOC record is poorly correlated with records of long-chain *n*-alkanes with a clear odd-over-even predominance indicative of terrestrial derived organic matter.

In addition to these proxies we measured the C_{35}/C_{31}-*n*-alkane ratio in the aliphatic fraction extractable by solvents. This C_{35}/C_{31} ratio has been shown (Schulte, 1997) to be enriched in surface sediments which are directly in contact with the oxygen minimum zone (OMZ) of the northern Arabian sea in which O_2 level reach values below 0.2 ml/l. Figure 1 shows the C_{35}/C_{31}-*n*-alkane ratios measured in a transect of box-cores located above, within and below the main OMZ (Schulte, 1997). Furthermore it has been shown that the isotopic composition of the C_{35}-*n*-alkane in a sample deposited within the OMZ differs significantly (up to 2 ‰ heavier) from a sample which was taken above the OMZ suggesting that this compound is contributed to the sediment by a special organism which lives under disaerobic conditions (Schulte, 1997). Due to the similar structures and chain length of C_{31} and C_{35} *n*-alkane, the C_{35}/C_{31} index should not be much influenced by diagenesis.

For the moment, we focused our analyses of core MD90963 on sediment sections corresponding to several maxima and minima of the Tot-C_{37}alk and TOC records. The C_{35}/C_{31} ratio varies between 0.16 and 0.68 with low values reflecting well oxygenated conditions and high ratios reflecting suboxic conditions. None of the measured C_{35}/C_{31} values reach the interval 0.8–1.4 which is typical of the modern sediments in contact with the core of the Arabian Sea OMZ (see Fig. 1). This suggests that at this location oceanic bottom waters did not become anoxic during glacial stages, in contrast with the conclusion by Sarkar *et al.* 1993. For the studied time period (180–250 kyr BP) the C_{35}/C_{31} and Tot-C_{37}alk records are positively correlated indicating that a

relationships exists between primary productivity and redox conditions. Rather than invoking a significant reduction of the bottom water O_2 concentrations we propose the following scenario to explain the correlation between C_{35}/C_{31} and Tot-C_{37}alk: An enhanced primary productivity during glacial stages resulted in an increased flux of organic matter leading to a much higher oxygen consumption. Suboxic conditions prevailed in the upper centimeters of the sediment column leading to the excess of C_{35} *n*-alkane. These observations and conclusions based on biomarkers are compatible with a companion study of authigenic trace metals in the same core (Pailler *et al.*, this issue).

References

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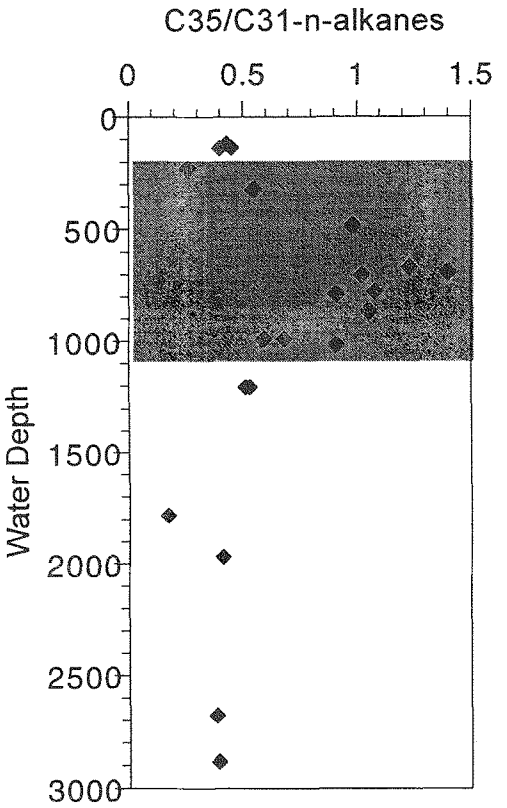

FIG. 1 C_{35}/C_{31}-*n*-alkane ratio of surface samples (upper 2 cm) off Pakistan versus water depth. The grey shaded area denotes approximately the depth range of the oxygen minimum zone.