Paleoceanographical Proxies

F. Jorissen, C. Barras, C. Fontanier, E. Geslin, E. Metzger, R. Schiebel, F. Cesbron, P. Diz, D. Langlet.

La reconstitution détaillée des climats du passé demande des proxies de plus et plus précis. Dans ce contexte, les foraminifères à tests carbonatés, qui sont préservés dans tous les milieux marins, sont précieux. Nous travaillons à la fois sur des proxies basés sur la composition des faunes et des proxies basés sur la composition chimique de leur test. A cause d'un besoin important d'équipement analytique sophistiqué, ces recherches font l'objet de nombreuses collaborations nationales et internationales. Dans ce domaine, nous apportons notre expertise dans l'élevage des foraminifères en conditions contrôlées. En ce moment, nous travaillons surtout sur des proxies de paléo-température, de paléo-salinité (rapports Mg/Ca, Sr/Ca, isotopes stables) et de paléo-oxygénation (composition des faunes, surface des pores, rapport Mn/Ca).

1. Paleotemperature and paleosalinity proxies based on benthic foraminiferal Mg/Ca ratios and $\delta^{18}O$ measurements

The Mg/Ca ratio of surface dwelling benthic foraminifera is the most popular proxy for the reconstruction of the temperature of oceanic bottom waters. For *Cibicides wuellerstorfi*, the existing calibration is based on core-top data in the 0-4°C range. We added measurements for samples in the 4-6°C range, thereby substantially improving the proxy calibration [6].

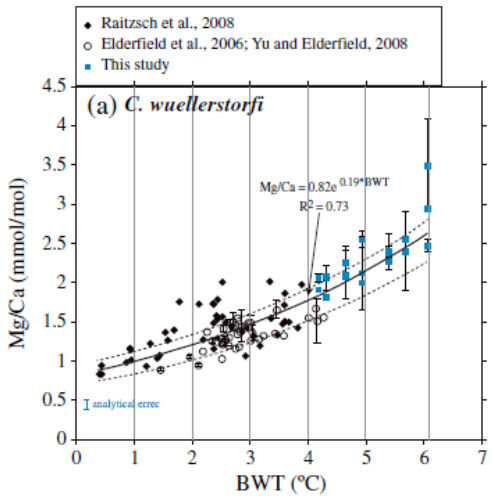

Fig. 1 : New calibration for the Mg/Ca ratio in *C. wuellerstorfi* as a proxy of bottom water temperature. [6].

The Mg/Ca ratio of the infaunal species *Bulimina marginata* shows only a weak relation with temperature [8]. Inter-individual variability is large, and is explained by: (1) an analytical error, (2) environmental effects, and (3) vital effect.

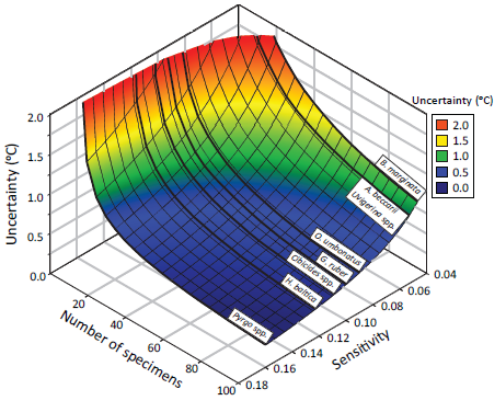

Fig. 2: Accuracy of Mg/Ca temperature calibration in function of the sensitivity of the calibration and the number of specimens measured. [8].

The intermediate water depth benthic foraminifer *Hyalinea balthica* constructs a high Mg carbonate test. Our temperature calibration, based both on core-tops and on tests grown in experimental conditions, shows that the Mg/Ca ratio of this species has a temperature sensitivity of ~12% per °C, which is about 4 times higher than in most deep-sea species [5]. We show that

the uncertainty in the reconstructions of bottom water temperature and salinity from paired Mg/Ca and $\delta^{18}O$ measurements of *H. balthica* is better than ±0.7°C for temperature and ±0.69 for salinity.
In order to unravel the influence of temperature and salinity on the test chemistry of the coastal species *Ammonia tepida/beccarii,* we cultured it under different temperatures and salinities [1,7]. No significant response of Mg/Ca and Sr/Ca was found to salinity, but Mg/Ca increased exponentially and $\delta^{18}O$ decreased linearly with temperature. The combination of Mg/Ca and $\delta^{18}O$ can be used to reconstruct seawater $\delta^{18}O$ and temperature.

2. Paleo-oxygenation proxies

In the Grevelingenmeer, part of an estuary closed 40 years ago, seasonal anoxia appears every year. A study of the living foraminiferal faunas shows that these intermittently anoxic environments do not contain viable faunas. A clear relationship between pore density and bottom water oxygenation has recently been shown for *Globobulimina turgida* [4], with a much higher pore density at lower oxygen concentration. At present, we develop a proxy of former bottom water oxygenation on the basis of pore patterns and Mn/Ca ratios measured in the same tests. (PhD thesis J. Petersen).

3. Taphonomical studies

Taphonomical processes are responsible for substantial differences between recent and fossil benthic foraminiferal faunas. When applying the composition of fossil faunas as paleoceanographical proxies, it is essential to understand the extent of these changes. In comparative studies of living and dead faunas from Cap Ferret and Whittard canyons, it appears that fossil faunas from open slope environments accurately reflect former ecosystem conditions. In submarine canyons this is no longer the case. In submarine canyons, the study of allochthonous elements incorporated in the fossil faunas can give insight in the sediment dynamics [2,3].

Collaborations

J. Bijma, A. Mackensen (AWI Bremerhaven)
S. Schmidt, S. Zaragosi (Bordeaux I University)
H. Kitazato, T. Yoyofuku (JAMSTEC, Japan)
C. Waelbroeck (LSCE)
L. de Nooijer, H. de Stigter, G. Reichart (NIOZ)
Y. Rosenthal (Rutgers University)
O. Friedrich (University of Frankfurt)
C. Slomp (Utrecht University)

Associated publications

[1] Diz, P., Barras, C., Geslin, E., Reichart, G. J**., Metzger, E., Jorissen**, F.J., Bijma, J., 2012. Incorporation of Mg and Sr and oxygen and carbon stable isotope fractionation in cultured Ammonia tepida. Marine Micropaleontology, 92-93, 16-28.

[2] Duros P., Fontanier C., de Stigter H. C., **Cesbron F., Metzger E., Jorissen F.J.,** 2012. Live and dead benthic foraminiferal faunas from Whittard Canyon (NE Atlantic). *Marine Micropaleontology*, 94-95, 25-44.

[3] Duros, P., Jorissen, F.J., Cesbron, F., Zaragosi, S., Schmidt, S., **Metzger, E., Fontanier, C.,** 2014. Benthic foraminiferal thanatocoenoses from the Cap-Ferret Canyon area (NE Atlantic). *Deep-Sea Research II*, in press.

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[6] Tisserand, A.A.,...., **Fontanier C., Jorissen F.J.,** 2013. Refining benthic foraminiferal Mg/Ca-temperature calibrations using core-tops from the western tropical Atlantic. Geochemistry, Geophysics, Geosystems, 14, 929-946.

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