Hypoxia and anoxia on continental shelves

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L'intensification des pratiques agricoles et la pression démographique grandissantes dans les environnements côtiers génèrent des flux de nutriments de plus en plus importants vers l'océan. La production primaire dans la zone côtière et sur les plateaux continentaux augmente et la dégradation de ces organismes génère une demande en oxygène très importante. Ceci est accentué par le fait que le maximum d'ensoleillement correspond souvent à un maximum de température et une stratification de la colonne d'eau plus importante. Le réchauffement climatique de ces dernières décennies accentue ces processus et diminue la solubilité des gaz comme l'oxygène rendant les épisodes d'hypoxie et d'anoxie plus fréquents et plus sévères dans des environnements aussi divers que les estuaires, les lagunes et aussi les domaines océaniques en bordure continentale comme les mers Baltique ou Adriatique.

1. How does anoxia affect diagenetic processes? In situ experimental approach

The sediment is a succession of redox fronts determined by the availability of organic carbon and different electron acceptors. While hypoxia is developing (Fig. 1 & 2), oxygen penetrates less into the sediment and redox fronts tend to migrate upward. Consequently, the sediment releases anoxic compounds such as free sulfide.

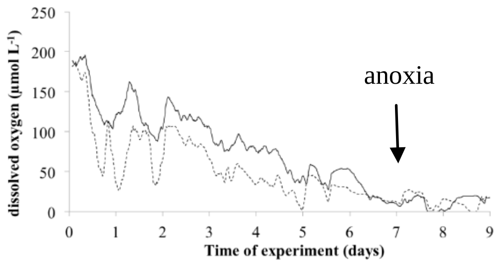

Fig. 1 : Oxygen concentration in the incubation chamber obtained in situ with microprobes. Anoxia is reached after 7 days.

In the experiment we conducted at Piran (Adriatic Sea), we observed such a migration. The death of macrofauna induced by anoxia generated an additional pulse of organic matter at the sediment surface, which was mineralized by sulfate reduction. It generated an inverse sulfide gradient never observed before. Metals responded to this peculiar situation and remained confined within the sediment. After 10 months, this process ran out of fuel (organic matter) and sulfide was oxidized by the sediment lattice [1].

Fig. 2 : incubation chamber after 10 months at 27 m depth in the northern Adriatic Sea.

2. How do benthic communities respond to anoxia? In situ experimental approach.

The in situ experience showed that the majority of the species of the benthic foraminiferal community survive up to 10 months of anoxia [2] (Fig. 3). The assemblage varied with time with some species being more sensitive and others more resistant to prolonged anoxia [3]. Some foraminiferal specimens seemed not only to respond to redox shifts but rather to increased organic matter content due to macrofaunal mortality.

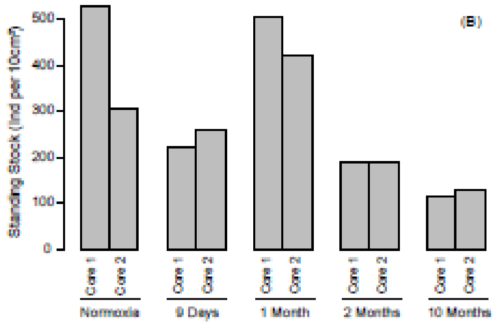

Fig. 3 : Foraminiferal standing stocks as a function of anoxia duration

3. Seasonal anoxia in the Grevelingenmeer

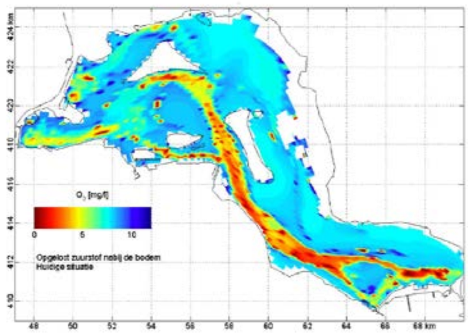

Fig. 4 : Bottom water oxygen concentrations in the Grevelingenmeer in July 2010.

The Grevelingenmeer is a former branch of the Dutch estuary, which has been closed about 40 years ago. Since then, it is the largest European salt water lake. Seasonal anoxia develop in the deepest parts in summer/autumn (Fig. 4). We studied the living benthic foraminiferal assemblages along a three stations bathymetric transect during various seasons (PhD thesis D. Langlet). At the sites affected by seasonal anoxia, benthic foraminiferal assemblages are very poor; it appears that these specimens do not represent viable populations, but rather isolated specimens which have been washed into the basin from shallower sites with higher oxygen concentrations The duration of the reoxygenation events (early winter – spring) are too short, apparently, to allow a full recovery of the deep benthic ecosystems.

Collaborations

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Publications

1 - **Metzger, E., Langlet, D.**, Viollier, E., Koron, N., Riedel, B., Stachowitsch, M., Faganeli, J., Tharaud, M., **Geslin, E.** and **Jorissen, F.**: Artificially induced migration of redox layers in a coastal sediment from the Northern Adriatic, *Biogeosciences Discuss.*, 10(7), 12029–12063

2 - **Langlet, D., Geslin, E.**, Baal, C., **Metzger, E.**, Lejzerowicz, F., Riedel, B., Zuschin, M., Pawlowski, J., Stachowitsch, M. and **Jorissen, F. J.**: Foraminiferal survival after long-term in situ experimentally induced anoxia, *Biogeosciences*, 10(11), 7463–7480

3 – **Langlet, D.**, Baal, C., **Geslin, E., Metzger, E.**, Zuschin, M., Riedel, B., Risgaard-Petersen, N., Stachowitsch, M. and **Jorissen, F. J.**: Foraminiferal species responses to in situ experimentally induced anoxia in the Adriatic Sea, *Biogeosciences Discuss.*, 10(7), 12065–12114