Adriatic hydrographic changes since 17 000 yrs as recorded by bioevents and foraminiferal stable isotopes

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It is becoming increasingly clear that variations in physical parameters of the sea water in conjunction with variations in the kind and availability of prey are major driving forces accounting for planktonic foraminiferal occurrences and abundances. The 8 ecozonations which have been identified within the last deglacial time interval in the Adriatic Sea (BORSETTI *et al*, this volume) invoke important hydrological changes. On the basis of these zonations, we propose the following hydrographic scenarios.

During the time interval corresponding to ecozone 8, the global sea level rise was rather weak (FAIRBANKS, 1989). Poorly stratified and cool waters still favoured the permanency of deep living species like *Globorotalia scitula* as well as other "cold" indicator species.

The successive ecozone 7 corresponds to the first deglacial freshwater discharge in the Adriatic and to an important global sea level rise. This situation may have induced a significant density stratification with nutrient rich waters from continental origin invading part of the basin. The surface production increased, favouring diatom blooms and foraminiferal species predating on them, such as *Globorotalia truncatulinoides*. The shoaling of the pycnocline and the formation of a deep chlorophyll maximum favoured the presence of abundant dextral *Neogloboquadrina pachyderma*.

Ecozone 6 corresponds to the classical Younger Dryas pause. In the Adriatic Sea, this climatic event appears strongly marked. The oxygen isotope record indicates that during this time interval freshwater discharges completely ceased. The permanency of Neogloboquadrinids however suggest that a deep chlorophyll maximum was still present. This may be explained by the fact that at that time, the Northern Hemisphere insolation reached its maximum at mid latitudes. The related seasonal stratification invoked the formation of a deep chlorophyll maximum.

Ecozone 5 corresponds to the beginning of the more recent fresh water discharge. Nutrient rich waters invaded again the Adriatic basin inducing an important surficial production, as suggested by the occurrence of foraminiferal species which predate on phytoplancton.This fact may have been associated with a seasonal shoaling of the thermocline, as suggested by the first entry of levantine species.

Ecozone 4 is marked by a rather important oligotrophism of surface waters. Only carnivorous foraminiferal species such as *Globigerinoides ruber ruber, Orbulina universa, Globigerina calida* and *Globigerina digitata* are dominant. The stratification of the water masses reached its maximum. Superimposed to the freshwater discharges, important precipitations may have occurred in the northern part of the Mediterranean basin . This in turn induced a strong salinity decrease, which prevented deep water formation in the Adriatic basin. This episod corresponds in fact to the deposition of Sapropel S1 in the Eastern Mediterranean and of low oxygenated levels in the South Adriatic basin.

During the time interval corresponding to ecozone 3, foraminiferal oxygen isotope data record a decrease in the freshwater discharge. The reappearance of species related to a deep chlorophyll maximum (*Neogloboquadrina pachyderma*) together with the last occurrence, in the Adriatic, of *Globorotalia inflata*, indicates a strong seasonal contrast with deep winter vertical mixing followed by the occurrence of a shallow pycnocline during intermediate season.

Ecozone 2 indicates important changes in the depth of the mixed layer. A good reoxygenation of the water column is supported by the presence of well diversified benthic associations.

Ecozone 1 corresponds to the present day hydrographic situation, withl a clear seasonal surficial oligotrophism.

The data, on their whole, suggest that foraminiferal associations with strong western affinities prevailed within the Adriatic basin throughout the entire deglaciation, until about 9.5 kyrs. After these date, they were replaced by species with clear levantine affinities which still dominate the present day association.

REFERENCES

BORSETTI A.M., ASIOLI A., CAPOTONDI L., COLANTONI P. and VERGNAUD-GRAZZINI C. 1992. - Adriatic hydrographic changes since 17,000 yrs. as recorded by bioevents and foraminiferal stable isotopes. This volume

FAIRBANKS R.A., 1989. - 17,000 yrs. glacio-eustatic sea level record : influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation. *Nature*, v. 342, pp. 637-642.

High resolution biochronology for the last deglacial period in the Adriatic sea, based on planktonic foraminiferal associations and oxygen isotope stratigraphy

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Biostratigraphic events

Five major biostratigraphic events have been recognized in the Adriatic sea for the last 17000 years. High resolution oxygen isotope stratigraphy on four selected cores, IN68-5, 9, 10 and 21 together with ^{14}C radiocarbon and AMS datings, allow us to date these events precisely as follows :

-Last occurrence of *Globorotalia scitula*, dated at about 13.5 kyrs BP;

-First strong reduction in dextral *Neogloboquadrina pachyderma* percentages, dated at about 10 kyrs BP;

-Last occurrence of *Globorotalia inflata* around 5 kyrs BP;

-Last occurrence of *Globorotalia truncatulinoides* at about 9.5 kyrs BP;

-Abrupt entry of the warm species association: *Globigerinoides ruber ruber, Globigerina calida ,Globigerina digitata*, at about 9 kyrs BP.

Local Adriatic Biozonation

On the basis of these major events, of quantitative changes in the abundances of some species as well as of temporary disappearances or reappearances, the following eight biozones can be identified :

- Biozone 8, up to 13.5 kyrs BP : the top of this zone is defined by the last occurrence of *Globorotalia scitula* and a strong increase in dextral *Neogloboquadrina pachyderma* percentages from about 20% to 40%. The association is almost completely constituted by "cold species" whereas *Globigerinoides ruber* group and *Neogloboquadrina dutertrei* are present with very low percentages.

- Biozone 7, from 13.5 to 11.5 kyrs BP : this zone is characterized by an increase in the percentages of the *Globigerinoides ruber* group and *Globorotalia inflata* (near 10%) and by the occurrence of *Globorotalia truncatulinoides* at very low percentages.

- Biozone 6, from 11.5 kyrs to 10 kyrs BP : in this zone, the *Globigerinoides ruber* group is completely lacking, *Neogloboquadrina dutertrei* generally occurs with percentages around 5%. The top of this zone is marked by the abrupt reduction in *Neogloboquadrina pachyderma* percentages.

- Biozone 5, from about 10 kyrs to 9 kyrs BP : this zone is characterized by the reappearance of *Globorotalia inflata* and of the *Globigerinoides ruber* group and by a brief and last occurrence of *Globorotalia truncatulinoides*. In this biozone, we have also the first occurrence of the "warm" species *Globigerina calida* and *Globigerina praecalida* .

- Biozone 4, from 9 kyrs to 8 kyrs BP : this zone is easily recognized by the high frequencies of "warm" species such as *Globigerinoides ruber ruber, Orbulina universa, Globigerina calida,* and *Globigerina digitata* which can account for 70 to 80 % of the whole association. *Globigerina bulloides* and *Globigerina quinqueloba* are also present . In the same interval one can also note that radiolarians and diatoms can be present while benthic foraminifers are absent.

- Biozone 3, from about 8 kyrs to 6.5 kyrs BP: this zone is characterized by the last occurrences of *Globorotalia inflata* and dextral *Neogloboquadrina pachyderma* in the Adriatic Sea with total percentages around 20%.

- Biozone 2, from 6.5 to 5. kyrs BP : this interval is characterized by the relative high frequencies of *Globigerinoides ruber ruber, Globigerinoides trilobus* and *Globigerinoides sacculifer*. The benthic foraminiferal associations is also rich and well diversified.

- Biozone 1, from 5 kyrs BP to the present : this zone is characterized by the modern association of "warm" species such as *Globigerinoides ruber* group, *Globigerinoides trilobus, Globigerinoides sacculifer*, low frequency of *Globigerina praecalida, Globigerina bulloides and Globigerina quinqueloba* are also present.

This ecozonation is different from those observed in other West and East Mediterranean areas. The time distribution of many species does not appear to be linked to surface temperature changes alone : this is the case for *Globorotalia truncatulinloides* or dextral *Neogloboquadrina pachyderma*, which may occur either during the earlier cold phase of the deglaciation or during the Holocene. This underlines the fact that hydrographic changes as well as eustatic and tectonic sea level changes are important forcing parameters for the biological components.