Deoxygenation of the southwestern margin of Baja California Peninsula: A foraminiferal-based record over the last 1 kyr

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Introduction

The zones of minimum oxygen (OMZ) are characterized by a concentration of dissolved oxygen (DO) <0.5 ml L^{-1}. In situ measurements of DO concentration suggest that the upper boundary of the OMZ is shallower than it was 60 years ago on a global scale, due to global warming. Numerous investigations have allowed us to understand how global warming can cause changes in the OMZ in the future. However, predictions of future changes in the OMZ require understanding of its past spatial and temporal variability. Benthic Foraminifera (BF) associations have been widely used in paleoceanographic investigations because these microorganisms have an extensive global distribution. Based on BF associations, a classification of oxygenation levels in the benthic environment has been established throughout the Northeast Pacific. The present research aims to analyze the diversity indices of BFs to infer the concentration of DO in the southwestern margin of Baja California Sur during the last 1200 years. The following methodology will be used: quantification of the percentages of disoxic, hypoxic and oxic foraminifera; calculate the BF association index and estimate the OD concentration, under the assumption that in the warm periods of the Holocene would expect to find BF associations indicative of severe hypoxic conditions and in the cold periods BF associations that suggest oxic conditions. These expected results will be contrasted with geochemical tracers, trace elements (TE) that corroborate severe hypoxic conditions in the Holocene Climatic Optimum and Medieval Warming, and oxic conditions in the Dark Age and Little Ice Age (LIA).

Study Area

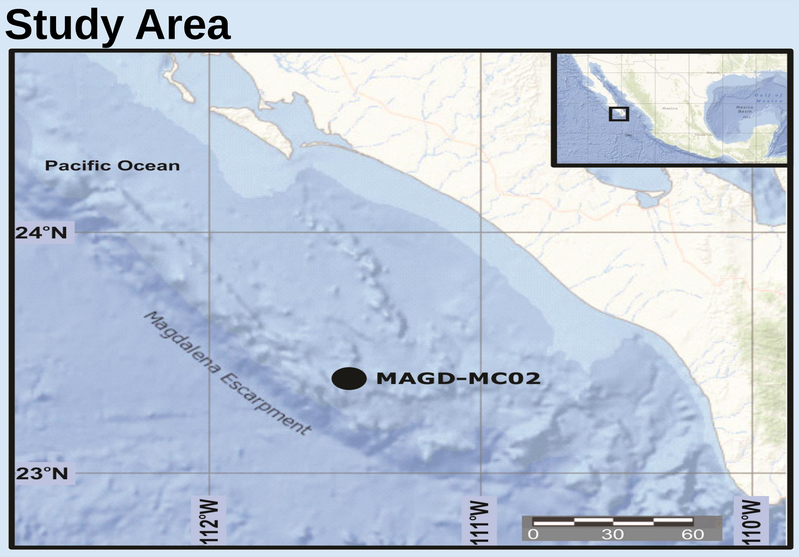

Fig. 1: Location of multicore MAGD-MC02 in Magdalena margin, Mexico (Sánchez et al 2016).

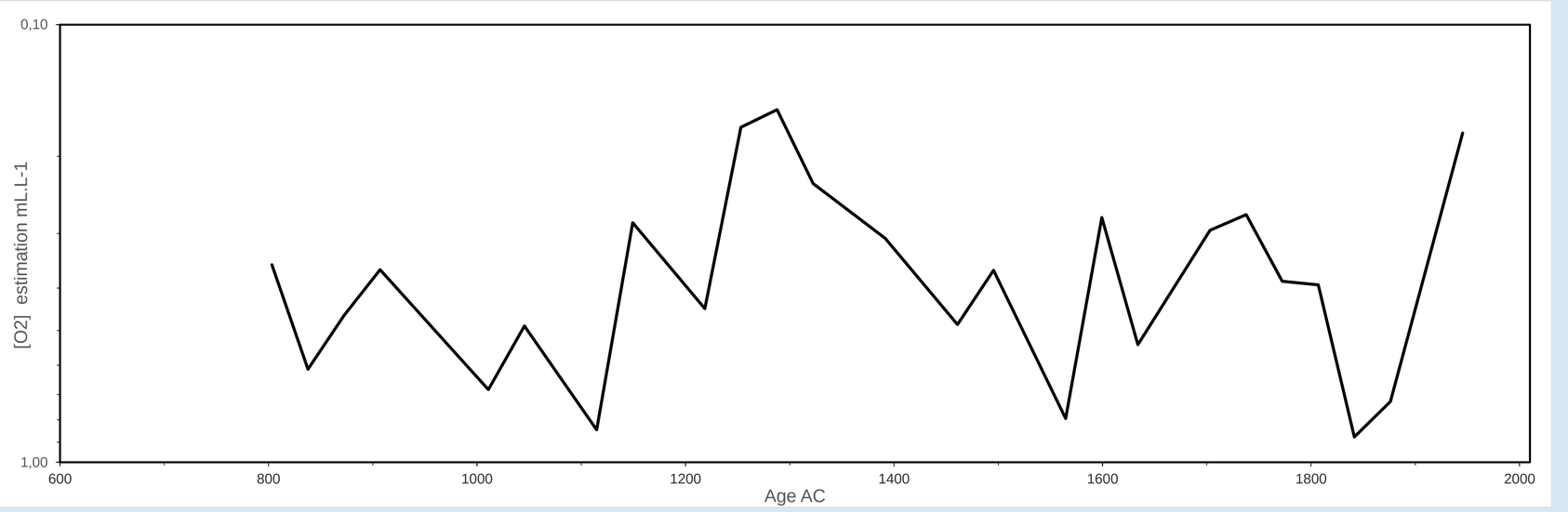

Fig. 3: Estimation of oxygen value over the last 1200 years in the southwestern margin of Baja California Peninsula.

Methods

A 42 cm sediment multicore MAGD-MC02 was recovered at 680 m of depth in the Magdalena margin during October 2009. It covers approximately the last 1200 years and was sampled at 1-cm intervals to obtain a high-resolution record of benthic foraminifera. A principal component analysis (PCA) was performed to identify the most significant species and a correspondence analysis (CA) was used to gather the samples according to their faunal composition and to investigate the taxonomic composition of samples in response to ecological trends.

BFAI = % dysoxic benthic forams - % oxic benthic forams

$$[O_2] = 0.317 \times \exp^{-0.0212 \times \text{Índice AFB}}$$

(Tetard et al., 2017, 2021)

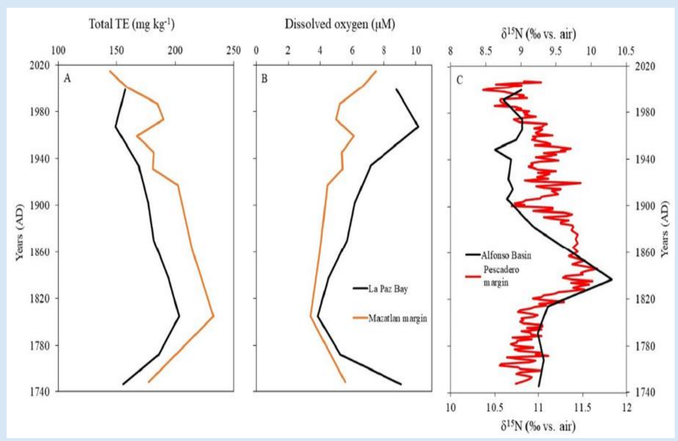

Fig. 4: (A) Total trace element content (V, Mo, U, and Ni) in the Alfonso Basin (Choumiline et al., 2019) and the Mazatlán margin (Nameroff et al., 2002; Ontiveros- Cuadras et al., 2019). (B) Dissolved oxygen concentration calculated from the exponential regression model in Fig. 3. (C) δ15N values of sedimentary organic matter in the Alfonso Basin (Ricaurte-Villota et al., 2013) and Pescadero margin (Tems et al., 2016). Note the change in scale in the $\delta^{15}N$ values of both sites, which is higher in the Alfonso basin (Sánchez et al 2022A).

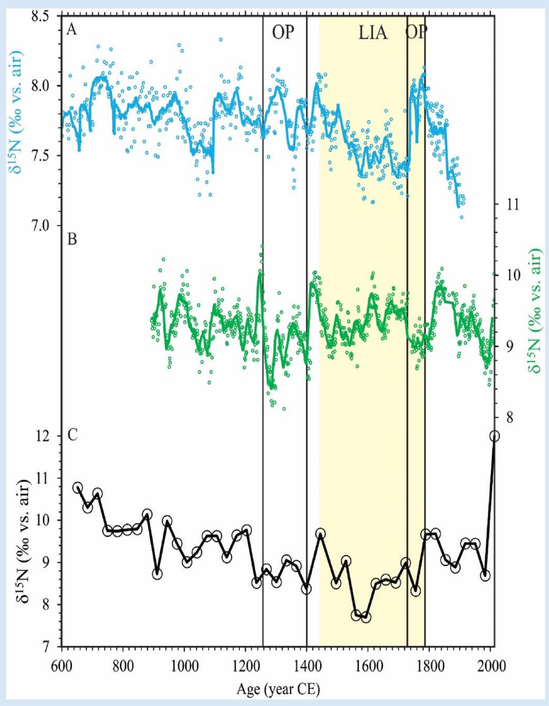

Fig. 5: Comparison of $\delta^{15}N$ of organic matter from (A) Santa Barbara Basin (cyan solid line, Wang et al., 2019), (B) Pescadero margin (green solid line, Tems et al., 2016) and (C) Magdalena margin (black solid line). Note the scale shift in $\delta^{15}N$ (‰ vs. air) for the Pescadero margin and Santa Barbara Basin. Cyan and green lines represent running averages of the Santa Barbara Basin and Pescadero margin. The yellow rectangle represents the Little Ice Age (LIA), and the empty rectangles represent the out-of-phase (OP) periods between the Santa Barbara Basin vs. the Pescadero and Magdalena margins (Sánchez et al 2022B).

Results

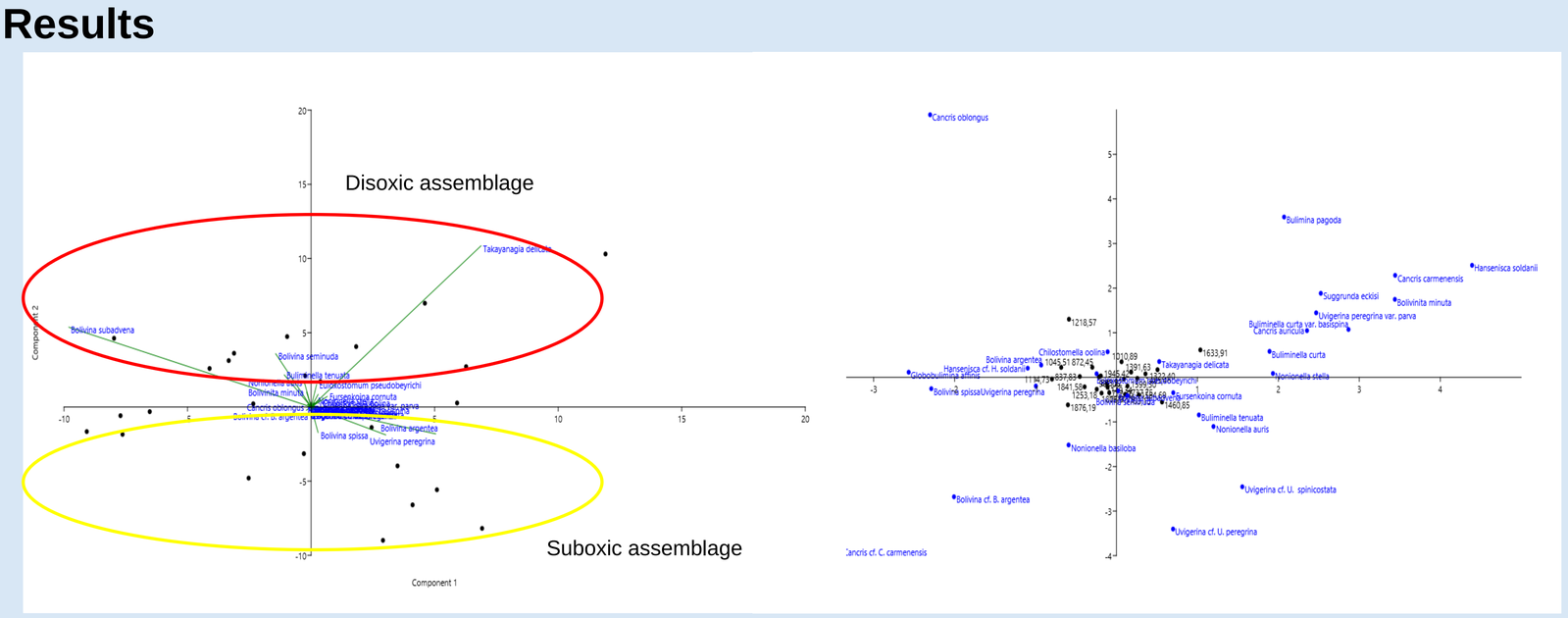

Fig. 2: Biplot of the principal component analysis (left) and correspondence analysis (right) based on the species abundance data set.

Conclusions

1. During the period of AC 1100 to 1350 (LIA), the estimation of $[O_2]$ from the BF assemblage suggests oxic conditions in the water column, simultaneously in this same period of time, the low content of biogenic opal and organic carbon indicate decreased productivity, indicating unfavorable conditions for upwelling development, a weak California Current, and a strengthened and/or more easterly Aleutian low pressure. On the other hand, the $\delta^{15}N$ of bulk sedimentary matter in the Magdalena margin points to a decrease in water column denitrification during the LIA.

2. From AC 1400 to the present, the estimation of $[O_2]$ from the BF assemblage suggests hypoxic conditions, on the other hand, the $\delta^{15}N$ values exhibited high values and the biogenic opal and organic carbon contents showed a constant increase, and this suggests favorable conditions for the development of upwelling due to the strengthening of a high pressure center of the North Pacific and the California current.

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