Carbonate – Biogeochemistry of the Benguela Upwelling

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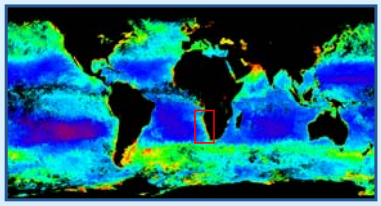

Fig.1: Benguela Upwelling Region

Introduction

➢ The Benguela is one of the 4 major eastern boundary current upwelling systems which are the most productive regions in the ocean.

➢ A major motivation to study the ocean carbon cycle is its importance in controlling the atmospheric CO_2 concentration.

➢ Latest results of carbonate and nutrient chemistry obtained during the GENUS expedition MSM17-3 in February 2011 are presented.

Results – Walvis Bay Transect (-23°S)

➢ N:P ratio at the offshore stations are in good agreement with the mean Redfield ratio. Maximum PO_4^{3-} concentrations didn´t exceed 2.3 µmol l^{-1}. On the shelf the N:P ratio decreased due to a preferential loss of NO_3^- and/or a preferential input of PO_4^{3-}. Maximum PO_4^{3-} concentration of 4.7 µmol l^{-1} is twice as high as the offshore values (Fig.2).

➢ The DIC: PO_4^{3-} ratio at the offshore stations matches the global mean ratio of 117:1. If the PO_4^{3-} concentrations exceed 2.3 µmol l^{-1} the ratio decreases to 60:1 which is also found at the shelf stations (Fig.3).

➢ An overall DIC:AOU ratio of 0.88 (r^2=0.93) (not shown) slightly exceeds the mean Redfield ratio of 106:138 (= 0.76).

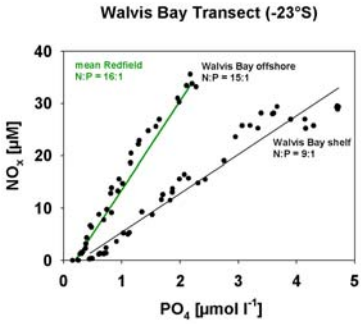

Fig.2: N:P ratios of the transect stations

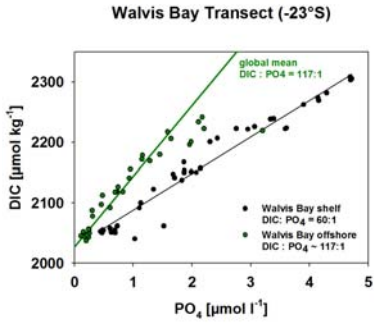

Fig.3: Correlation of DIC and PO_4 of the transect stations

➢ The highest DIC concentrations of up to 2300 µmol kg^{-1} were measured in bottom and coastal surface waters due to inputs of DIC across the sediment water interface and coastal upwelling (Fig. 4).

➢ An increasing DIC reduces the pH (Fig.5) and the carbonate ion saturation state ($\Omega \leq 2$) in bottom and coastal surface waters (Fig.4).

➢ Bottom water samples obtained from three multicorers showed an elevated pH implying the dissolution of $CaCO_3$ in the surface sediments.

➢ The solution of $CaCO_3$ increases the pH of the overlying waters (Fig.5) and the associated inputs of DIC could explain the enhanced DIC:AOU ratio.

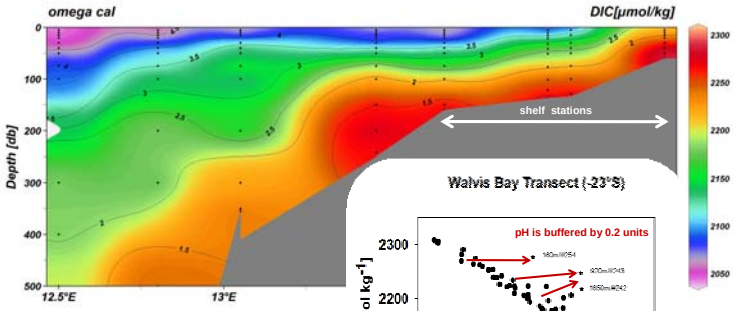

Fig.4: Distribution of DIC [µmol kg^{-1}] (color shading) and carbonate saturation state [Ω cal] (isolines) along the -23°S transect.

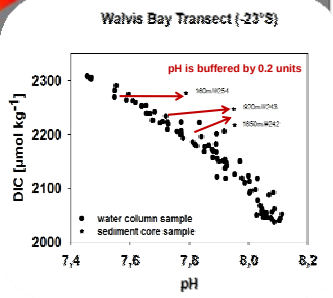

Fig.5: Correlation of DIC [µmol kg^{-1}] and pH for water column samples (black dots) and sediment core samples (black stars).

Conclusion

- **The results show a pronounced separation of offshore and shelf stations in terms of their Redfield-behavior along the Walvis Bay Transect.**
- **The reasons seem to be a preferential loss of nitrate due to denitrification and/or Anammox and inputs of phosphate across the sediment water interface.**
- **High organic matter decay increases the DIC levels and decreases the carbonate saturation state which in turn leads to carbonate solution in shallow sediments.**
- **Assuming that the nitrate loss can be compensated by N-fixation, our results imply an efficient biological pump due to an effective recycling of phosphate.**

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