Assessing the effect of salinity on foraminiferal Mg/Ca by culturing *Bulimina marginata*

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Introduction

Climates of the past can only be reconstructed with the help of a variety of proxy relationships. One of these proxies is the Mg/Ca ratio of calcite tests of foraminifera which are often used to reconstruct past temperatures of the water column. Other parameters, such as salinity, alkalinity and Mg/Ca ratio of the seawater are, however, also potentially influencing foraminiferal Mg/Ca. Foraminifera have been cultured varying these parameters to study these effects on Mg/Ca. Salinity is often varied by adding or evaporating water, causing major changes in the carbonate chemistry of the seawater, potentially obscuring the Mg/Ca-salinity relation (Nürnberg et al., 1996, Lea et al., 1999). Here we evaluate for the first time the influence of salinity on the Mg/Ca ratio of benthic foraminifer species *Bulimina marginata* independently by keeping all other parameters constant.

Methods

Salinity	34.1	36.7	39.5
Gravimetric Salts	(g)	(g)	(g)
NaCl	23.9260	27.2814	30.6916
Na_2SO_4	4.0080	4.5701	5.1413
KCl	0.6770	0.7719	0.8684
$NaHCO_3$	0.1960	0.1960	0.1960
KBr	0.0980	0.1117	0.1257
$B(OH)_3$	0.0260	0.0260	0.0260
NaF	0.0030	0.0034	0.0038
Volumetric Salts	(ml)	(ml)	(ml)
1M $MgCl_2$	52.80	60.20	67.73
1M $CaCl_2$	10.30	11.74	13.21
1M $SrCl_2$	0.10	0.11	0.13

Table 1: Formula for Artifical Seawater (1 kg) preparation (Kester et al., 1967)

- Salinity is varied by changing the concentration of salts in each solution according to Table 1
- Each solution is mixed with 1 kg of Natural Seawater of 35 psu
- Experiments are placed in a 10°C climate room and bubbled with air to maintain equilibrium with the atmosphere (pCO_2)
- Newly grown chambers are recognised under the Fluorescent microscope using Calcein staining
- Mg/Ca ratios are measured by Laser Ablation-ICP-MS

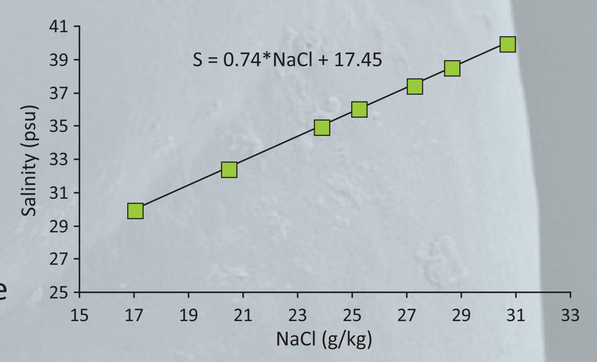

Figure 1: NaCl concentration for 1 kg Artificial Seawater mixed with 1 kg of Natural Seawater versus salinity

Experiment

- Alkalinity, Salinity, Temperature and Mg/Ca ratio of seawater are constant during the experiment

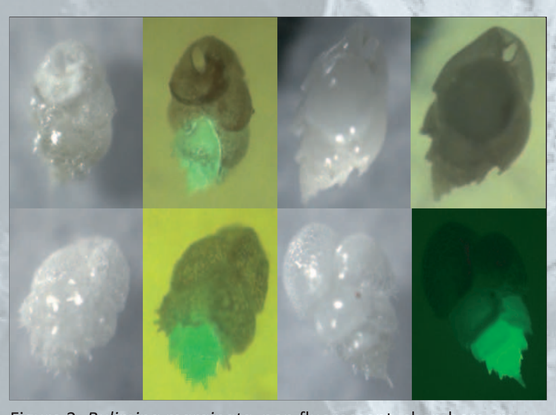

Figure 2: *Bulimina marginata*, non fluorescent chambers are grown in the experiment

	Temperature (°C)	Salinity (psu)	Alkalinity (µmol/kg)
S 34.1	10.82	34.13	2505.0
σ	0.13	0.16	39.0
σ %	1.24	0.47	1.6
S 36.7	10.80	36.68	2488.8
σ	0.10	0.25	31.3
%	0.97	0.69	1.3
S 39.5	10.87	39.51	2496.5
σ	0.12	0.16	28.9
σ %	1.13	0.41	1.2

Table 2: Seawater parameters of the experiments

	34.1	36.7	39.5	Average	σ	%
Temperature	10.82	10.80	10.87	10.83	0.03	0.32
Salinity	34.13	36.68	39.51	36.78	2.69	7.31
Alkalinity	2505.0	2488.8	2496.5	2496.8	8.1	0.3
DIC	2259.6	2213.0	2244.7	2239.1	23.8	1.1
pH	8.13	8.16	8.08	8.12	0.04	0.48
HCO_3	2062.8	2001.1	2047.5	2037.1	32.1	1.6
CO_3^{2-}	181.9	198.6	181.2	187.2	9.8	5.3
CO_2	15.0	13.4	16.0	14.8	1.3	8.9
Ω_c	4.36	4.68	4.19	4.41	0.25	5.7

Table 3: Carbonate system parameters. Parameters are calculated with the CO_2sys program of Lewis and Wallace, 1998

- Carbonate system parameters of the experiment are constant and calculated from Alkalinity and Dissolved Inorganic Carbon (DIC)

Figure 3: Experiment setup

Discussion

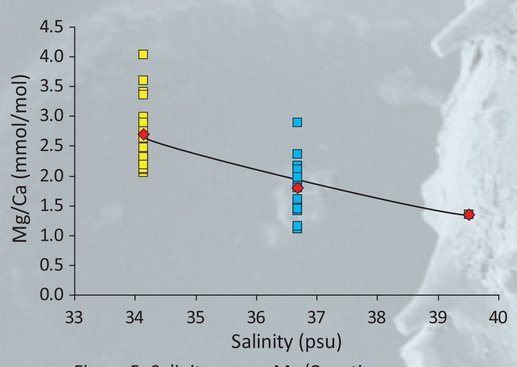

Figure 5: Salinity versus Mg/Ca ratio

Preliminary results from this study suggest a negative correlation between Mg/Ca and salinity. This is in contrast to relations found in previous culture studies (Nürnberg et al., 1996, Lea et al., 1999). In the current study salinity is varied by adding different amounts of salts to each solution, which influences ion activity. At higher salinity ions interact more with each other, leading to complexation, which could be different for Mg and Ca. Alternatively foraminifera adjust the composition of the calcification fluid, by removing Mg^{2+}, which is a calcification inhibitor. Simultaneously H^+ is removed, while Ca^{2+} is pumped into the calcification fluid to increase Ω, which allows calcification (Zeebe and Sanyal., 2002). Because salinity determines Mg and Ca concentrations, changes in these could indeed influence the calcification process of foraminifera and, therefore, their Mg/Ca ratio. Since, our relation is based on a relatively short salinity range, additional culturing experiments are planned to further constrain the relationship between foraminiferal Mg/Ca and salinity and to distinguish between both hypotheses.

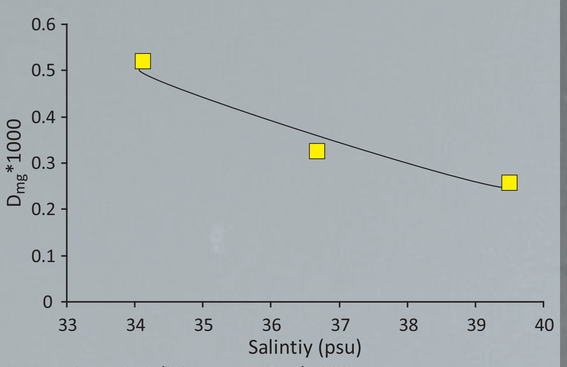

Figure 6: Salinity versus D_{mg}*1000

References

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