Earth and Planetary Science Letters 452 (2016) 90–103

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Evaluating controls on planktonic foraminiferal geochemistry in the Eastern Tropical North Pacific

Kelly Ann Gibson [a,*], Robert C. Thunell [a], Maria Luisa Machain-Castillo [b], Jennifer Fehrenbacher [c], Howard J. Spero [c], Kate Wejnert [d], Xinantecatl Nava-Fernández [b], Eric J. Tappa [a]

[a] School of the Earth, Ocean, and Environment, University of South Carolina, Columbia, SC, 29205, USA
[b] Instituto de Ciencias del Mar y Limnología de México, Universidad Nacional Autónoma de México, Unidad Académia Procesos Oceánicos y Costeros, Circuito Exeriro s/n, Ciudad Universitaria, 04510, México DF, Mexico
[c] Department of Earth and Planetary Sciences, University of California Davis, Davis, CA 95616, USA
[d] Fernbank Science Center, Atlanta, GA 30307, USA

ARTICLE INFO

Article history:
Received 31 January 2016
Received in revised form 20 July 2016
Accepted 21 July 2016
Available online 10 August 2016
Editor: D. Vance

Keywords:
foraminiferal geochemistry
Mg/Ca
Eastern Tropical North Pacific
water column hydrography
secondary calcite
pH/[CO_3^{2-}]

ABSTRACT

To explore relationships between water column hydrography and foraminiferal geochemistry in the Eastern Tropical North Pacific, we present $\delta^{18}O$ and Mg/Ca records from three species of planktonic foraminifera, *Globigerinoides ruber*, *Globigerina bulloides*, and *Globorotalia menardii*, collected from a sediment trap mooring maintained in the Gulf of Tehuantepec from 2006–2012. Differences in $\delta^{18}O$ between mixed-layer species *G. ruber* and *G. bulloides* and thermocline-dweller *G. menardii* track seasonal changes in upwelling. The records suggest an increase in upwelling during the peak positive phase of El Niño, and an overall reduction in stratification over the six-year period. For all three species, Mg/Ca ratios are higher than what has been reported in previous studies, and show poor correlations to calcification temperature. We suggest that low pH (7.6–8.0) and [CO_3^{2-}] values (~70–120 μmol/kg) in the mixed layer contribute to an overall trend of higher Mg/Ca ratios in this region. Laser Ablation Inductively Coupled Mass Spectrometry analyses of *G. bulloides* with high Mg/Ca ratios (>9 mmol/mol) reveal the presence of a secondary coating of inorganic calcite that has Mg/Ca and Mn/Ca ratios up to an order of magnitude higher than these elemental ratios in the primary calcite, along with elevated Sr/Ca and Ba/Ca ratios. Some of the samples with abnormally high Mg/Ca are found during periods of high primary productivity, suggesting the alteration may be related to changes in carbonate saturation resulting from remineralization of organic matter in oxygen-poor waters in the water column. Although similar shell layering has been observed on fossil foraminifera, this is the first time such alteration has been studied in shells collected from the water column. Our results suggest a role for seawater carbonate chemistry in influencing foraminiferal calcite trace element:calcium ratios prior to deposition on the seafloor, particularly in high-productivity, low-oxygen environments.

1. Introduction

Production in the Eastern Tropical Pacific (ETP) accounts for 10% of total global primary productivity (Pennington et al., 2006). As such, the region plays an important role in the global carbon cycle. In the Eastern Pacific Warm Pool (EPWP), changes in sea level pressure (SLP) gradients between the Atlantic and Pacific Ocean basins lead to wind-driven upwelling of nutrient-rich subsurface waters that support locally high primary productivity (Pennington et al., 2006). The impacts of future warming on SLP gradients and wind-driven upwelling are uncertain, with conflicting reports from different coastal systems (Garcia-Reyes et al., 2015). Continued warming will almost certainly influence productivity and ocean-atmosphere CO_2 fluxes in these regions. Reconstructions of water column hydrography can be used to assess SLP gradient-driven changes in upwelling in the past. These changes are key to understanding how warming trends will impact productivity and changes in the carbon cycle in this region in the future.

Foraminiferal Mg/Ca ratios are a widely used tool for reconstructing changes in water column temperature. Samples used in

* Corresponding author at: University of South Carolina, School of the Earth, Ocean and Environment, 701 Sumter St EWS 617, Columbia, SC, 29208, USA.
E-mail address: kgibson@geol.sc.edu (K.A. Gibson).

http://dx.doi.org/10.1016/j.epsl.2016.07.039
0012-821X/

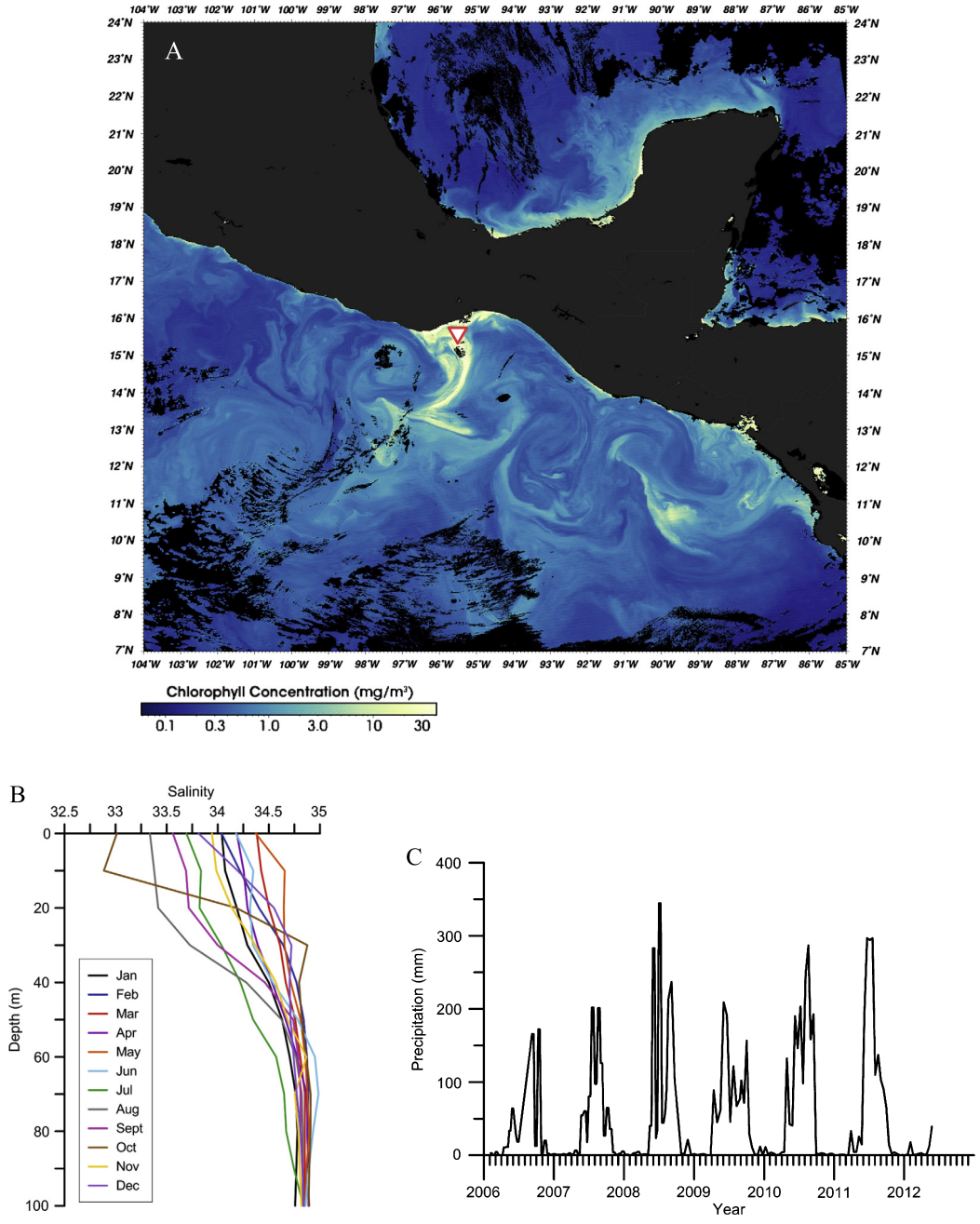

Fig. 1. Regional setting for the GoT sediment trap mooring. (A) January 2005 chlorophyll concentrations (http://oceancolor.gsfc.nasa.gov/cms/) associated with a "Tehuanos" wind event, with the location of the sediment trap mooring (white triangle). (B) Variation in salinity (WOA 13) throughout the year over the upper 100 m of the water column. (C) Biweekly precipitation totals for the study period from the TRMM satellite (Huffman et al., 2007).

the development and calibration of this proxy have come from laboratory culture, sediment traps, plankton tows and core-tops, and nearly all regions of the world's oceans. Consistent throughout all of these calibration studies is an exponential Mg/Ca ratio:temperature sensitivity of 8–10% change in ratio per °C (Anand et al., 2003; Bolton et al., 2011; Dekens et al., 2002; Lea et al., 1999; Martínez-Botí et al., 2011; Mashiotta et al., 1999; McConnell and Thunell, 2005; Regenberg et al., 2009). The influences of secondary factors such as salinity and carbonate chemistry are still being evaluated, and in many cases appear to be species – and/or region-specific (Arbuszewski et al., 2010; Dekens et al., 2002; Evans et al., 2016; Hertzberg and Schmidt, 2013; Hönisch et al., 2013; Kısakürek et al., 2008; Russell et al., 2004).

In this study we investigate the relationship between water column hydrography and the $\delta^{18}O$ and Mg/Ca signatures of three species of planktonic foraminifera, *Globigerinoides ruber, Globigerina bulloides*, and *Globorotalia menardii*, collected between 2006 and 2012 from a sediment trap moored in the Gulf of Tehuantepec (GoT), located in the EPWP (Fig. 1). The goal is to establish the utility of using these species to reconstruct water column hydrography and changes in upwelling in this region. *Globigerinoides ruber* records mixed-layer temperatures (Fairbanks et al., 1982) and is typically found in relatively low numbers throughout the year in the GoT, only dominating the assemblage during El Niño conditions (Machain Castillo, pers. comm.). *Globigerina bulloides* is the most abundant species of foraminifera in GoT surface sediments (Machain-Castillo et al., 2008), and is present throughout the year in sediment trap samples. Therefore, this species was selected to provide the most complete temporal coverage for this study, despite the fact *G. bulloides* often displays seasonal