HOLOCENE PALEOCLIMATE AND PALEOPRECIPITATION VARIABILITY IN THE TROPICAL PACIFIC – LAMINATED SEDIMENTS FROM LA PAZ BASIN, SOUTHERN GULF OF CALIFORNIA

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Abstract

Results of a paleoclimatic and paleoceanographic study of a Holocene sediment sequence from the La Paz Basin in the southern Gulf of California are presented. The sediment sequence is finely laminated and spans the past 7300 cal yr BP. The study is carried out in a 145 cm long core recovered from the basin slope, within the oxygen minimum zone. Laboratory measurements include major and trace element geochemistry, microfossil and rock magnetic properties. In this note, we focus on the magnetic properties (low field magnetic susceptibility). Major changes in the records are observed at *ca*. 5300 cal yr BP, with shifts occurring at *ca* 4000, 2100 and 1500 cal yr BP. Radiolarian records indicate a drop in primary productivity between 5300 to ca 4000 cal yr BP and terrigenous records a gradual change from wetter to dryer conditions. The low and high frequency magnetic susceptibility logs show a cyclic variation with a periodicity of around 1500 yr.

Keywords: Holocene, Palaeoclimate, Rock magnetic properties, Gulf of California

Introduction

The marginal and central basins in the Gulf of California preserve high resolution paleoclimatic and paleoceanographic records. The sediment sequences are being studied to reconstruct the past climate and oceanographic changes during the late Pleistocene and Holocene (*e.g*., Molina-Cruz *et al*., 2002; Barron *et al*., 2004; Gonzalez-Yajimovich *et al*., 2005; Pérez-Cruz, 2006, 2013).

The sediments in the southern Gulf of California record the climatic and oceanographic conditions in the tropical Pacific, which plays a major role in the global climate (*e.g*., Cane, 1998; Chiang, 2009). Studies have long highlighted the links of the North American monsoon in the paleoprecipitation patterns and the effects of El Niño Southern Oscillation (ENSO) events (Pérez-Cruz, 2006; Pahnke *et al*., 2007). Recently, the influence and control mechanisms associated with latitudinal migration of the Inter-Tropical Convergence Zone (ITZC) in the precipitation in the tropical Pacific have been discussed (Leduc *et al*., 2009; Pérez-Cruz, 2013). The monsoon climate variability in southern North America has been less studied, with relatively few detailed records available (*e.g*, Poore *et al*., 2005; Roy *et al*., 2013). The controls of the ITZC migration in the precipitation in the Atlantic basins have long been documented, with detailed records now available for the Cariaco and the Gulf of Mexico basins (*e.g*., Peterson and Haug, 2006; Montero-Serrano *et al*., 2011). Our interest is to extend the studies into the Tropical Pacific Ocean.

Here, we present the initial results of a study of a hemipelagic finely laminated sediment sequence cored in La Paz Basin in the southern Gulf of California (fig. 1).

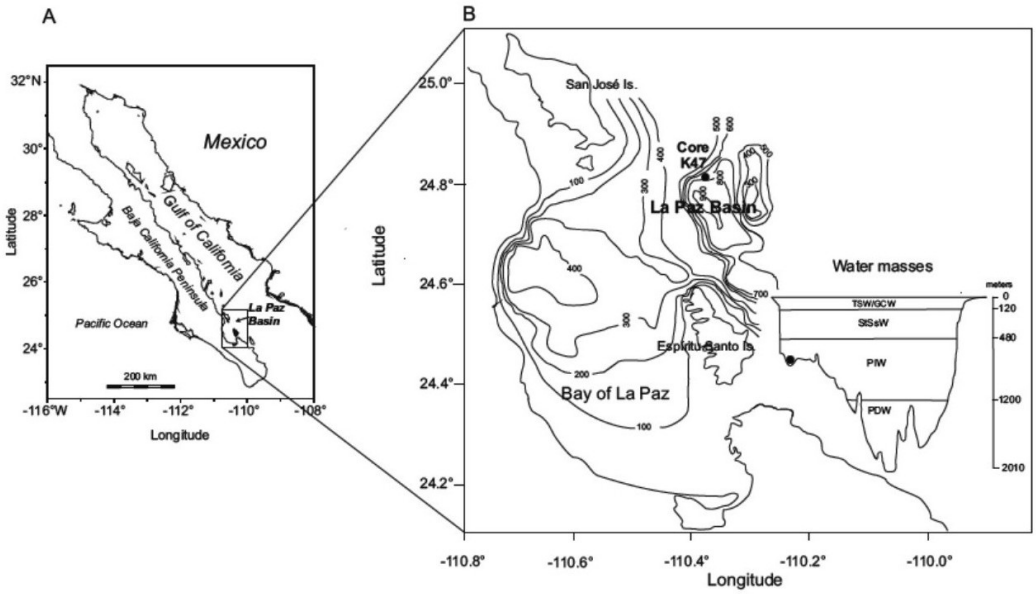

Figure 1. **A**) La Paz Basin in the southwestern part of Gulf of California. **B**) Location of the core K47 (indicated by black point) in la Paz Basin showing the isobath contour lines (From Álvarez, *et al*., 2012).

Sediment sequence

The study area is in the southern Gulf of California, in the La Paz Basin on the eastern margin of southern Baja California peninsula. The margin is characterized by the presence of thick silicic volcanic tuff sequences of the Comondu Formation, which constitute the source for sediments deposited in the basins (Pérez-Cruz, 2006). Oceanographic conditions in the area of La Paz Basin have been studied by several authors (*e.g*., Pegau *et al*., 2002; Figueroa *et al*., 2003).

The DIPAL-III K47 core was collected from the western basin slope at 830 m depth within the oxygen minimum zone. Radiocarbon AMS dating indicates that the core spans the period from *ca*. 7300 cal yr BP to 1000 cal yr BP. Estimated sedimentation rates vary from 0.2 to 0.29 mm/yr, with lower rates for the Middle Holocene. We have carried out different studies, including geochemical, rock magnetic and microfossil analyses. The core, with a length of 145 cm, was cut in halves and sub-sampled at 1-cm intervals for the geochemical, microfossil and rock magnetic analyses. Major and trace elements are measured with an X-ray fluorescence Nitton analyzer. Measurements in sub-samples include low and high frequency susceptibility, intensity and direction of natural remanent magnetization (NRM), alternating field (AF) demagnetization and acquisition of isothermal remanent magnetization (IRM). Magnetic hysteresis, IRM acquisition and back field demagnetization were measured in microsamples using a MicroMag instrument. Magnetic susceptibility was also measured along the core using a Bartington high resolution surface probe.

Rock magnetism

The magnetic susceptibility log shows high values in the upper sediments, followed by an apparent cyclic pattern (fig. 2). Magnetic susceptibility in the upper 10-15 cm varies up to 26 10^{-5} (SI units) at about 5 cm. Below about 15 cm, susceptibility varies around 3 10^{-5} (SI units). In the hysteresis remanent and saturation magnetizations, higher values are in the upper 15 cm, which are

characterized by small Hc/Hcr coercivity ratios. The coercivity ratios show a tendency to increase with depth. The trend correlates with the variation of Hc coercivity that shows a decreasing trend with depth.

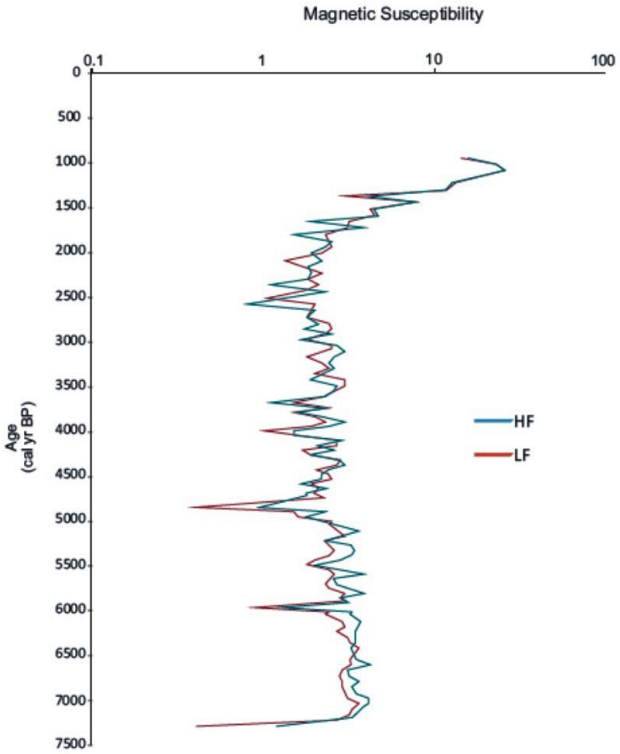

Figure 2. Magnetic susceptibility log for the DIPAL III K47 core from La Paz Basin in the southern Gulf of California. Magnetic susceptibility is given in 10^{-5} SI units. The low and high frequency logs are shown in blue and pink, respectively.

The apparent cyclicity is shown in the NRM intensity, frequency dependence factor, and in the hysteresis magnetization parameters. Domain states inferred from Day plots correspond to pseudo-single domain (PSD), with relatively high coercivity ratios. The paramagnetic correction parameter S* shows two peaks in the middle and towards the bottom of the core at about 60 cm and 115 cm depths. AF demagnetization plots show two or multiple component magnetizations. The median destructive fields (field required to reduce initial NRM intensity in 50 %) vary around 30-35 mT, with values ranging from 9 to 50 mT. Characteristic directions estimated from the intermediate-low coercivity portion in the vector plots show downward inclinations of around 30-45 degrees.

Paleoclimate and paleoprecipitation interpretation

Four climate scenarios have been documented from analyses of radiolarian assemblages, major and trace element chemical (Al, Ba, Ca, K, Si, Ti, Zr and Zr/Al, Ba/Al) and magnetic data. From *ca.* 7300 to *ca*. 5300 cal yr BP, in general, paleoproductivity is high with some oscillations related to persistence of warm and oligotrophic tropical waters. Between *ca*. 5300 and 4000 cal yr BP primary productivity induced by upwelling decreases abruptly, with some species of radiolarians favoured probably by turbulence mix and mesoscale gyres. Between ca. 4000 to 2700 cal yr BP

productivity fluctuates; radiolarian assemblages suggest that two different physical mechanisms could promote productivity in form of upwelling and gyres. From 2700 to 1000 cal yr BP, it seems that productivity is driven mainly by the east-west gradient across the Gulf of California due to the intensification of NW winds. From 2200 to 1600 cal yr BP, a multi-centennial drought is registered, with conditions in the basin similar to current winter conditions where climate is cold and dry and NW winds are dominant.

Discussion

The control mechanisms of the North America monsoon and effects of ENSO events in the paleoprecipitation patterns have been the focus on recent studies (Pérez-Cruz, 2006; Pahnke *et al*., 2007). The influence of latitudinal migration of the ITZC in the precipitation in the region is also being examined (*e.g*., Leduc *et al*., 2009; Pérez-Cruz, 2013). Here we present results of a study of a laminated sediment sequence cored in La Paz Basin in the southern Gulf of California. The magnetic susceptibility log shows high values in the upper 10-15 cm that span the last 1500 cal yr BP, followed by an apparent cyclic pattern in the rest of the core. The low and high frequency susceptibility logs are plotted as a function of age derived from the AMS radiocarbon age model (fig. 2). Spectral analysis shows a period of around 1500 yr. The pattern is also observed in the other magnetic parameters, notably in the hysteresis remanent and saturation magnetizations. The magnetic property logs show variation patterns with depth similar to those determined in the nearby Alfonso Basin (Pérez-Cruz and Urrutia-Fucugauchi, 2009, 2010), where susceptibility logs also show higher values in the upper shallow sediments, followed by small amplitude cyclic variation with depth.

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