

Century-to-decade scale modulation of ENSO recorded by postglacial laminated sediments from the Peru continental margin

G. Skilbeck¹, M. Gagan², I. Goodwin³, M. Watson¹, and D. Fink⁴

¹Department of Environmental Sciences, University of Technology, Sydney. P.O. Box 123 Broadway. NSW. Australia. 2007. g.skilbeck@uts.edu.au

²Research School of Earth Sciences, Australian National University. Canberra, A.C.T. Australia. 0200.

³School of Environmental and Life Sciences, University of Newcastle. Callaghan, NSW. Australia. 2308.

⁴ANSTO-Environment, PMB 1, Menai, NSW, Australia.

Introduction

Cores collected from three sites on the continental margin of Peru during ODP Leg 201 recovered >5 m of LGM-recent sediment. At Site 1227 Holocene sediments are absent, but a well preserved early last glacial-interglacial transition (LGIT) section spanning ~17,200-15,900 cal yrBP is present. The sediments are predominantly diatomaceous oozes with subtle dark and light laminations which may be annual in origin. The chronology of drill-core at this site is well-constrained by five bulk sediment ¹⁴C dates that define a linear sedimentation rate of ~270 cm/ka (Skilbeck and Fink, 2004).

In contrast, Holocene sediments are well-represented at Sites 1228 and 1229. Sedimentation rates over this period suggest the Holocene can be subdivided into two regimes. The older period spans the early and middle Holocene (~10,000 yrBP to ~2,800 yrBP) during which time the sedimentation rate was relatively slow at 4-6 cm/ka. However, we cannot exclude the possibility of unconformities in this part of the stratigraphic section, and this rate should therefore be considered a minimum. From ~2,800 yrBP to the present day, the chronology at both sites is well defined by multiple ¹⁴C ages that allow us to confidently define linear sedimentation rates of 70-100 cm/ka (Skilbeck and Fink, 2004). At both sites, the late Holocene appears to be stratigraphically complete.

Time Series Analysis

In order to investigate an El Nino origin for the laminae on this part of the Peru shelf, we have undertaken two independent lines of study. First, high-resolution (0.1 mm per pixel) scanned colour images were analysed for all of the cores. For the early LGIT and the late Holocene, the chronological model indicates that sub-annual layers can be resolved, where present. Accordingly, we have used the red colour intensity band from the scanned images to carry out time series analysis of ENSO-band (2-8 year) variability. Analysis of Hole 1228B shows two cyclicity peaks in the ENSO band over the past 10 ka. One of these, at a peak period of 5.3 yr, dominates over the last 3 ka, with the overall Holocene pattern very similar to that shown by Rodbell et al (1999), Moy et al. (2002), and Riedinger et al. (2002). In contrast, spectral analysis of ENSO band data from Hole 1227B, shows a strong decadal variance peaking at 16.5 and 22.5 yr and only weak variance in the ENSO band (4.7 yr). In addition, there is a well-developed oscillation in the variance of these data with cyclicity of about 110 yr which we believe is similar to that proposed by Tudhope *et al.* (2001).

Geochemical Analysis

We have sought to test that the laminations do indeed contain a climate signal by undertaking several geochemical and mineralogical studies. The sediments are dominantly diatomaceous oozes, but contain other minor components, including

terrigenous sediment and organic matter. We analysed $\delta^{13}\text{C}$ of bulk organic matter, $\delta^{18}\text{O}$ of planktonic foraminifer tests, organic carbon content, carbonate content, and terrigenous sediment (quartz/feldspar) percentages of representative dark and light laminae in upper part of Hole 1227B. Our hypothesis is that El Niño events will produce warmer and wetter conditions (lower foraminiferal $\delta^{18}\text{O}$) and increased terrestrial sediment input (increased quartz and feldspar and lower $\delta^{13}\text{C}$ of organic matter). At the same time, the bulk organic carbon and carbonate data will reflect a decline in water-column productivity driven by the suppression of upwelled nutrients during El Niño events. Taken together, our preliminary analyses (Figure 1) indicate that the dark laminae represent periods of warmer sea surface temperatures and increased terrestrial runoff associated with El Niño events.

Conclusions

Independent time series and geochemical analysis of LGM-Holocene sediments from the Peru continental margin indicate the presence of an El Niño/La Niña climate signal preserved in alternating dark and light laminae. Time-series analysis of long (>1000 yr), stratigraphically continuous sequences from the late Holocene and the early LGIT reveal decadal (~15-20 yr) and century (~110 yr) scale modulation of ENSO climate variability.

Acknowledgements

We would like to thank Dennis Mather and the staff at The Australian Institute of Nuclear Science and Engineering (AINSE) for grants supporting radiocarbon dating in this project (Nos 02/169 & 04/139), and the Australian ODP Office for their assistance in providing funds for collection and analysis of material.

References

- Moy, C.M., Seltzer, G.O., Rodbell, D.T. and Anderson, D.M. 2002. Variability of El Niño/Southern Oscillation activity at millennial timescales during the Holocene epoch. *Nature* 420, 162-165.
- Riedinger, M.A., Steinitz-Kannan, M., Last, W.M., Brenner, M., 2002, A ~6100 ^{14}C yr record of El Niño activity from the Galapagos Islands. *Journal of Paleolimnology*, 27, 1-7.
- Rodbell, D.T., Seltzer, G.O., Anderson, D.M., Abbott, M.B., Enfield, D.B., Newman, J.H., 1999. An ~15,000-year record of El Niño-driven alluviation in southwestern Ecuador. *Science* 283, 516-520.
- Skilbeck, C.G. and Fink, D. 2004: Radiocarbon dating and sedimentation rates for Holocene-Late Pleistocene sediments, eastern equatorial Pacific and Peru continental margin. *Submitted to* D'Hondt, S.L., Jørgensen, B.B. Miller, D.J. et al. (eds) *Controls on microbial communities in deeply buried sediments, eastern equatorial Pacific and Peru margin*. Proc. ODP, Scientific Results. [CD-ROM], 201: College Station TX (Ocean Drilling Program).
- Tudhope, A.W., Chilcott, C.P., McCulloch, M.T., Cook, E.R., Chappell, J., Ellam, R.M., Lea, D.W., Lough, J.M., Shimmield, G.B., 2001, Variability in the El Niño-Southern Oscillation through a glacial interglacial cycle. *Science* 291 (5508), 1511-1517.

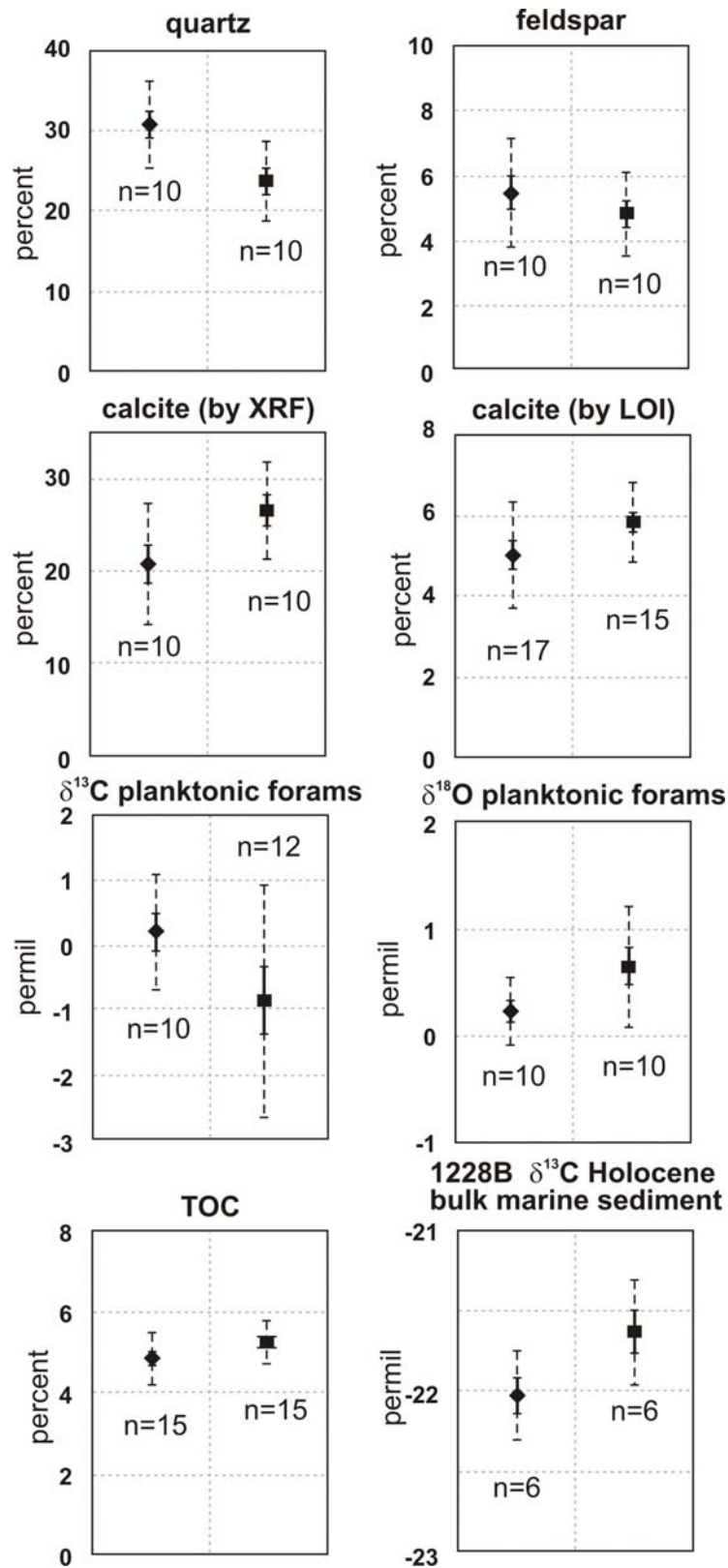


Figure 1: Plot of mean and range data for various geochemical and mineralogical data from Peru continental margin. All data from LGIT unless otherwise indicated. Diamond symbols are the mean values for “dark” layers, square symbols are the means for “light” layers. Dashed bars are standard deviation, solid bars are standard error of the sample mean.