12.740 Paleoceanography

Spring 2008

Paleoceanography 12.740 Spring 2006 Lecture 13

Coral evidence for temperature, salinity, and nutrient changes

I. Corals as sub-annual resolution paleoceanographic archives spanning (at least) hundreds of thousands of years: a brief history

A. 1972: Buddemeier and coworkers: used autoradiographs (bomb fallout) of Eniwetok corals to establish that x-ray visible density growth bands were annual in nature (at least at that site). Weber and Woodhead established O18-T relationship (offset in "light" direction from equilibrium) for some corals.

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Source: Fairbanks and Matthews, 1978 adapted from Weber and Woodhead, 1972.

B. 1973: Weber shows inverse correlation between coralline Sr/Ca and temperature.

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Source: Smith et al. (1979).

C. 1974: Moore and coworkers: used other $^{228}Ra/^{226}Ra$ to date corals from other islands. In time, Moore and other workers would extend these radioisotope methods to other radioisotopes, such as ^{90}Sr, $^{14}C/^{12}C$, ^{210}Pb...

D. 1977: Shackleton and Matthews do first study of ^{18}O in Barbados high stand terraces.

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D. 1978: Emiliani establishes annual cyclicity of coral ^{18}O. Nozaki and Turekian present a 200 year record of $^{14}C/^{12}C$: evidence for history of bomb ^{14}C and initial explorations of $^{13}C/^{12}C$ as a tracer. Druffel and coworkers report other bomb ^{14}C histories. Fairbanks and Matthews examine ^{18}O from old (on-land) drilled coral terraces.

E. 1979: Fairbanks and Dodge examine annual cycles of ^{18}O and ^{13}C in corals. ^{18}O seems to go with T, but ^{13}C may reflect light intensity (or growth rate, or some other correlated parameter).

F. 1980's: lots of work on O18, C13, ^{90}Sr, ^{14}C, ^{210}Pb. Shen begins first work on trace elements in corals (Pb, Cd).

G. 1989: McConnaughey shows that portions of a contiguous annual band of a coral can show significantly different $\delta^{18}O$ and $\delta^{13}C$, depending on orientation of band relative to sunlight.

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Source: McConnaughey, 1989.

Adkins modified McConnaughey calcification model:

Image removed due to copyright considerations.
Source: Adkins et al. (2003) GCA, figure 7.

G. 1990's: the era of global change and the quest for understanding of decadal-century scale climate processes and variability.

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Source: Cole et al., 1993.

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Source: Dunbar et al. (1994).

H. 1992: Edwards and coworkers and Shen and coworkers begin the use of high precision TIMS Sr/Ca measurements as a temperature tracer.

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Source: deVilliers et al. (1995).

I. 1993: groups of Edwards and Shen report that U/Ca is also temperature-dependent (even more so than Sr).

J. 1994: Fairbanks and coworkers report coherent ^{18}O and Sr/Ca data from 18K Barbados corals suggesting >5°C temperature change during last glacial maximum.

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Source: Guilderson et al. (1995).

K. El Nino in fossil 124 kyrBP Indonesian coral? – oxygen isotopes and Sr/Ca in a fossil coral that grew 124,000 years ago in Indonesia "reflect interannual variability in precipitation and sea surface temperature (SST) due to El Niño/Southern Oscillation (ENSO)."

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Source: Hughen et al., 1999, figure 2.

II. Deep Sea Corals

Deep-sea corals grow for 50-200 years as solitary individuals attached to a hard surface (sometimes "mounds" of these occur growing on top of each other). Optical density banding is observed and the number of bands is approximately equal to the age of the coral (Cheng et al., 2000; but it is uncertain whether these bands are always annual, and it is not clear how to sample the coral to bring out temporal signals apart from moving from the attachment end towards the growth edge.

Smith et al. (1997) pointed out that deep sea corals could be used to tackle paleo problems. Adkins et al. (1998) showed that ^{230}Th/U, ^{14}C, and Cd/Ca could be used to demonstrate decadal-scale changes in deep water properties in the deep Atlantic.

Image removed due to copyright considerations.
Source: Adkins et al. (1998).

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