Exam Paleoclimate M.Sc. GEO4-1405 **November 8, 2005**

Read the questions carefully, check if your answers fully reply to the questions
Preferably give your answers to Questions-5 on (a) separate sheet(s)

Q1) The "Binge Purge" model of sub-Milankovitch climate change was introduced by MacAyael in 1993.
a) What is according to this model the driving force for sudden collapses of the ice sheets?
b) Describe the sequence of events that, according to the "Binge Purge" model, would result in a semi periodicity in ice sheet collapse.
c) Explain why a good correlation between ^{14}C, ^{10}Be and ice sheet collapse would be an argument in favor or against the "Binge Purge" model.
d) In 2004 Hulbe et al came up with a link between the "Binge-Purge" model and solar activity. Describe how they linked model and solar activity.
{14 pt}

Q2)
In the geological past there have been several episodes characterized by wide spread dysoxic conditions in the water column. Dysoxic conditions often develop first at mid depth, below the so-called mixed-layer.
a) How do you call this water layer of low oxygen concentrations?
b) Why is it that low oxygen conditions in the water column usually start at mid depth? (hint: the oxygen concentration of a water mass is a function of which two processes?).
c) Give two proxies for water column dysoxia, describe the processes involved in the proxy recording and possible pitfalls.
d) Why does nitrate become enriched in ^{15}N as a consequence of water column dysoxia?
e) Large scale changes in denitrification have been invoked to explain differences in pCO_2 on a sub-Milankovitch time scale (Altabet et al., 2002). Explain how according to this theory mid depth dysoxia is regulating global pCO_2.
{16 pt}

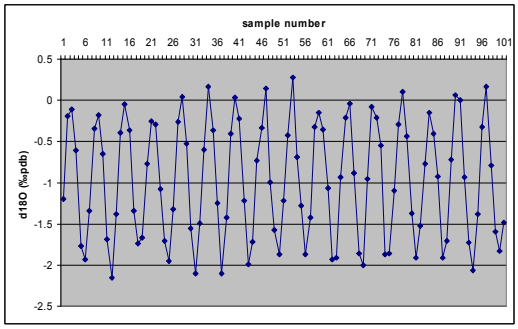
Q3)
Three coral samples have been analyzed for their 14C content

Sample	$(^{14}C/C)_{formation}/ {}^{14}C/C)_{today}$
A	0.321
B	0.098
C	0.004

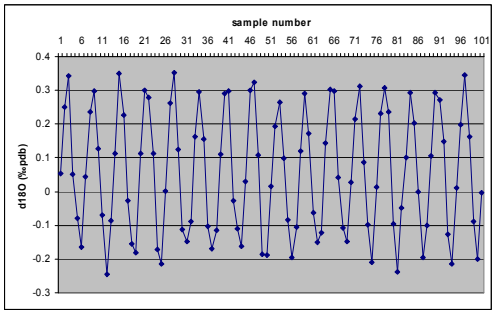
Hint:
$^{14}C/C)_{today} = {}^{14}C/C)_{formation} * e^{-\lambda t}$
λ = 8200 yrs

a) Calculate ages for the three samples.

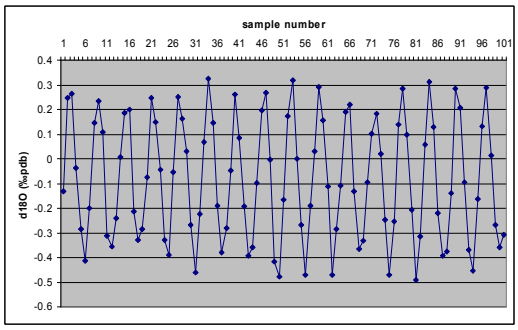
The samples were recovered from raised coral terraces of Oman. There is very little rain fall in this area. Sea surface temperatures vary as a function of upwelling intensity.
b) From these samples also the oxygen isotopes were analyzed. How would you interpret the changes in $\delta^{18}O$? What would a change in the amplitude of $\delta^{18}O$ suggest?



A

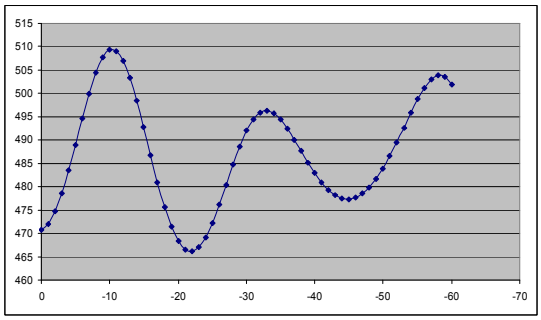


B



C

c) Compare the changes you see in $\delta^{18}O$ for the three time intervals (A,B and C) with local insolation curves. Give a scenario in which you link the observed changes to the insolation curve.



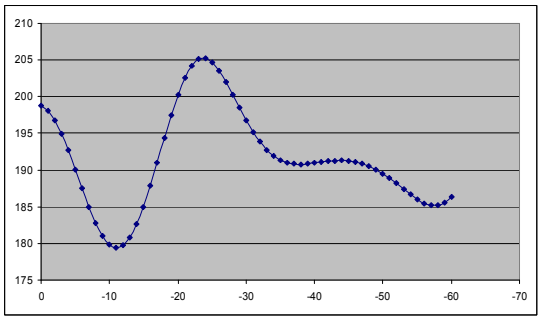


Figure at the left: July insolation, right hand figure: December insolation. Time is in kyrs before present.

d) From the oldest sample we also analyzed U/Th ages. These ages are consequently older. This is probably related to the basic principal according which ^{14}C dating is based. Briefly explain this basic principle and why this could be responsible for the observed offset.
{16 pt}

Q4) The most common tool used by paleoceanographers for dating their records of climate change beyond the interval in which ^{14}C can be used is correlation to the SPECMAP-stack standard isotope record.
a) How was the SPECMAP curve dated itself?
b) The large and rapid changes associated with deglaciations during the last 600kyr are roughly paced how many (kilo)years apart?
c) Interaction between which orbital parameters might have been responsible for this frequency?
{10pt}

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Q5. For this exercise, a simplified Global Ocean circulation system with deep water formation in the North Atlantic alone, may be assumed (i.e. neglecting possible mixing processes and additional deepwater formation in the Southern ocean). For additional information and data, see also "Additional information", below. In the first part of this question, some important parameters will be qualitatively introduced, whereas in the second part, a more quantitative approach follows.

a. give the sequence of deepwater ages for the major ocean basins (i.e. for Indian, Pacific, and Atlantic ocean, specifying North and South for each ocean). Motivate briefly
b. for the same basins, give the sequence for the deep water concentrations of: Ca, Ba, PO_4, O_2, Cd; explain briefly
c. Give the Redfield ratio
d. give in your own words a qualitative definition for 'export productivity', and for 'burial efficiency'
e. explain in your own words how export productivity relates to primary productivity, and give a usually assumed % from one to the other

{18 pt}

After this <u>qualitative</u> assessment, we will now try to <u>quantify</u> things. If you seem to lack adequate information (see also Additional Information given below), you may take a number that you think is reasonable (but motivate your choice)

f. what export productivity do you expect for the average world ocean (give your answer in gC m^{-2} y^{-1}, and briefly motivate)
g. give an estimated average organic carbon flux that will arrive at the average seafloor ocean (give your answer in gC m^{-2} y^{-1}, and briefly motivate)
h. what is the average flux that will be found in the sediment (give your answer in gC m^{-2} y^{-1}, and briefly motivate)
i. calculate the total average organic carbon flux that is decomposed in the average deep water (give your answer in gC m^{-2} y^{-1}, and briefly motivate
j. determine from the previous information the oxygen, PO4, and Ba concentration in the deep water of the Northern Pacific (in umol/l)
k. what parameters would you measure in Glacial benthic foraminifera so as to detect any changes in Global deep water circulation patterns, and from what part of the ocean would you prefer to get your samples? Motivate your answers.

{26 pt}