Examination Quaternary Geology and Climate Change GEO3-4303

Thursday 21 April 2004; Grand Lecture Theatre AW Building
Teacher: Dr. H. Middelkoop

Carefully read the questions and give complete answers (in Dutch or English)!

1. Definitions

Briefly indicate the meaning of the following items:

a. Forebulge
b. Heinrich event
c. Orbital tuning
d. Global Warming Potential
e. Equilibrium line of a glacier

2. Time control

The ^{14}C method has been widely applied in dating materials containing carbon. Due to various reasons ^{14}C ages must be converted to absolute, calibrated ages.

a. Using which methods a ^{14}C calibration curve can be established? Give at least three methods with their associated time range.
b. Explain what will be the effect of the anthropogenic emission of greenhouse gases into the atmosphere during the past decennia on the shape of the ^{14}C calibration curve for the most recent decennia.

c. Explain how records of paleomagnetic reversals can be used as a dating method in Quaternary climate research.

3. Climate forcing and response

Orbital variations are a major cause of climate change during the Quaternary. Figure 1 shows the changes in 3 orbital parameters during the past 800 ka.

a. Indicate which curve represents which parameter.
b. Explain the variation in amplitude of the lower of the three curves.

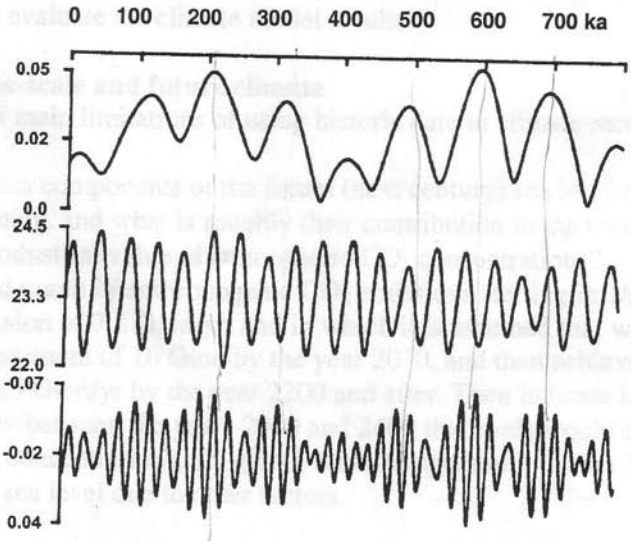

Figure 1 Variation in orbital parameters during the past 700 ka.

3 – continued -

c. Which variation in insolation seems to be the main control for the occurrence of ice sheets? Which orbital parameter mostly determines this variation?
d. Which insolation variation and which orbital parameter control monsoon intensities?
e. The $\delta^{18}O$ curves of benthic forams in Ocean cores reflect the volume of continental ice sheets, but the timing of the curves does not exactly coincide with the timing of the orbital forcing. Is there a lead or lag; explain why this happens.
f. Sapropel records in the Mediterranean Sea and freshwater diatom records in ocean cores near Africa both reflect variations in monsoon intensity. Do these show a lag or lead when compared to the timing of the orbital forcing? Explain why.

4. Ice core and ocean records

a. Explain whether or not you can reconstruct changes in ice volume from the $\delta^{18}O$ curves of continental ice sheets, and –if so- how this is done. Can you reconstruct quaternary ice sheet volumes without any $\delta^{18}O$ data from ice cores? Explain.
b. Draw the shape of the $\delta^{18}O$ curve for the past 150.000 years in the Summit (GISP2/GRIP) ice record from Greenland; indicate (schematically) glacial and interglacial periods, Dansgaard-Oeschger cycles and Bond cycles. Also indicate the approximate range of $\delta^{18}O$ values.
c. ^{13}C isotope records ($\delta^{13}C$) from forams in Pacific Ocean cores show fluctuations that represent glacial cycles. Explain the mechanism that causes these fluctuations and how glacial-interglacial cycles are derived from them.

5. Climate modelling

A research team proposes to use a General Circulation Model (GCM) to reconstruct the climate fluctuations that occurred during the Younger Dryas period and the subsequent transition to the Holocene.

a. What is a major cause for the cooling during the Younger Dryas?

For this experiment three groups of data are required: 1) data indicating the climate forcing; 2) geographical inputs to the model, 3) climate proxy data to verify the model results.

b. Which forcings (in addition to what is asked under a) determined the global climate during the Younger Dryas, and how can the magnitude of each of these forcings be reconstructed for this period? Mention at least 3 different forcings.
c. Which geographical data that influence the global climate patterns are required to carry out the simulations, and how are these reconstructed (and dated) for the simulated period?
d. Which proxies (and how can these be dated) for the climate during the Younger Dryas might be used to evaluate the climate model results?

6. Historic time-scale and future climate

a. Explain at least 3 main limitations of using historic data in climate reconstructions of the past millennium.
b. Which are the main components of the future (next century) sea level rise due to the greenhouse warming, and what is roughly their contribution in the total sea level rise?
c. What is the pre-industrial value of atmospheric CO_2 concentrations?
d. Draw a simplified graph of anthropogenic CO_2 emissions starting in 1800 AD, to the current CO_2 emission of 7.1 Gton/yr, and in which it is assumed that we will increase the emissions to a maximum of 10 Gton by the year 2070, and then achieve a gradual reduction back to 3 Gton/yr by the year 2200 and after. Then indicate in this graph schematically how between the years 2000 and 2400 the levels would develop of (1) atmospheric CO_2 concentrations, (2) global mean temperature, (3) sea level due to ice sheet melting (4) sea level due to other factors.